Centre on Regulation in Europe
Improving network industries regulation

Empowering electricity consumers in retail and wholesale markets

Project report

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About CERRE

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- its scientific independence and impartiality;
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The project, within the framework of which this report has been prepared, has received the financial support of a number of CERRE members. As provided for in the association's by-laws, it has, however, been prepared in complete academic independence. The views expressed in this CERRE report are those of the author(s). They do not necessarily correspond to those of CERRE, to any sponsor or to any (other) member of CERRE.

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Her research interests are in the area of Industrial Organization, and she has published widely on privatization, regulation and the introduction of competition, especially in energy markets. She is particularly interested in the distributional impact of regulatory reform, and consumer choice in newly opened markets, both in the UK and elsewhere.

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[1] The authors are grateful to Silvi Berger for her excellent research assistance for section 2; and to Miguel Flores and Minyan Zhu for their co-authorship in associated research and help in identifying the original findings reported in section 2.2.2.

1. Introduction[2]

1.1 Demand and supply

Markets provide an efficient solution to implement the optimal allocation of scarce resources, but only under a set of stringent conditions. Among these conditions, the agents' awareness, willingness and capability are necessary ingredients. A seller who does not know where or when demand is high; or who knows but is not inclined to take advantage of lucrative opportunities; or who knows how to and wants to but is prevented from doing so by a barrier of any kind, will most likely take decisions that are both individually and socially suboptimal. As incompetent and uninformed sellers may be quickly eliminated by skilled competitors, in most markets the supply side works reasonably well under the scrutiny of competition authorities and industry regulators. Things are less positive on the demand side. Many consumers have poor information on prices, or lack rationality to buy what they really need, or cannot change from one seller to another due to a lack of time and financial and other resources. In a nutshell, many markets do not function well because of demand weakness, and some governments feel obliged to intervene to protect endangered consumers.

The energy sector provides a caricature of these symptoms of maladjustment. From the very beginning of the liberalisation process at the end of the 1990s, the industry's opening to competition has been hampered by the failure of a large proportion of consumers to consider electricity as a commodity, maybe because it is an essential ingredient for many recurrent uses. Although the product is by definition homogeneous, a relatively small proportion of consumers engage in the market, so that a considerable amount of money is ‘left on the table’. Such inaction has particular policy relevance when it is those who are vulnerable, whom society may feel are in need of some protection or assistance, who are failing to benefit from better deals available in the market.

1.2 Degrees of reactivity

Final consumers can be reactive to external signals in very different ways. They may not conform to the economics model and, at worst from this perspective, they can be fully ignorant of any data concerning their provider and its competitors, including knowledge of the ability to switch provider. This is a severe handicap when products are horizontally or vertically differentiated. It is less important in the case of electricity because of product homogeneity. However, aside from the quality of service, the difference in retail prices, as well as the type of meter and payment methods proposed on the market, are a source of excessive expenditures and inefficient consumption decisions. If they are poor and/or old and/or face educational or cognitive limitations, these consumers may need some form of public tutorship to realise potential

[2] This report was largely completed before the publication of the Proposal for a Directive of the European Parliament and of the Council on common rules for internal market in electricity (recast) on November 30th 2016.

benefits from participating in the market, or direct protection from high prices. This is one of the arguments often used to justify regulated tariffs and energy checks. Across the European Union, between 10% and 15% of energy consumers belong to one of these categories (EEPE, 2006).

However, most consumers have the opportunity and ability to receive and use information regarding energy supply. For large consumers, in particular industrial customers and municipalities, the energy bill is a substantial part of the operating cost, so they have strong incentives to look for the best opportunities and sign new contracts as soon as they can.

For small business and domestic consumers, the incentives are weaker. When the energy bill is less than 10% of total expenditures, saving 5% on energy can be viewed as insufficient to cover the costs of bargaining with the current supplier or looking for a new one. Even in the UK, one of the first EU Member States that fully opened energy retail markets to competition, some 70% of domestic consumers do not seize the opportunities they have to cut their bill (CMA, 2016). However, in 2015 there were around 3.4 million electricity transfers and 2.7 million gas transfers in the UK, which represented around 12% of all electricity meters and gas meters. Because 'switchers' are an important piece in the competition process for energy retail, most governments try to increase their number, in particular by facilitating the access to information on contract offers and prices.

Improving competition between suppliers is good for efficiency in retailing, but it has little influence on the other parts of the industry, particularly on production. In practice, because of the non-storability of electricity, demand and supply on wholesale markets are matched at prices varying every hour or half-an-hour, whereas final consumers pay prices that are fixed for several months or years, based on average electricity costs. This disconnection of the final consumer from the technical reality of production is not a problem when the product is storable. By contrast, it is a significant source of inefficiency in the electricity industry where consumers do not adapt their behaviour to upstream scarcity signals in real time. Making final consumers responsive to wholesale prices would significantly increase the overall efficiency of the electricity industry by reducing the production capacity necessary to meet peak demand.

Some large consumers can be direct active players, selling into the market a fraction of the baseline they have subscribed to, but most will need the help of skilled intermediaries. This can be done by suppliers proposing time-varying retail prices, by distributors controlling consumption data from installed meters, by system operators in charge of the permanent equilibrium of injections and withdrawals, or by intermediaries able to aggregate scattered shedding capacities.

1.3 Outline of the report

The purpose of the report is to shed light on the problems raised by the lack of engagement of electricity consumers in market activities and to examine the solutions that are currently put forward. We will focus on two solutions currently considered in several EU countries: incentivising switching to low price retailers and promoting demand response. Other questions such as encouraging prosumers, developing storage, increasing energy efficiency and investing in smart grids will be addressed indirectly.

The report is organised as follows:

- In Section 2, we review the variety of factors that deter consumers from participating in the retail market, exploring in particular their expectations of potential gains; and we identify different conditions of vulnerability which may limit potential and realised benefits from the market for particular groups. Raw switching rates may be a misguided target and policy-makers require a variety of tools if they are to address consumer participation and ensure appropriate safeguards for vulnerable consumers. We first identify what is known about consumer response, using information from several British and EU sources, in particular the characteristics associated with (in)activity (2.1). The concept of vulnerability and its relationship to affordability are then explored further (2.2). Finally, we assess which policies are likely to be successful in protecting vulnerable consumers in which circumstances (2.3).
- Section 3 is dedicated to the questions raised by demand-side response (DSR), that is the ability of some consumers to keep an eye on wholesale scarcity signals and to reduce demand or to sell load reductions when the price or some reward is sufficiently attractive. We first point out that consumers' lack of flexibility is damaging to both consumers and the whole electricity system (3.1). We then list the main gains that can be expected from the development of DSR and the associated costs (3.2). In the following Section (3.3), we review the institutional support for DSR in the EU and we give some quantitative information on the level currently reached. The basic microeconomic model that sustains DSR is outlined in Section 3.4 where we address the questions of determining the efficient reward and controlling for the risk of strategic behaviour by consumers participating in DSR programs. In 3.5, we consider the problems raised by the participation of small consumers in DSR, which requires the intervention of aggregators and 3.6 overviews the problem of bundling DSR services with energy sales. Section 4 draws some conclusions.

2. The consumer and the retailer

Consumer response in switching to new suppliers is important both in its own right and because activity (or lack of it) has implications for demand side management: the same businesses and households are involved. Engagement of households and small businesses in switching between energy suppliers has been disappointing, and policy-makers have struggled to engage consumers in accessing the potential gains available from the market. Equity demands that all consumers, including those who are considered vulnerable, should have access to equivalent opportunities, but ensuring that all consumers respond equally, and have equivalent outcomes in terms of expenditure on energy, is more difficult to arrange in a market which depends on choice rather than regulatory allocation. Evidence shows that consumers do not participate in energy markets for a variety of reasons, and that removing one barrier does not guarantee high consumer engagement. Similarly, the definition of vulnerability is more multi-faceted than the traditional consideration of affordability, though this remains an important dimension. In this section, we review the existing evidence, present some new analysis of original data from two UK surveys, in particular on expectations of gains from engagement, and discuss the implications for developing policy.

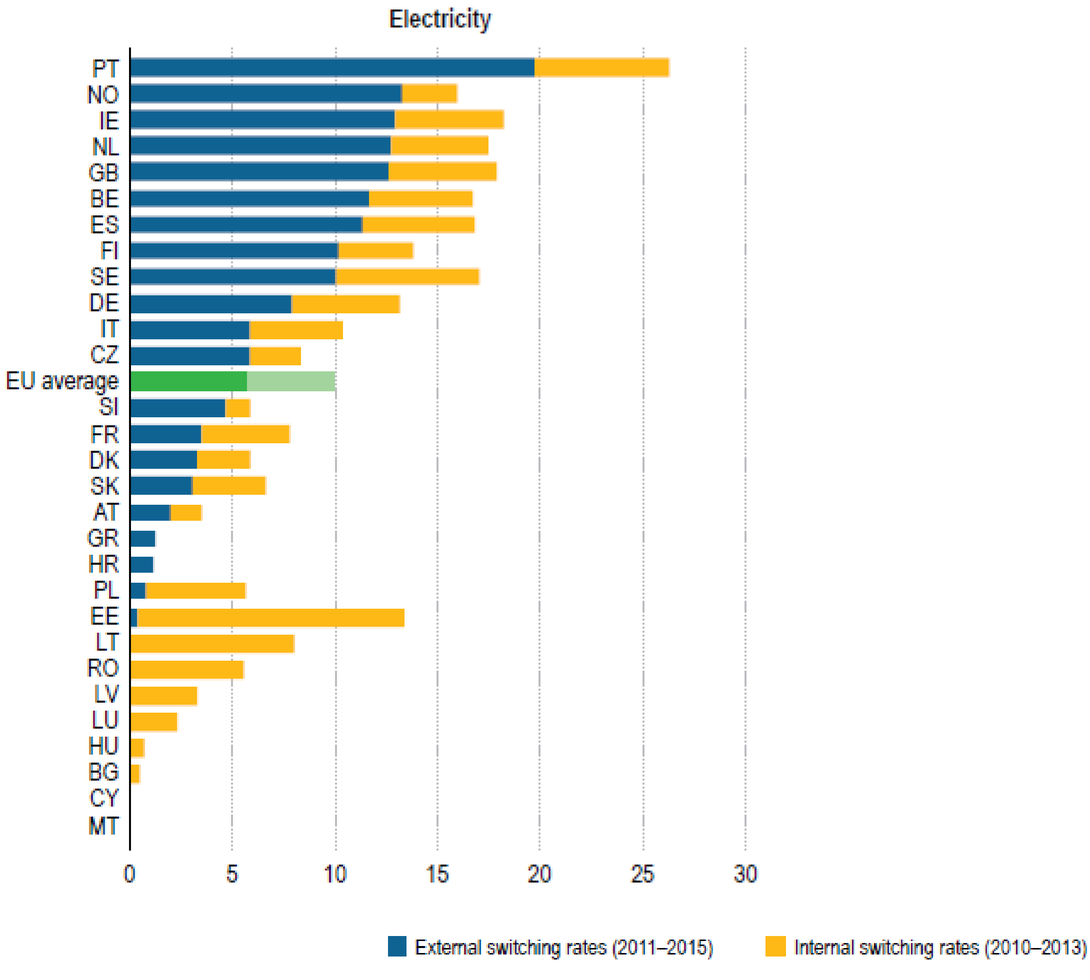
We first identify what is known about consumer response in energy markets, using information from the 'Council of European Energy Regulators Report on commercial barriers to supplier switching in EU retail energy markets' (CEER, 2016), the Competition and Markets Authority report on the British energy market (CMA, 2016) and academic research in this area. The concept of vulnerability is then explored, including its relationship to affordability, and the particular factors associated with engagement in the energy market. In particular, we explore what is known about the characteristics associated with (in)activity, some of which may be indicators of vulnerability, and present new evidence on limitations and bias in consumers' expectations. Third, we discuss policies which may be used to address such issues.

2.1 Active and (dis)engaged consumers

In 2014, the average switching rates (to a different supplier) in European Union Member States were 6.3% for electricity and 5.5% for gas, with ranges from zero (in ten Member States) to 31.1% for electricity; and zero (in eight Member States) to 16.7% for gas (CEER, 2016, Figure 1). The highest switching rate for both fuels was in the Republic of Ireland. In terms of cumulative switching since the markets had opened, while DECC (2014) reported that nearly two thirds of domestic electricity consumers in Great Britain were no longer with their home company, the British market has seen more switching than many: only in six Member States had 20% or more of consumers left their incumbent electricity supplier, and only in five Member States had a similar proportion left their incumbent gas supplier. This consumer inertia has left high concentrations on the supply side in many countries, and it is partly for this reason that consumer activity is seen as an important part of discipline for energy markets. However as the figures above show, many consumers stay with their current suppliers, both in any twelvemonth period and over the longer term. We explore the reasons for this and the characteristics of these less active consumers.

Figure 1, below, is taken from the 2015 ACER/CEER Market Monitoring Report (ACER/CEER, 2016) and shows the variation in both external (between companies) and internal (switching to a cheaper tariff within companies) switching rates across Europe.

Figure 1: Five-year average of external switching rates and three-year average of internal switching rates of electricity and gas household consumers – 2011-2015 and 2010-2013 (%)



Source: CEER National Indicators Database (2016) and ACER calculations.

Switching at any one time may be subject to transient influences. For example, in Britain rates fell after the imposition of non-discrimination clauses (Hviid and Waddams Price, 2012; Waddams Price and Zhu, 2016a; CMA, 2016) but rose following raised political salience of the energy market (Papworth et al., 2015). Over five years, we see considerable differences between European countries, both in external and internal switching. The CEER report on barriers to switching (CEER, 2016) suggests that there are four main reasons for inertia: insufficient gains available (or anticipated by consumers); lack of trust in the process or the players in the market; a complex process of switching (or that consumers expect such complexity); and loyalty to existing suppliers. These categories are similar to those identified by

He and Rainer (2015) in a survey of attitudes in the British energy market, which is one of those open longest to competition and with the highest historical switching rates. The British market has recently been subject to a two-year investigation by the Competition and Markets Authority, concluded in summer 2016. The investigation focused on the importance of weak consumer response, and emphasised that consumer engagement and activity are not binary, but rather on a spectrum according to the different dimensions of (in)activity (CMA, 2016). A major additional barrier is that around one tenth of consumers are unaware that they have a choice of energy suppliers. This figure is confirmed in a number of reports on different countries, e.g. for the UK 11% in 2016 (CMA, 2016); 9% in 2015 (Papworth et al., 2015); for Sweden 9% in 2005 (Ek and Söderholm, 2008). Giulietti et al (2005) showed that this was a particular problem in newly opened markets, and that while awareness increased over initial months, it levelled off, and might perhaps even fall after the initial publicity surrounding the opening of the market had subsided. While this report does not discuss this particular factor further, it may be an important target for policy-makers to ensure that consumers are aware of the possibilities, particularly since potential gains are such an important factor, as section 2.1.2 shows. First, however, we discuss the role of expectations in consumers' activity levels.

2.1.1 Expectations

Relatively low switching rates, even where there are high potential gains, raise questions about whether consumers' *anticipated* gains reflect those which are available in the market. The CEER report on barriers to switching emphasises the importance of consumer perception and how feelings of insecurity may bias choices. Papers on the GB electricity market by Waddams Price and Zhu (2016b) and Flores and Waddams Price (2013) deliberately focus on consumers' *expectations* of gains, in order to abstract from any mismatch between expectations and market possibilities.

Research from both Spain and the Netherlands showed that consumers' expectations of potential gains were considerably lower than those available in the market (CEER, 2016). In the Netherlands, consumers perceived the average annual expected savings to be €85, while those who had switched believed they had saved an average of €147 a year, and the average difference between the average and lowest price was €222. While this may be partially due to different opportunities available to the two groups, the gap seems large. Calculating potential gains without taking account of changed payment methods and tariffs risks ignoring consumers' preferences and valuation of such characteristics. However, it is difficult to know how much consumers' inertia is due to such preferences, and how much is due to unawareness of the alternatives.

Expectations vary across different demographic groups, which may themselves provide some indication of vulnerability, as we demonstrate in section 2.2 below.

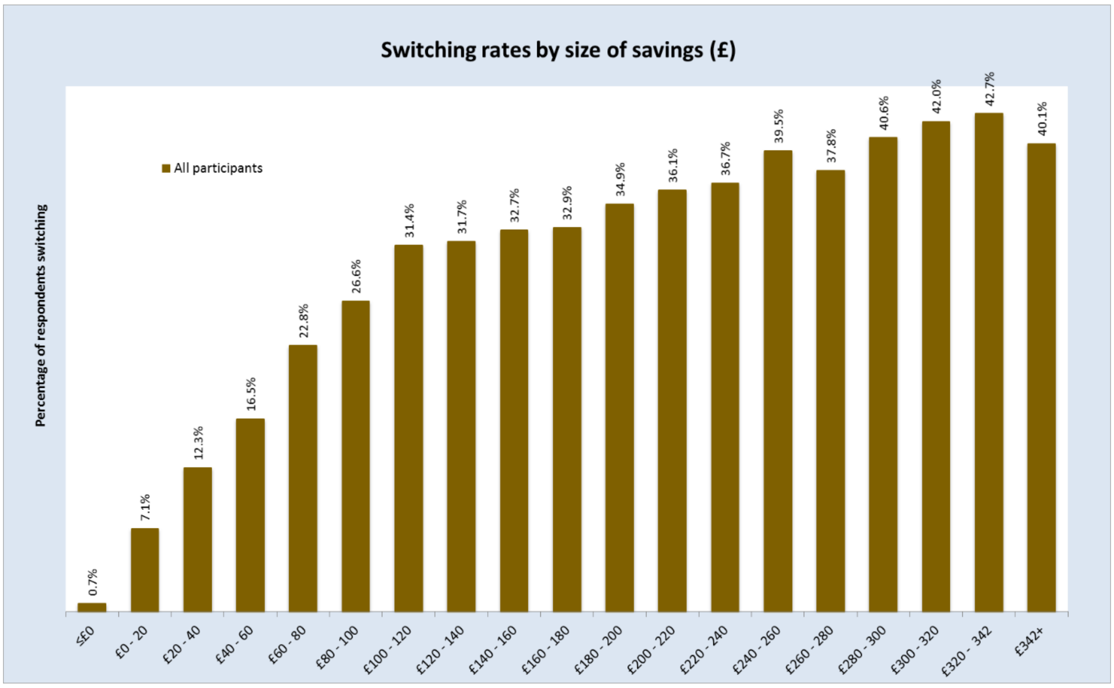
2.1.2 Insufficient gains

For those consumers who do have some idea of what they might gain, switching energy suppliers can be seen as an investment in finding out about, and taking the effort to change to, a better offer, which will only be undertaken if the benefits are expected to exceed the costs. As He and Reiner (2015) confirmed, potential financial gain is a consistent motivator for activity in the market. This was shown by Giulietti et al (2005) for the early GB gas market, if respondents expected such gains to be persistent; later surveys in the British market (Flores and Waddams price, 2013; Waddams Price and Zhu, 2016b) showed a consistent positive influence of higher expected savings on both searching and switching activity, but also that there are considerable differences in the strength and power of this relationship for different groups. This is just one piece of evidence that consumers vary considerably in their responses in the market – something that the marketing departments of energy suppliers have known for a long time, and which has important implications for policy-makers, in particular in addressing concerns about vulnerable consumers.

For the Netherlands Pomp and Shestalova (2007), and for Sweden Ek and Söderholm (2008) confirmed the significance of expected gains as a driver of engagement. ACER/CEER (2016) and the CMA (2016) related switching to gains available in the market: ACER/CEER found a positive relationship between switching rates and potential savings (Figure 6, p. 12). The CMA found that price is the most important driver of choice of energy supplier. However, the complexity of the choice from the consumer perspective was emphasised by the CMA's analysis of different gains available according to willingness to change payment, tariff or contract type, even though the products themselves are quintessentially homogeneous by their nature.

Deller et al (2014) report an opportunity to observe switching decisions in a large collective switch, where participants were offered a personal savings quotation, in Great Britain. Here again, switching rates increased with the size of the gain offered, but the rate seems to level off at around 40% at high levels of potential savings (see Figure 2). This collective switching process enables the observation of consumers making a pure switching decision, since the search process had been undertaken through preparation for the auction itself. Since participants needed to exert very little further effort to realise the offered savings, the low take up from consumers who had already shown themselves attracted to switching by entering the auction, is particularly interesting. This evidence informs our recommendation of an opt-out auction as one policy response.

Figure 2: Switching rates in The Big Switch according to savings offered



Source: Deller (2014)

The gains available may themselves be limited by other policy measures, in particular in those EU countries where prices remain regulated: the protection which these offer to consumers also restricts the 'headroom' for offers from new entrants, and so the potential gains available for those who do wish to take advantage of cheaper offers. While the distribution of potential gains across Member States is difficult to identify, the CEER report[3] shows that substantial potential annual gains from switching of €450 were available in Germany in 2014, with gains of over €150 per year in Great Britain, Portugal and Romania. Yet the switching rates in these countries remained low: 8% (Germany), 11% (Great Britain), 1% (Portugal) and zero (Romania).

2.1.3 Lack of Trust

Both CEER and CMA report lack of trust as a major factor in not engaging in the market. Across the EU, electricity and gas services score relatively low in the 10th Consumer market scoreboard (CEER, 2016, p.25), with only financial services scoring worse. (Dis)trust is a very amorphous concept, and can refer to individual suppliers, the market or the switching process itself. In both Ofgem and DECC surveys, GB respondents' trust was lowest in their supplier providing them with a fair deal or alerting them to the best tariff (CMA, 2016). CEER report that in Spain there is particular distrust and confusion around door-to-door canvassing by new energy suppliers. The CMA report grouped together 'Capabilities, confidence and experience' focusing on consumer related characteristics of trust. For example, they note that "52% of respondents who distrust their own energy company said they would find it difficult to find the right energy deal

[3] Figure 5 in the report.

compared with 31% of all respondents" (A9.1-69). The CMA made a positive link between confidence and use of price comparison websites (PCW).

Both the CEER report and He and Reiner (2015) emphasise the link between trust and previous experience with switching in the energy market. Similarly Giulietti et al. (2005), Waddams Price and Zhu (2016) and Flores and Waddams Price (2013) all find that those who had switched providers for other similar products (with a default relationship with the supplier) were more likely to look for better deals and change suppliers in energy. CEER found that consumers were particularly reluctant to trust new energy suppliers, and Ek and Söderholm (2008) found that incumbents were trusted more, effectively posing a barrier to entry. This barrier may rise if new entrants exit the market as energy prices rise, as is widely expected. One example, GB Energy, has already occurred in Britain, and the generous arrangements for customers who are taken over by the default supplier provide an important reassurance: consumers who sign on to new suppliers need not fear their 'failure' in the market, because their customers will be protected. The CMA also found that those who distrusted their own energy suppliers were less confident in their ability to estimate potential gains, again imposing a barrier to a well-functioning market.

2.1.4 Complexity of Switching

The costs of investing in searching and switching are clearly raised if the process/gains are difficult to understand or very complex. Such complexities might affect the search costs in terms of how easy it is to find details of alternative offers and the conditions attached to them, the difficulties of changing supplier, particularly if there are fears that things may 'go wrong' with such an essential service, or confusion about the nature of the contract and what any penalties for early termination might be. He and Reiner (2015) found that complexity of the switching process was a more important deterrent than satisfaction with current suppliers, and the CMA report it as a major reason to remain with the incumbent supplier. Complexity increases the anticipated time required to switch. CEER reports that consumers perceive the switching process to be more complex than it actually is. In quantitative terms, the 10th consumer scoreboard reports that those who have switched score the ease at 7.7, while those who have not rate it at 6.3 (though it is difficult to deduce whether these figures are significantly different in statistical terms).

Moreover transaction costs of switching are raised by the current tendency of British suppliers to offer fixed price deals for a certain period (usually one or two years), with automatic reversion to a more expensive standard variable tariff at the end of the period unless the consumer switches again at that time to a new fixed tariff or alternative supplier. Thus to retain substantial gains beyond the initial period, a switcher needs to anticipate continuing to switch as immediate deals expire, and some respondents to Ofgem surveys have cited the 'treadmill' of switching as a reason to stay with their current supplier.

Centre for Competition Policy (CCP) surveys also analyse the relation between search and switching activity and estimated time to search and switch. This varies across the surveys, but in general the disincentive effect of expected time and effort is less consistent and weaker than the incentive effect of potential gains. In the 2011 survey, consumers did not appear to be deterred by higher expectations of search and switching time once other factors had been controlled for, suggesting that these expectations were themselves related to general attitudes to shopping, recall of marketing approaches and demographic variables. However, this applies only to the minority of customers who can estimate potential gains and costs: others may indeed be deterred by not knowing how large they are.

2.1.5 Loyalty to existing supplier

He and Reiner (2015) find that loyalty to the existing supplier was the next most important factor explaining non-switching, after the expected benefits and costs of switching. More generally, studies have found that consumer loyalty plays an important role in reducing intention to switch (Henard and Szymanski, 2001), and Gamble et al (2009) concluded that attitude towards switching was more negative in the electricity market than in other markets, and that this was related to loyalty to current supplier. Consumer surveys in both the Netherlands (ACM, 2015) and Ireland (CER, 2015) showed that the most important reason for not switching was loyalty to the current incumbent. How far such loyalty reflects a status quo bias, as CEER suggests (2016 p. 31) is difficult to disentangle, and there are important policy implications of the interpretation. If the loyalty reflects true consumer satisfaction (even at a passive level), low switching levels can indicate a well-functioning market with consumers whose needs are met; but if it is based on a status quo bias, as many commentators believe, it represents a barrier to the market working well.

The CMA report shows that consumers are consistently more 'loyal' in their attitudes to smaller suppliers than to the incumbent Big Six providers, though here a different bias may affect the results. Those who are with the Big Six include many who have never changed supplier, and so are likely both to switch less and have a very passive view of their supplier; while those with smaller suppliers have made a deliberate move to change suppliers, and so may wish to justify their action by declaring greater loyalty. However, those who have already switched are more likely to do so again, and so while their relative loyalty may be to their existing supplier, they are intrinsically more likely to switch away to a better deal. Since there are increasing numbers of consumers with new suppliers, it is interesting that the time trend of loyalty is downwards, showing an underlying trend of decreasing loyalty. However to the extent that such loyalty discourages switching, this may be declining over time, so long as the lack of allegiance to one firm does not reflect general distrust of the market. As Ek and Söderholm (2008) point out, some of the loyalty may reflect uncertainty about the alternative outcomes, rather than positive satisfaction with the current situation.

2.2 Vulnerability and affordability

Vulnerability is increasingly understood to be a complex situation, which can arise from a number of different factors, and may be temporary or long term. There is growing evidence that policy-makers and regulators recognise such complexity, and the consequent necessity for nuances in addressing it. Both the Electricity and Gas Directives require Member States to take appropriate measures to protect final consumers and, in particular, to ensure that there are adequate safeguards for vulnerable consumers.

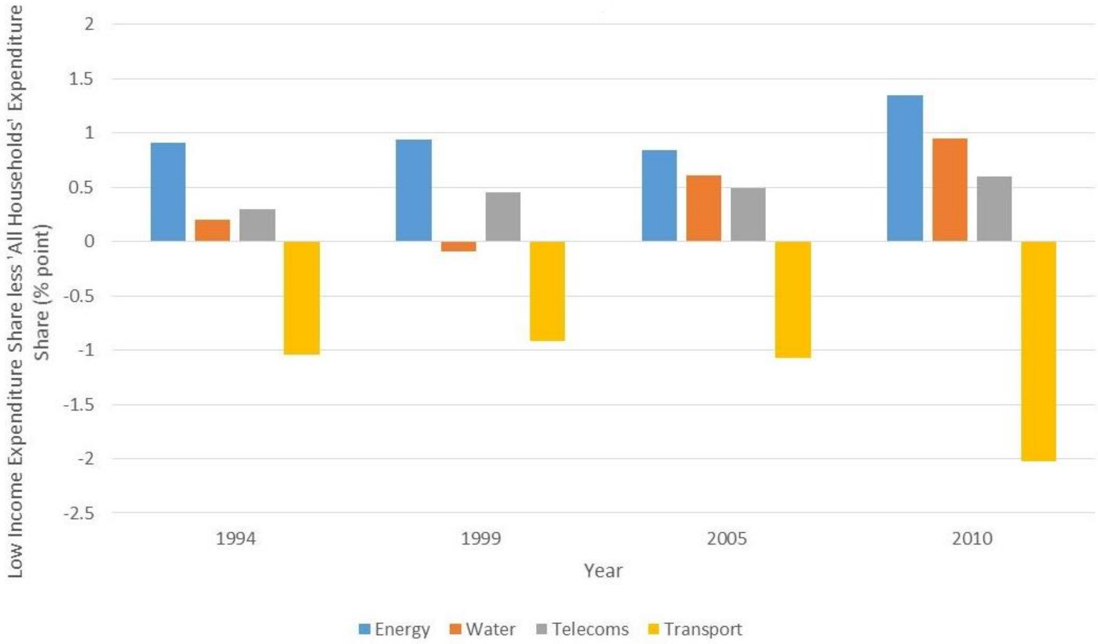
The relationship between energy markets and vulnerability is complex and contended. The high proportion of income spent by low-income households on energy has generated arguments to protect vulnerable consumers through the market in some EU countries, rather than using more general social policy as a completely separate instrument for such consumers, and focusing on efficiency within the energy market. The political pressure is underlined by the increasing differences between the proportions of income spent on energy by the poorest group in society, compared with the average, across EU Member States, shown in Figure 3 below.

One particular concern is that vulnerable consumers may be 'leaving money on the table' through their disengagement with the market and missing out on better offers; this may be a concern both for how well the market functions and whether such markets have a detrimental effect on vulnerable consumers. This is likely to be a particular concern if suppliers are able to separate responsive and less responsive groups, compete ever more intensely for those who are responsive, and raise prices for those who are not likely to change. That those who do not switch are disadvantaged *relative* to those who are active (at least in Great Britain) is clear; what is less certain is whether they are worse off in absolute terms than they would have been if the market had remained closed and regulated. Some argue for a 'waterbed' effect, in which suppliers raise their prices to the disengaged to subsidise competition for other consumers, through the allocation of fixed costs to those unlikely to switch; but it is unclear why companies should be able to charge more to the non-responsive consumers when they are competing for others, so long as they are not selling below costs in the competitive sector. Some have suggested that since regulators tend to look at overall profits and/or average margins, there is a trade-offs which will enable higher prices to be charged to some if they are balanced by lower prices charged to other consumers. However, it is not clear that the market process itself fosters such a relationship. Another suggestion is that companies with a large proportion of disengaged consumers can raise the price to them so that they are offering deals at below cost in the competitive section of the market to exclude rivals who lack such a 'cushion' of loyal consumers. However this is hard to establish, since the marginal cost of energy is extremely difficult to define, given the variety of hedging and other contractual arrangements in the sector; if such actions could be demonstrated, they would contravene Competition Law on predatory pricing.

If it cannot be established that others are adversely affected in absolute terms by competition, the question arises about whether it matters that those who gain most from the market are more likely to be those who already do well in society and the economy.

Affordability is one dimension of vulnerability which is particularly pertinent to energy because of the pattern of expenditure across different income groups. This is demonstrated vividly in the CERRE report on 'Affordability of utilities' services: extent, practice, policy', (Waddams Price and Deller, 2015), and illustrated by Figure 3 below, from that report. This shows both how the proportion of expenditure devoted to energy by low income households is considerably higher than that for households as a whole (with the gap being greater for energy than for other 'utilities'); and that this gap increased in 2010, after a modest decrease between 1995 and 2005.

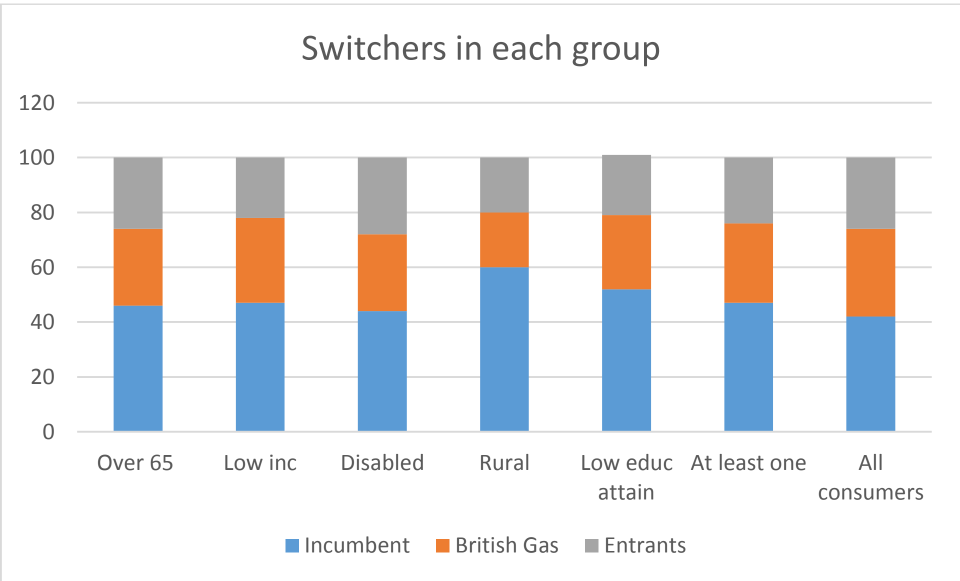
Figure 3: The Difference in Expenditure Share Spent on Utilities by Households in the Bottom Income Quintile compared to All Households: EU15



Source: Waddams Price and Deller 2015 (chart 8, p.20): Eurostat collated national household budget survey data.

2.2.1 Link between vulnerability and market activity

Figure 4: Switching behaviour in different demographic groups, UK, 2005



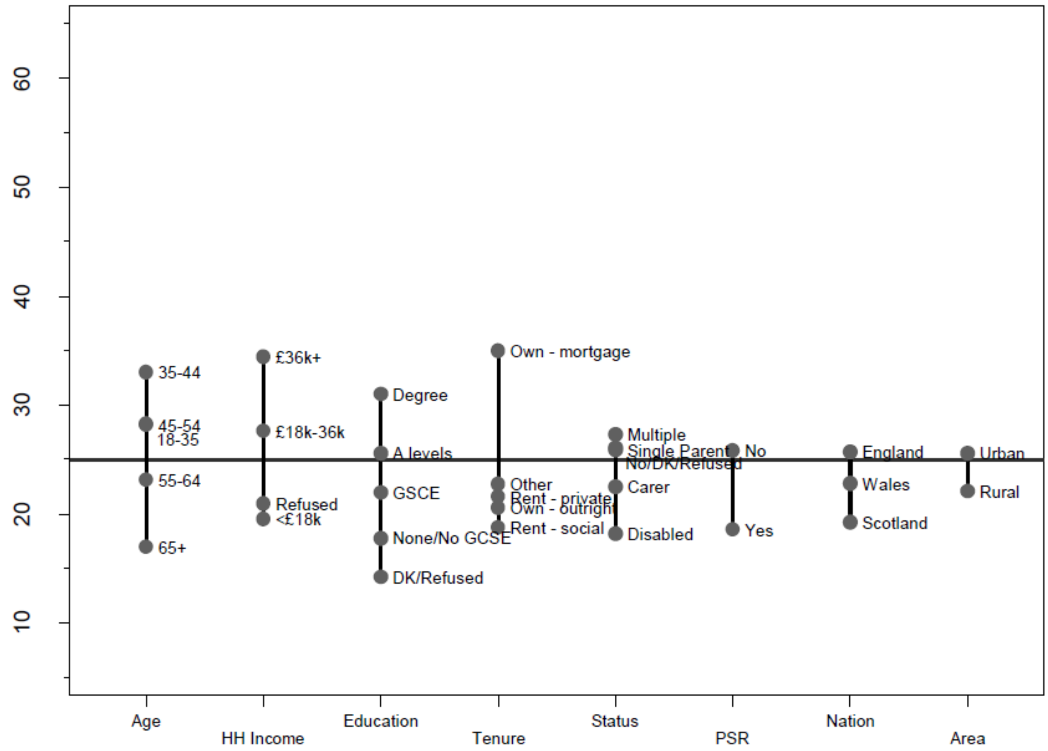
Source: from CCP 2005 survey; authors' analysis.

We see from figures comparatively early in the opening of the British market (2005) that some groups who are considered vulnerable were more likely than average to stay with the incumbent (blue blocks), and that this was true of those who had at least one characteristic which might indicate vulnerability. The first four groups (over 65, low income, disabled and living in rural areas) are identified in statute as those for whose needs the regulator has particular (unspecified) responsibility. The complexity of the issue (and appropriate policy responses) is demonstrated by this chart. Even at this early stage (six to seven years after market opening), a majority of such consumers reported that they had switched away from the incumbent electricity supplier. Although a smaller proportion in these groups had switched than for consumers as a whole, any cross subsidies from switchers to non-switchers would result in a majority of those with one vulnerable characteristic (as defined here) paying more rather than less for their electricity. In general, policies to protect particular groups who need such support within society are likely to be more effectively delivered through social agencies than through markets, where errors of both inclusion (helping those who do not need it) and exclusion (not helping those who do) are inevitable. However, in jurisdictions where there are self-imposed or other limitations on direct social policy, intervention through markets may provide a very imperfect substitute to alleviate hardship. Unfortunately, intervention to assist some groups may dampen any consumer engagement which already exists and introduce supply side responses which result in worse deals for all consumers, including those who were the original target of the policy.

Some have suggested that because they are getting a less good deal in the market, non-switchers should themselves be defined as vulnerable, an approach close to that of the CMA in its report on the British market. While ability to gain 'advantages' from markets may vary systematically across groups, it does not automatically follow that groups who appear to use markets less effectively should be classed as vulnerable. Such an approach carries the danger of 'pathologising' consumer behaviour, which may just as well reflect preferences or high expected costs of switching. Ensuring that consumers have equal opportunities to gain from the market, including minimal barriers to taking advantage of such opportunities, is a better way of working with the grain of the market rather than against it.

The CMA identified the characteristics of those who have switched energy provider in GB in the last three years, as shown in Figure 5.

Figure 5: Proportion of switching by demographic and household characteristics



Source: CMA analysis of survey and supplier data.
Notes:
1. Derived from responses to questions K1, K3, K4, K5, K6 and records provided by supplier. PSR indicates whether respondent is on the PSR. Those who were unable to respond to relevant questions (ie answered 'do not know') have been excluded.
2. 'DK' indicates responded who answered with 'Don't Know' to the relevant surveys question
3. Base = age 6,901, income 6,999, education 6,665, tenure 6,999, status 6,999, PSR 6,990, nation 6,999, area 6,976.

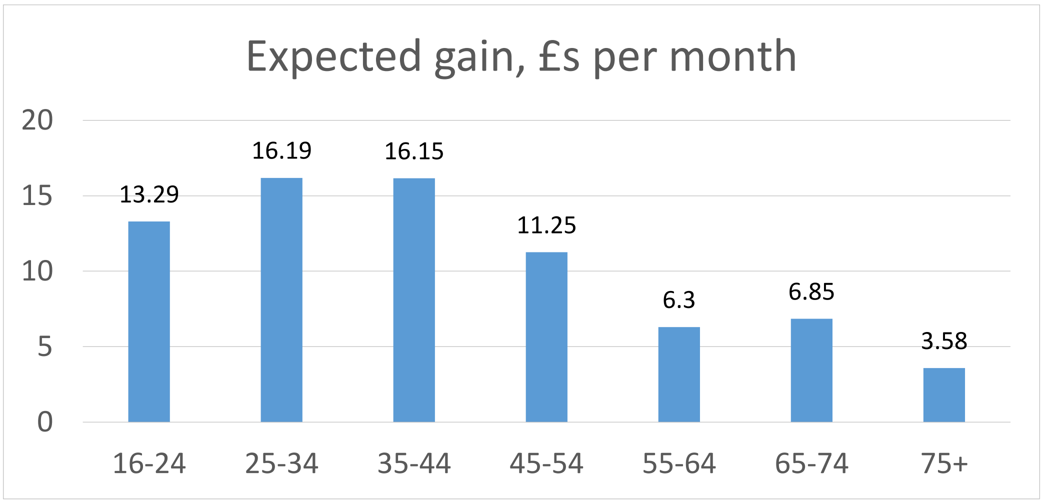
Source: (CMA report Appendix 9.1)

Here we see that older people, those on lower incomes, with lower educational qualifications, in rented accommodation, disabled, on the priorities services register as needing special help in case of interruption to supply, in Scotland or in rural areas are less likely to have changed supplier in the previous three years. Some of these household characteristics may be relevant to identifying vulnerable consumers. In contrast to evidence on less switching (and presumably foregoing some benefits), Fernandez-Gutierrez et al (2016) provide interesting evidence that while some vulnerable consumers feel that both telecoms and energy are less affordable than do their less vulnerable counterparts, the gap is inversely related to the switching rate. They conclude that demand side remedies which boost consumer switching rates can reduce (perceived) inequalities. Focusing such remedies on those considered vulnerable may improve their perceptions still further. One interesting feature of their findings is that it is activity in the market, rather than the supply side characteristic of (inverse) market concentration, which affects affordability perceptions in this way.

2.2.2 Variation of expected gains with demographic characteristics

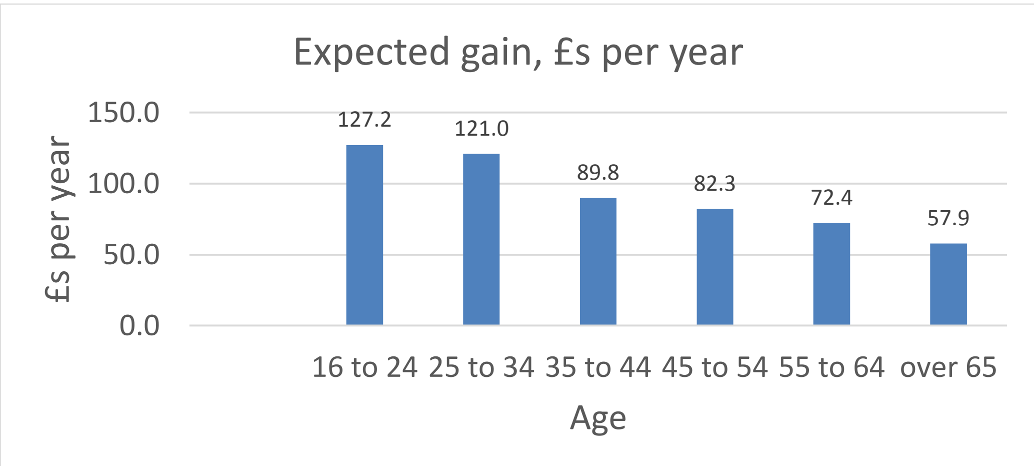
As discussed above, consumers' declared expectations of potential gains are the figures most likely to affect their behaviour, and we can provide some evidence about expectations in the energy market, and a consistent bias with age, based on original analysis for this report of CCP surveys. We find from two large nationally representative surveys (in 2005 and 2011) in GB that older consumers anticipate much lower gains than their younger counterparts. Some of this may reflect reality in the market, since consumption levels for retired households are around 12% lower than those for non-retired households; however the CMA found that the proportion of their bills which they could save in the market was slightly higher than for other groups, presumably because they have been rather less active in the market in the past. The lower expectations revealed by both these surveys show that the difference in estimated gains substantially exaggerated the actual differences.

Figure 7: Expected gain from switching energy provider by age group



Source: 2005 survey.

Figure 8: Expected gain from switching energy supplier by age group, 2011



Source: 2011 survey.

These expectations help to explain one conundrum from previous analyses – that while the raw statistics do indeed show that older people are less active than others (as in Figure 4), once expectations and other variables are controlled for, they appear to be more active than those in younger groups. Clearly, there is a role for policy-makers to inform older consumers about the potential gains available to them in the market. However one small-scale experiment, reported in Lorenc et al. 2013, showed that while direct interventions with vulnerable households did stimulate activity amongst some groups, results were disappointing among older participants.

Even more striking than the differences in expectations are the large number of respondents to both surveys who are not able to provide estimates of expected gains and likely time involved in searching and switching, the basic ingredients needed to decide whether to invest such time in finding a potentially better deal. In 2005 only 617 out of 1460 (42%) electricity users (who were aware of choice and singly or jointly responsible for choosing who supplied household energy) could provide an estimate of expected gains, and in 2011 the proportion was very similar (812 out of 1992). Given the numerous information campaigns, as well as heavy advertising by energy companies and third party intermediaries, such uncertainty shows how disengaged many consumers were after several years of market opening. Those unable to provide estimates were in general much less active in the market (but not entirely inactive), suggesting that they are using other heuristics to determine whether or not to engage in the market. Reluctance to name potential gains was not unique to energy – in the 2005 GB survey across eight similar markets which involved a default relationship with a supplier, only in car insurance was the proportion able to estimate gains from switching higher (49%) (Waddams Price and Zhu, 2016b). This suggests that different campaigns may be needed if both the better and less informed are to be stimulated to more activity in the market.

2.3 Policies for empowering consumers in competitive markets

As the discussions above have shown, engagement with liberalised energy markets has been disappointing compared to initial hopes, even where there are substantial gains to be made from switching providers and/or contract types. Many regulators have been trying to identify and remove barriers to engagement, and some policies have been discussed here. It seems unlikely that there will be a major increase in engagement, unless this is part of an automated scheme, like relatively new developments Voltz and Flipper in Britain, or further similar developments. Here the consumer delegates decisions to a third party intermediary, who takes the role of an agent, in some cases making the switch for the consumer, to minimise engagement or 'hassle'. Such solutions raise additional questions, including the need for the consumers to take action in signing up. These centre around the role of the intermediary (are they able to make their own offers? offer exclusive deals?), their relationship with the suppliers, and how they compete among themselves, particularly where they are operating across several utilities and services. Some concerns may be alleviated by transparency of business models, but this may be difficult to achieve, and might stifle further developments through supply side repercussions such as facilitating co-ordinated effects. Despite these issues, such innovations have the potential to introduce a step change in the extent of consumer involvement in the market.

All the evidence suggests that increases in expected gains are the main incentive for those who can estimate them, so policies which reduce such gains (for example through the imposition of non-discrimination clauses) are likely to lower switching rates and dampen competition, as happened in the UK. However, only a minority of consumers are able even to estimate what gains might be available to them by switching. These variations between groups raise the question of how to direct policies: should these be to the already active; to the occasionally active, who may be easier to stimulate into more action; or to the majority who are currently inactive. The barriers identified vary between these groups, and the heterogeneity of consumer response to the market suggests that differentiated policies will be needed. The implications for the market also differ. The least cost way to increase total involvement is probably to address the barriers faced by the 'almost' active group. These consumers are less price sensitive than the existing active group, but more so than the rest of those who do not currently engage with the market. Moving them from the inactive group to the active group is likely to reduce the aggregate price sensitivity of both groups, and might lead to suppliers raising prices for both groups.

There is mixed evidence on how far competition helps those who are considered vulnerable. Inequality between perceptions of affordability is reduced by more active switching rates in the market, but there some potentially vulnerable groups switch less, and so realise fewer benefits from competitive offers in the market. Given that the identified barriers to switching vary according to consumer attitudes in general, recall of marketing (particularly from family and friends) and some demographic characteristics, these would be sensible foci for campaigns to encourage switching, particularly among those groups who are seen as needing special protection. One group who might be stimulated by a targeted information campaign are older consumers, who seem to consistently underestimate the gains which they could achieve.

To the extent that groups which may be considered vulnerable are less active than others, and therefore can often benefit from higher gains than others, one obvious way to help is to provide direct assistance to them to engage in the market, and such help is often provided by policy-makers and agencies. However past efforts to encourage increased switching have had mixed results, with high levels of ignorance and disinterest remaining.

An alternative to reducing the barriers is to bypass them, accepting that a large number of consumers will not engage at a personal level, and to organise opt out collective switching, particularly for groups who are considered vulnerable. This could also apply if vulnerability is itself defined by inaction, as some have controversially suggested. Such consumers and their energy consuming characteristics could be identified, and companies invited to bid to supply them, with the winner being the supplier who offers the best deal. This is effectively competition for, rather than in, the market, and mirrors a number of collective opt-in schemes, one of which has been cited in this paper. It could be used with the CMA database of non-switchers to be made available to competing companies, which could then offer them deals, but avoids many of its pitfalls. Consumers would not have to take any initiative, and would be able to opt-out both before the auction and when the offer is made to them, but inaction at both stages would result in them being transferred to the winning deal. This has the merit of leaving to individual governments and regulators the consideration of which groups should be helped through such a mechanism, preserving the role of Member States in social policy. Such an opt-out scheme raises a number of issues, including confidentiality of consumer data, which are also likely to vary across Member States. There are some disadvantages if it shields consumers from market engagement and reduces positive externalities which might arise in other markets. But it does provide one way of addressing barriers to switching, if only by bypassing them, and would deliver consumers better deals, empowering them in terms of outcome rather than action. Such 'automation' for benefiting from the market mirrors recommendations on obtaining optimal benefits from demand management potential, is discussed in the next section.

3. Demand response protocols

Demand side response (DSR) is a voluntary reduction in electricity consumption taken from the grid by retail customers to react to an increase in the power price, or to some form of incentive payment. Even though the results may seem identical, demand response is somewhat different from demand side management (DSM), which is a form of flexibility where consumers buy electric power at a low price because they accept the risk of being disconnected by their provider. DSM is an old concept widely used by system operators and electricity producers in their relationship with large industrial customers. The latter pay discounted rates for energy contracts where the dates and volumes of consumption cuts are decided by the former. For example, in France article L321-19 of the Energy Code stipulates that in case of threat to the grid, the supply to electricity-intensive firms (aluminium, chemistry) that voluntarily entered the program can be interrupted by the system operator from 15 minutes to 1 hour in exchange for a discount on their next bill.[4]

With DSR, consumers are individually responsible for their decision. Upon receiving a scarcity message, in particular a very high day-ahead price at a specified hour, they can decrease their consumption at that hour by disconnecting specific appliances, or use distributed generation equipment and/or rely on storage capabilities. Theoretically, it is a more efficient flexibility tool than DSM … as long as the consumers bear all the costs and benefits of their decision, which requires information processing and cleverness.

3.1 Consumers' lack of flexibility

In a world of passive consumers, there are two elementary solutions for balancing the electricity system:

- Supply first: poor countries are unable to satisfy electricity needs most of the time, in particular because many consumers are connected to the grid but do not pay for their withdrawals. The system is technically balanced through recurrent brownouts and blackouts that indiscriminately hit those who pay their energy bill and those who do not. Energy scarcity would justify high uniform prices, but they are politically unacceptable. High prices would also encourage energy stealing, feeding the vicious circle of underinvestment.
- Demand first: in order to guarantee security of supply, rich countries install a large volume of production capacity, a share of which remains unemployed most of the time. With a consumption price constant in time, since the short-run marginal cost is almost permanently below the long-run average cost, pricing efficiently - that is at average short-run marginal cost - would not cover fixed costs. In the traditional utility framework, the solution was to price uniformly at long-run marginal cost, or,

[4] For an overview on flexibility in the electricity industry, see SMART GRID TASK FORCE (2015) EG3 REPORT, "Regulatory Recommendations for the Deployment of Flexibility", January. http://ec.europa.eu/energy/sites/ener/files/documents/EG3%20Final%20-%20January%202015.pdf.

when accepted, to discriminate *à la Ramsey*. In the liberalised framework, since market equilibrium is reached at a price equal to the short-run marginal cost, the desired excess capacity can be maintained only thanks to some capacity payment in addition to energy prices.

In both cases, it would be welfare improving to make demand reactive to price variations, at least to changes in retail prices, at best to changes in wholesale prices. Ideally, the objective of the demand response process is to lower electricity use at times of high wholesale market prices or when system reliability is threatened. It relies on those end-use customers who can intentionally modify their "normal consumption patterns", either actively in response to signals coming from the grid operator or the market operator, or indirectly by signing contracts with service providers who will implement automated solutions to reduce consumption.

A preliminary to the promotion of demand response is to be able to measure it. This necessitates the quantification of normal load patterns and their comparison with actual consumption in real time. In other words, it necessitates high quality statistics on the "consumption-as-usual" trend and smart appliances to keep track of the real behaviour.[5]

Assuming that measurement is feasible, operators can consider two types of DSR mechanisms: [6]

- Incentive-based demand response (also called "active demand response"): customers are paid if they decrease their consumption relative to a counterfactual called baseline. They are not really reselling electricity; they sell consumption options at Peak Time Rebates.
- Price-based demand response gives customers time-varying rates offered by electricity suppliers (real-time pricing, critical-peak pricing, time-of-use tariffs)[7] that reflect the wholesale cost of electricity in different time periods. Armed with this information, customers are expected to use less electricity at times when prices are high. [8]

They all necessitate smart metering and billing systems for charging time-varying rates and customers making decisions on a daily or hourly basis, be it for consuming or "reselling" energy. It will take time before a sufficient number of customers are equipped and change their behaviour to directly participate in market mechanisms through Real-Time Pricing or Peak Time Rebates. In the meantime, programs with Critical Peak Pricing or Time of Use pricing where

[5] On the deployment of smart meters, see http://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union.
[6] U.S. Department of Energy (2006), "Benefits of demand response in electricity markets and recommendations for achieving them", February, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_Benefits_of_Demand_Response_in_Electricity_Markets_and_Recommendations_for_Achieving_Them_Report_to_Congress.pdf.
[7] **Real time pricing**: different price levels apply to different time periods on an hourly or sub-hourly basis. **Critical peak pricing (or "passive demand response")**: a default constant price is set for all days but a limited number of days per year, chosen by the seller after the contract is signed, during which the per-unit price increases significantly. **Time-of-Use pricing**: instead of a single flat rate for energy use, rates change for broad blocks of hours. The price for each period is pre-determined and constant. (Eurelectric (2015).
[8] The two categories are sometimes referred to as Explicit and Implicit Demand Responses respectively. See Smart Energy Demand Coalition (2015) and Eurelectric (2015).

suppliers play a more active role should facilitate the transition. [9] Some economists consider that Peak Time Rebate should not be encouraged because "there is a significant risk of creating conditions that will crowd out true price response by focusing too much on DR programs with unverifiable baselines and reliability-based rather than price-based mechanisms for obtaining consumption reductions." (Bushnell et al., 2009).

Crowding out did occur. Obsessed by the will to convince citizens that renouncing to energy consumption is environmentally friendly, EU and national authorities now all focus on some form of payment to those who consume less than expected. It is this form of DSR that we mainly analyse in the following paragraphs.

3.2 The pros and cons of DSR

Several reasons are put forward for why DSR must be encouraged:

- by consuming less at peak hours, consumers reduce their energy bill; this should be the driver for DSR development at the individual level, but the stakes are low;
- decreases in consumption result in energy savings,[10] and consequently in a reduction of CO_2 emissions;
- DSR lowers the need for peaking units and thereby decreases the capacity costs of the industry, both in production and distribution; it adds flexibility to counterbalance intermittent sources of production;[11]
- having consumers active in the wholesale market boosts competition since demand reductions are a substitute for peaking plants;
- participating in the balancing of the energy system increases the feeling of being a good citizen who improves the security of supply; DSR is strongly supported by green parties.

Conflicting with these advantages, in addition to the costs incurred by a deployment of DSR technologies, several difficulties must be emphasised:

- the regulation of DSR is not clearly settled, in particular because of divergent views between promoters of the business model, regulators, and economists (we come back to this conundrum in Section 3.4.);

[9] "Benefits of demand response in electricity markets and recommendations for achieving them." A report to the US Congress pursuant to section 1252 of the Energy Policy Act of 2005. http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_Benefits_of_Demand_Response_in_Electricity_Markets_and_Recommendations_for_Achieving_Them_Report_to_Congress.pdf. See also THINK (2013).

[10] "Demand response is an important instrument for improving energy efficiency, since it significantly increases the opportunities for consumers or third parties nominated by them to take action on consumption and billing information and thus provides a mechanism to reduce or shift consumption, resulting in energy savings in both final consumption and, through the more optimal use of networks and generation assets, in energy generation, transmission and distribution." Directive 2012/27/EU of 25 October 2012 on energy efficiency, http://www.seai.ie/EEOS/Energy-Efficiency-Directive-2012-27-EU.pdf.

[11] If it is a mere shift of consumption to a different point in time where price is lower, for example by delaying the use of a washing machine, there is no energy saving. However the need for peak production and transmission capacity is reduced.

- energy savings might be overestimated because savings at peak hours may be partly or totally offset by higher consumption when power is back, in particular to restore the desired in-house temperature;
- in the rebalancing of a market, decreasing consumption is not fully equivalent to increasing production in terms of reliability, duration, and ensuing effects;[12]
- being exposed to volatile wholesale prices is a risky activity that most small consumers will dislike; paying higher non-varying prices is just the same as buying an insurance contract;
- consumption baselines are hard to estimate. Big consumers can inflate their reference load and then pretend that their real consumption is below the expected one;
- DSR development necessitates Energy Service Companies and load-shedding aggregators, which means smaller gains for curtailed consumers since the intermediaries will pocket most of the profits;
- DSR development necessitates a costly adaptation of the infrastructure, in particular distribution assets must be made smart.[13]

3.3 The current state of demand response

3.3.1 Institutional context

EU level

At the EU scale, the initial institutional framework of DSR is set by the third Electricity Directive (2009/72/EC)[14] and the Energy Efficiency Directive (2012/27/EU).[15] Art 15.8 of the latter stipulates that Member States must ensure that national energy regulatory authorities encourage DSR to participate alongside supply in wholesale and retail markets. They must ensure that Transport System Operators (TSOs) and Distribution System Operators (DSOs) treat

[12] ENTSOE (2015) insists that "*Reliability requirements must be an integrated part of technical and market rules and pre-qualification terms for DSR product delivery*."
[13] See Smart Energy Demand Coalition (2016).
[14] In the Electricity Directive, DSR is still named demand management and systematically associated with energy efficiency; e.g. " 'energy efficiency/demand-side management' means a global or integrated approach aimed at influencing the amount and timing of electricity consumption in order to reduce primary energy consumption and peak loads by giving precedence to investments in energy efficiency measures, or other measures, such as interruptible supply contracts, over investments to increase generation capacity, if the former are the most effective and economical option, taking into account the positive environmental impact of reduced energy consumption and the security of supply and distribution cost aspects related to it". Annex I.2 of the Electricity Directive is closer to the modern notion of DSR: "the implementation of intelligent metering systems … shall assist the active participation of consumers in the electricity supply market".
[15] "Demand response can be based on final customers' responses to price signals or on building automation. Conditions for, and access to, demand response should be improved, including for small final consumers. Taking into account the continuing deployment of smart grids, Member States should therefore ensure that national energy regulatory authorities are able to ensure that network tariffs and regulations incentivise improvements in energy efficiency and support dynamic pricing for demand response measures by final customers. Market integration and equal market entry opportunities for demand-side resources (supply and consumer loads) alongside generation should be pursued. In addition, Member States should ensure that national energy regulatory authorities take an integrated approach encompassing potential savings in the energy supply and the end-use sectors." (Directive 2012/27/EU). In the USA, the demand response rule is based on FERC Order 745.

DSR providers, including aggregators, in a non-discriminatory manner, on the basis of their technical capabilities. National energy regulatory authorities in close cooperation with demand service providers and consumers must define technical modalities for participation of DSR in balancing, reserve and system services markets. Such specifications have to include the participation of aggregators.

In COM(2015) 339 final (Delivering a New Deal for Energy Consumers), the European Commission notes that insufficiently developed markets for residential energy services and demand response narrow consumers' choices. It calls for the offer of supply contracts based on dynamic pricing, or contracts that involve load control responding to market or grid conditions.

Note also that the European Commission in its Energy Union Communication (COM(2015) 572 final) announced that it would put special emphasis on stimulating demand response participation as a means to increasing efficiency and flexibility in energy networks.

In the recent "Proposal for a directive on common rules for the internal market in electricity" (COM(2016) 864 final), the European Commission insists on the role of "active customers" in a smart electricity system: "an 'active customer' means a customer or a group of jointly acting customers who consume, store or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes provided that these activities do not constitute their primary commercial or professional activity" (article 2.6). Article 17 is specifically dedicated to demand response.

The Smart Energy Demand Coalition

The Smart Energy Demand Coalition (SEDC) published a report in 2015 providing an overview of regulation in sixteen European countries for the implementation of Incentive-based (or explicit) Demand Response.[16] National markets are ranked according to four criteria:

i) enabling consumer participation and aggregation;

ii) appropriate program requirements;

iii) fair and standardised measurement and verification requirements, and

iv) equitable payment and risk structures.

A synthesis of these criteria shows three groups of countries:

- Belgium, Finland, France, Great Britain, Ireland, and Switzerland have reached a level where DSR is a commercially viable product offering;
- in Austria, the Netherlands, Norway and Sweden, although DSR companies are being established, significant regulatory barriers remain an issue and hinder market growth;[17]
- finally, in Denmark, Germany, Italy, Poland, Slovenia and Spain, aggregated DSR is either illegal or its development is seriously hindered for all market participants (large industrial sites, suppliers or independent aggregators) due to regulatory barriers.

[16] Smart Energy Demand Coalition (2015). See also European Commission (2016).
[17] For example in Austria a consumer may be required to install a secured and dedicated telephone line to participate in the balancing market.

The report emphasises the inclusion of DSR in the Network Codes.[18] It "represents a critical, positive step toward widespread consumer engagement in Europe. For the first time, there is a high-level structure enabling the participation of demand-side resources across markets and Member States."

However, SEDC notes that the most significant changes made between 2014 and the first half of 2015 concerned solidification rather than shifts in position. Significant progress was made only by those Member States that took a decision to enable Explicit Demand Response in 2013-14. Other Member States were still bogged down in the process of regulatory reviews or had decided against making any significant changes at the time.

3.3.2 Expected and actual gains

Hopes

The initial expectations regarding DSR were very optimistic. In a 2008 report, Capgemini announced impressive potential results.[19] The forecasts for 2020 were:

- 202 TWh of annual energy savings (equivalent to the combined annual residential consumption of Germany and Spain;
- 100 mt of CO_2 emission reductions annually (half of the reduction target imposed to utilities by the 20-20-20 directive);
- €50bn in avoided investment relating to peak generation capacity and T&D (equivalent cost of 150 medium-sized gas power plants);
- €25bn annual savings in electricity bills for customers (equivalent to the 2006 annual residential electricity consumption of Finland's 5 million inhabitants).

However, the study acknowledged that these potential results were unlikely to be achieved because of the lack of commitment by the Member States and the energy industry, the main barrier being the slow deployment of smart meters in Europe. As a result, only a fraction of the impressive figures above could be concretised.

Even though Capgemini were right in emphasising the necessity of installing hardware pieces of networks for extracting the full potential of DSR[20], the report seems to have underestimated the important role of soft pieces in the puzzle. Among the missing pieces, we have to mention:

- network codes as the 2015 SEDC report pointed out;
- regulation (discussed in section 3.4);
- the privacy and security of behavioural data collected over the years;[21] and
- the (in)ability of final small consumers to understand and take full advantage of quickly varying scarcity signals, be they prices or quantitative messages.

[18] See also ENTSOE (2015).
[19] Capgemini (2008), "Demand Response: a decisive breakthrough for Europe. How Europe could save Gigawatts, Billions of Euros, and Millions of tons of CO_2".
[20] Torriti et al. (2010) also insist on the need for smart meters.
[21] Eurelectric (2011).

Reality

Current estimates suggest that only 10% of demand response potential is being collected.[22] European residential and small business users account for about 70% of final electricity consumption. So far, their participation is still limited even though there is progress when it comes to real time metering infrastructure, smart electricity grids and smart appliances at the consumption location.[23] Another obstacle to the development of commercially viable aggregation applications is regulatory and market barriers, e.g. establishing clear rules for the technical validation of flexible demand-response transactions.

One important weakness of DSR is the so-called "rebound effect": consumers react more by shifting than by saving because the load-shedding actions mainly concern heating and air conditioning installations. With consumers choosing not to cut back on global consumption, actual energy savings are much smaller than expected. Ofgem (2010) has estimated the indicative benefits of consumers shifting 5% and 10% of their electricity use in order to flatten peak demand. The reported potential impacts are:

- £0.4m to £1.7m daily wholesale cost savings;
- £129m to £536m annual avoided capital costs for new generation;
- £14m to £28m annual avoided capital costs for networks.

There are also potential environmental benefits. This level of demand response would immediately lead to a daily reduction in carbon emissions of up to 0.5%: between 800 and 2,550 tCO_2 per day.

The above figures are quite large. Actually, they are less impressive when evaluated per capita. For example, using data from the French power market, Léautier (2014) estimates that, for the vast majority of residential customers whose peak demand is lower than 6 kVA, the net surplus from switching to Real Time Pricing is lower than 1€/year for low demand elasticity, 4€/year for high demand elasticity. These results cast a doubt on the economic value of rolling out smart meters to all residential customers, for both policy-makers and power suppliers. Actually, the value of price responsiveness lies overwhelmingly with large customers. These big consumers are important players in the demand response game because any decrease in their consumption can have significant effects on the balancing of supply and demand. Indeed, in most industrial countries, some 0.1% of customers consume close to 40% of the electricity production.[24]

Clearly, the overall gains from DSR are less striking than the figures announced 10 years ago. However, there is today an additional potential gain: capacity payments. Most governments are considering or already applying market or administrative mechanism to complement the revenues earned by producers from the sales of energy. The availability of production capacity would receive some payment, even if this capacity is not called by the market operator. No

[22] European Commission (2013).

[23] "Interventions to automate responses deliver the greatest and most sustained household shifts in demand where consumers have certain flexible loads, such as air conditioners or electric heating." Frontier Economics (2012), page 4.

[24] See for example page 13 in http://www.cre.fr/documents/publications/rapports-thematiques/etat-des-lieux-des-marches-de-detail-2015-et-2016/consulter-le-rapport.

surprise then if the advocates of DSR claim for the right to participate in these mechanisms, making DSR more profitable.[25] With consumers being paid not only for not consuming but also for the potential of not consuming, the whole balancing of the system will have to be reconsidered. In particular, as explained in section 2 of this report, poor people are weakly reactive to any price signal, so that they will not be able to participate in DSR programs. Since capacity payments will be passed through in retail prices, it will be necessary to compensate vulnerable households for this additional burden.

3.4 Baseline and price

With consumers becoming active players in the wholesale market, the first issue that has attracted academics' and policy-makers' attention is the price customers must pay to have access to upstream markets and the price they obtain when reselling purchase options. This has led to contentious debates in several jurisdictions. Basic microeconomics shows that consumers who participate in the adjustment market by reducing their expected consumption must be paid the price of the adjustment market, provided they have acquired the rights to participate, i.e. they paid the retail price for every kWh of their expected consumption or withdrawal profile. This is shown in paragraph 3.4.1.

This payment rule is not clearly understood by some businesspeople and regulators (in particular the FERC in the USA) who consider that consumers should not have to pay for the non-consumed kWh. This is obviously wrong since it would mean that consumers are allowed to sell something they do not own.

Even if the adjustment market is designed in line with ownership rights, a second issue of interest is consumers' potential strategic behaviour. Customers are paid for the difference between the consumption-that-would-have-happened, called their baseline, and their actual consumption. They thus have incentives to inflate that baseline (see section 3.4.2). In a particularly illuminating example, the demand response operator at the main Baltimore baseball stadium turned on the stadium's lights to create false demand that it was then paid to reduce. This behaviour was detected, and the operator was subsequently fined by the Federal Energy Regulatory Commission.[26]

3.4.1 The basic mechanism

To keep things simple, in this section we omit the role of intermediaries between producers and consumers. Consider a competitive day-ahead market in equilibrium at price *p*. The Market Operator (MO) informs all bidders about their rights and duties at this price:

i) consumers who have bid below *p* will not be served and producers who have bid above *p* will not be called;

ii) the other agents will have to withdraw or inject what they have committed to.

[25] Nera (2014) analyses the participation of demand side in capacity auctions.
[26] See the FERC order at http://www.ferc.gov/enforcement/civil-penalties/actions/143FERC61218.pdf.

Let u be the use value of one MWh of electricity and c its production cost. Denoting by n the last demand bid served and by m the last supply bid called at equilibrium, given that the efficient ranking of bids by the MO follows the merit order, we have that $u_n \geq p \geq c_m$, where $u_{n-1} > u_n$ and $c_m < c_{m+1}$.

Optimal adjustment

One of the m producers supposed to be active at equilibrium informs the MO that he will fail to deliver 1MWh. There are two elementary rebalancing solutions:

- the MO (or the System Operator when in charge of rebalancing) calls the first producer excluded from the initial merit order to supply the missing MWh : it will cost c_{m+1}; or
- the MO asks the planned consumer with the lowest electricity valuation to reduce its demand by 1MWh ; the cost is the lost gross surplus u_n.

It is clear that the least costly adjustment rule is:

- call producer m+1 if $c_{m+1} < u_n$
- curtail consumer n if $c_{m+1} > u_n$.

Decentralised adjustment

Assume that there is no organised market for rebalancing. The responsible producer is legally obliged to find a solution on its own. If it organises an auction between available producers to buy the missing quantity, competition will drive the adjustment price to $p_a = c_{m+1}$. In this solution, the defaulting producer is like a supplier without generation assets that buys from a wholesale market at price p_a and sells at price p as it had committed to. His net loss is $p_a - p = c_{m+1} - p > 0$.

The second possibility faced by the deficient producer is to propose a compensation r to some of its customers because they will not be served. The faulty producer prefers to buy the missing production and serve demand as planned if $r > c_{m+1} - p$ and to propose a curtailment deal to consumers otherwise. This decision is in line with the optimal adjustment portrayed in the previous paragraph only if $r = u_n - p$. Therefore, the power-cut deal must be concluded with customer n, the one with the lowest willingness-to-pay among those who hold the right to consume. Moreover n must be compensated only for their net surplus. Consequently, if customer n has already paid the market price p to the defaulting producer and if they are called to rebalance the system, the producer must pay them u_n so that they are rewarded $u_n - p$ for not consuming. If they have not already disbursed p, they must be compensated up to $u_n - p$.

Adjustment market

The same applies if there is an adjustment market open to consumers.[27] All agents participating in the adjustment market must be treated equally:

- They must hold either production capacity or consumption rights to be accepted in the market.

[27] Crampes and Léautier (2012) explain how financial flows are balanced.

- They must receive the same price p_a when called to produce or to decrease consumption.

Having paid p to acquire consumption rights, each consumer interested in DSR compares the gain from consuming (u) to the gain from reselling (p_a). If $u > p_a$ the consumer will prefer to consume and their net gain is u-p. Otherwise, they sell their right (i.e. they do not consume) and their net gain is p_a-p.

This has some similarity with buying a put (a sale option) except that the "exercise price" u cannot be written in the contract since it is not observable by the MO. When a direct contingent contract is signed between a big industrial consumer and a producer, a strike price p' can be included in the contract: the client will pay energy at the market price p as long as $p<p'$ and will not be supplied otherwise. The strike price can for instance be the cost of producing electricity locally with a diesel group. If the consumer has no replacement source of energy, the contracted value p' is just a proxy for u.

Misleading regulation

In some jurisdictions, particularly in the USA (FERC Order 745) consumers who participate in DSR are to be paid the wholesale market clearing price p_a instead of the net value p_a-p when they reduce demand. Under this rule, consumers curtail their consumption too often as compared with the efficient solution. The net gain from consumption is u-p and the net gain from no-consumption is p_a. So, in all events where $u<p+p_a$ the consumers curtail their demand whereas we have seen that it should be the case only if $u<p_a$. Therefore, in all events where $p_a<u<p+p_a$, there is excess curtailment.

This misleading ruling has been criticised by economists (e.g. see Hogan, 2010). In 2014, Order 745 was overturned by the US Court of Appeals for the D.C. Circuit, but mainly on legal grounds.[28] Finally, on January 25 2016, the Supreme Court ruled that the FERC was within the scope of its authority under the Federal Power Act when it issued Order 745. As a result, the current US regulation is overly generous.[29] It inefficiently encourages DSR to the detriment of reserve producers.[30]

3.4.2 Consumers' strategic behaviour

Demand reduction payment opens the risk of opportunistic behaviour by consumers.[31] As seen in the former paragraph, badly designed DSR rules can exaggerate demand reduction by decreasing consumption beyond the efficient level during a demand response event.

[28] “FERC can regulate practices affecting the wholesale market ..., provided the Commission is not directly regulating a matter subject to state control, such as the retail market.” USCA (2014). Electric Power Supply Association v. FERC, May, Case #11-1486, https://energylawprof.files.wordpress.com/2014/06/epsa-v-ferc.

[29] https://www.supremecourt.gov/opinions/15pdf/14-840_k537.pdf.

[30] For a detailed proof, see Brown and Sappington (2016).

[31] Astier and Léautier (2016) present a formal proof. The intuition is that Peak-Time-Rebates contracts in day-ahead electricity markets contain a structural flaw: embedded arbitrage opportunities. Consumers are allowed to buy their baseline power at a constant state-independent price while this power is worth more since resale occurs only when the state-dependent wholesale price exceeds the fixed contract price. Under asymmetric information, this incentivises strategic consumers to inflate their baseline.

Additionally, they can create an incentive to inflate the consumption of DSR participants if the latter is used to determine their reference profile. For consumers, this extra consumption is costly in the short term, like an investment, but the objective of the strategic consumer is to harvest profits later.

To address the issue of strategic *ex ante* overconsumption, a first possibility is to develop algorithms that provide a robust estimation of the baseline. However, having a statistically correct benchmark based on observed past consumption is not neutral if "investment" in overconsumption is counted in. Ideally, the reference profile should be independent from the specific behaviour of each consumer, for example by establishing the individual baseline as a fixed proportion of an aggregate load profile, with all the defaults of average values. (See for example Chao and DePillis, 2013).

Another approach is to recognise that some consumers will always have better information than retailers on their baseline, and therefore to design retail contracts that explicitly acknowledge this private information. The analysis then requires contract theory to build models of consumers' strategic behaviour under asymmetric information (Crampes and Léautier, 2015).

When the retailer perfectly knows consumers' preferences, if the adjustment market is well-designed and frictionless, resale is *ex post* efficient: consumers resell power precisely up to the point where their marginal value for power equals the price in the adjustment market. Furthermore, if there is no friction in the retail market, *ex post* demand response does not distort the retail contract either, which is then efficient. In other words, neither customers nor suppliers have an incentive to distort the retail contract from the efficient one when consumers are allowed to intervene in the adjustment process. Opening the adjustment market to customers thus increases net surplus.

This result does not necessarily hold under imperfect information. Suppose there are two types of customers with different willingness-to-pay, not observable by the supplier. Contract theory states that the supplier must propose a choice between two contracts, one leaving an information rent to customers with the higher willingness-to-pay (high-type customers), and the other reducing consumption of the low-type customers. The result is that while the retail contract remains efficient for high-type customers, it is no longer efficient for low-type ones. Thus, customers' potentially strategic behaviour, which gives rise to the information rent, may defeat the efficiency of adjustment markets. What is the net surplus impact of customers' participation in the adjustment market? In some instances, the information distortion for low-type customers is so large that opening the adjustment market to customers reduces total net surplus.

The policy implication is not that policy-makers should exclude consumers from adjustment markets for fear of inefficiency. Rather, policy-makers and regulators ought to be aware that consumers will have strategic behaviour when possible, i.e. when they have more information on their own needs than their provider. To (partially) accommodate the lack of information on consumers' willingness-to-pay, the second best solution is to offer a menu of nonlinear prices, in particular two-part tariffs that are made of a fixed component, independent of the quantity consumed, and a variable component, proportional to consumption. The menu, designed by using the incomplete information of the provider, allows consumers to self-select. It is a form of discrimination since consumers will pay different unit prices depending on the contract they choose, but it is legal as the whole menu is proposed to everybody.

3.5 Distributed load-shedding

The principle of distributed load-shedding consists in combining the shedding capacities of a large number of small consumers in order to obtain a significant volume across the whole system. These load curtailments are managed via an electronic box installed at the consumer's premises, controlled by a remote intermediary. The intermediary (or 'aggregator') can be a retailer who proposes DSR services in addition to energy supply, or a cooperative, that is a not-for-profit organisation such as a consumer association or a group of neighbours, or else a for-profit entity with DSR services at the core of its business model, for example Energy Service Companies.[32] The commitment and payment rules they should follow in the wholesale and retail markets are the same as the ones we have depicted for individual participants in the former sections.

In the aggregation business, there are economies of size (scale, scope, density) as well as indirect network externalities (compatibility, technological complementarity, potential for two-sided payment) at the central level. By and large, the costs incurred at this level depend neither on the number of subscribers nor on the volume of energy to be curtailed. Unfortunately, it is also necessary to install command and control equipment at each location, on all premises. The total cost function of distributed load-shedding therefore has a high fixed part and increases more or less proportionally with the number of subscribers. By contrast, the potential revenue of the aggregator is a function of the curtailed volume, not the number of curtailed devices. Then, having a small portfolio of big consumers interested in DSR is much more profitable than having a large portfolio of small consumers. Apparently, given the costs and revenue of the activity, aggregating the load-shedding of small consumers is still not profitable at all.[33] Residential demand response aggregators in continental Europe have therefore chosen a poor business model. This explains why the firms that have entered this activity are intensively lobbying to obtain subsidies.

For several years, aggregators in the EU (and in the United States) have tried to get consumers to shoulder the cost of their mistakes, convincing lawmakers to grant them unwarranted subsidies. Three arguments have been put forward in turn.

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[32] Energy Service Companies (ESCOs) provide energy services to final energy users such as the supply and installations of energy efficient equipment, and building refurbishment. Contrary to the traditional energy consultants or equipment suppliers, ESCOs can also finance or arrange financing for the operation and their remuneration is directly tied to the energy savings achieved. Therefore ESCOs bear some degree of risk in the achievement of improved energy efficiency. For more details, see http://iet.jrc.ec.europa.eu/energyefficiency/esco.

[33] A second reason for non-profitability is overcapacity on the electricity grid in continental Europe. It results that electricity market prices, thus the value of any megawatt hours saved, are very low.

First, the aggregator should not pay electricity suppliers for the saved electricity as it was not consumed. We have shown in section 3.4.1 that this pricing rule is an economic mistake. It initially convinced lawmakers, but things are changing.[34]

The second argument is as follows: as any non-consumed MWh helps reduce the amount of polluting energy (remember that peak-time production uses thermal power plants), the aggregators should receive a premium in addition to the price of the adjustment market. For example, the French government published a draft decree proposing a €30 premium per non-consumed MWh. All the institutions that examined the decree voiced serious concerns: the Competition Authority during its inspection in January 2014 of the draft decree expressed its reservations with regard to the methods of subsidisation,[35] the 'Conseil Supérieur de l'Electricité' voted to reject the premium decree at the start of December 2014, and the Energy Regulatory Commission issued a negative report and proposed a lower premium in mid-December 2014. The government nevertheless issued a decree in January 2015 setting the premium at €16 per MWh during peak times, and €2 per MWh outside of peak times.[36]

The third argument is even trickier: non-consumed MWh contribute to reducing the price of electricity for all users, so aggregators could legitimately receive some of the money saved.

None of these three arguments makes any economic sense. We have already addressed the first one in Section 3.4.1. As regards the "green premium", it could be economically rational if the load-shedding operators were competing against producers emitting pollutants at no cost. This is not the case, since they all are submitted to the European Emissions Trading System. As producers participating in the adjustment process by burning fossil fuel are punished for not being green, giving a premium to load curtailers counts the green component twice. Finally, the third argument is an encouragement to anti-competitive behaviour. A competitive market is defined as a market where all agents are price-takers, so that individual market decisions result in the first best allocation of resources. By contrast, if some buyers or sellers can influence the equilibrium price by their purchase or sale decisions and pocket the ensuing price variation, the market outcome is not the one that maximises social welfare. A premium based on the potential use of monopolist power would then be attacked by competition authorities.

The unprofitability of aggregators could come to an end during the next decade with the increasing number of electric vehicles. Indeed, charging a battery is an individual decision that does not consume much energy, but thousands of car owners charging at the same time in the

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[34] In November 2015, the French National Assembly rejected the bill 3146 "encouraging a reduction in CO_2 production through the development of direct load control". The full payment rule does not appear in the French Law 2013-312 of April 2013 that emphasises the role of shedding operators.
At the EC level, it is less obvious that things are changing. In the "Proposal for a directive on common rules for the internal market in electricity" (COM(2016) 864 final), one can read a worrying paragraph in Article 17: "aggregators shall not be required to pay compensation to suppliers or generators". Absent any definition of 'compensation' it may be feared that the EC is following the wrong way as explained at the end of section 3.4.1.

[35] http://www.autoritedelaconcurrence.fr/user/standard.php?id_rub=592&id_article=2369.

[36] Again, in November 2016, the French competition authority expressed its negative view on a new draft decree. And since it had little hope that the government would follow its advice, the authority had several recommendations to avoid distorting competition on the market.
http://www.autoritedelaconcurrence.fr/user/standard.php?id_rub=630&id_article=2905&lang=en.

same load pocket create local peaks that can endanger the electric system. Then, the ability to organise the timing for charging batteries at the least cost, that is without adding demand to peak-periods, can be both socially and privately advantageous. Additionally, provided that batteries are connected to the grid, the aggregator can supply energy coming from distributed sources, along the model of computer networks.

3.6 Bundling

The economic theory of DSR is still in its infancy. In particular, whether energy suppliers can offer curtailment services on equal grounds with independent curtailment operators is still waiting for a rigorous analysis.[37] *A priori*, energy suppliers have an informational advantage as regards the baseline thanks to regular billing. However, regulators can oblige them to make this information accessible to independent operators by creating a mandatory database similar to the one CMA wants to implement following its investigation on the British energy market.[38] Additionally, whereas bills give financial information on the willingness to pay of consumers, most of the quantitative information on load profiles comes from meters, and with the deployment of smart meters, much more will be known on individual consumption habits from this source. Moreover, in most countries the electricity meters are not owned or controlled by suppliers, rather by DSOs or independent metering companies or municipalities. The second essential input in the provision of DSR services is a mix of local electronic devices, remote computers and ICT know-how. Being an energy supplier does not give specific advantage to master these items. Many outsiders from the ICT world can do at least as well. Then, absent any technical reason that would support economies of scope, independent operators and integrated operators should compete fairly in the DSR market if integrated operators apply a mixed bundling policy. It means they will have to propose three distinct products: energy-only contracts, DSR-only contracts and two-service contracts. Pure bundling would probably trigger an investigation by competition authorities.[39] Note that the integrated energy supplier will face a dilemma to increase its revenue: should it push its customers to consume more or should it convince them to save energy? Some energy suppliers will maybe prefer not to enter the active DSR segment and rather focus on energy sales with time-varying prices, another form of incentives to control demand.

Another form of bundling is analysed by Campaigne and Oren (2016) who assume that a monopolist aggregator has two sources from which it "produces energy": a variable energy resource such as windmills, producing electricity with known probability distribution, and a population of DSR participants, with whom it signs contracts at the beginning of the season, buying the option to curtail them with specified probabilities.[40] The aggregator can commit to

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[37] ENTSOE (2015) presents a sketch of the possible solutions.
[38] One of the remedies CMA wants to implement is an Ofgem-controlled database of 'disengaged customers' who have been on the default tariff for three years or more, to allow rival suppliers to prompt them to engage in the retail energy market. See https://www.gov.uk/cma-cases/energy-market-investigation.
[39] See Kühn et al (2015).
[40] "The growth of variable renewable energy makes demand response ever more important." COM(2015) 339 final (Delivering a New Deal for Energy Consumers).

produce a given quantity in the day-ahead market despite the variability of the green resource because it can later adapt to the observed state of the wind by triggering DSR clauses, given the penalties for positive and negative deviations from the day-ahead commitment quantity. This use of DSR as an insurance against the randomness of carbon-free resources is a promising avenue of research. It also reminds us that DSR is only one flexible resource among others to compensate for the disturbances created by unreliable energy sources feeding the grid.

3.7 Can we expect more flexibility on the demand side?

The profitability of DSR should not be evaluated in isolation nor, as we have done, only in comparison with fossil-fuel production plants. Other sources of flexibility such as imports, storage and "prosuming" should be included in deeper analysis. One can also expect the development of local platforms where electricity can be traded among neighbours more or less specialised in production, consumption and storage of electricity, in fixed or mobile batteries. It will necessitate small-scale digital applications integrating curtailment procedures. This is not for the near future and it will not concern a large fraction of the population, except in green municipalities where local officials consider it is politically profitable.[41] Distribution operators will obviously have to adapt to these new framework where connection to the grid is just an insurance against local scarcity.

For the time being, given our former developments, it clearly appears that consumers must be separated into three distinct groups when it comes to demand response:

i) Big consumers are the main players because of the large quantity of electricity they take from the grid. These customers can curtail their consumption from the electric grid either because they can interrupt their activity for short periods (industrial clients) or because they are equipped with alternative sources (large stores). Provided DSR regulation is well-designed, big consumers can pocket profits from a more active direct participation in wholesale markets or by the subscription of retail contracts with time-varying clauses. To avoid any risk of opportunism, their baseline must be carefully calculated.

ii) Medium and small consumers equipped with electric heating and air conditioning, as well as those who own energy storage capacity (for hot water or electricity) can be aggregated into subgroups by specialised operators. For this category of agents, the expertise in ICT is essential. Indeed, at each consumer's location, automation and remote control will necessitate large investment. Here, the gains are not in terms of energy saved because of the rebound effect. Consumption will be shifted to shoulder periods with two benefits: less capacity of production will be required and, since the peaking capacities are generally fossil fuelled power stations, lower polluting emissions can be expected. The number of consumers in this category will increase given the European Commission project to decarbonise the economy by electrifying housing and

[41] Article 16 of the "Proposal for a directive on common rules for the internal market in electricity" (COM(2016) 864 final) is dedicated to 'local energy communities'.

transport.[42] Currently, the main brake is the fuzzy regulation of aggregators' business model.

iii) Finally, all the other consumers should be kept out of the wholesale market zone. For them, there is almost nothing to gain individually and collectively from DSR. In the short run, public authorities must encourage these small consumers to be more aware of retail opportunities[43] and to switch whenever they find better offers. Switching will not help in balancing the electricity system, but it can put pressure on retailers and then on upstream demand. In the long run, gains should come from a better insulation of dwellings and the use of more efficient electric appliances, accompanied by the addition of automated devices.

[42] https://ec.europa.eu/energy/en/topics/energy-strategy/2050-energy-strategy.

[43] See for example the "database remedy" of the British competition authority (CMA): ": (a) the CMA will require […] suppliers to disclose to the Gas and Electricity Markets Authority (GEMA) certain details of their domestic and microbusiness consumers who have been on one or more default tariffs for three or more years (subject to customers' ability to opt out), and (b) the CMA has recommended that GEMA retain, use and disclose these details (via a secure database) to rival suppliers for the purposes of prompting such customers to engage in the retail energy markets." https://assets.publishing.service.gov.uk/media/5805db47ed915d4b72000008/energy-market-database-order-for-consultation.pdf.

4. Conclusion

The response of consumers to increased opportunities for managing their energy bills in the competitive market, through taking advantage of better deals available from alternative suppliers, has been disappointing. Suppliers have been able to segment the market, so increasing the potential gains and, correspondingly increasing the gap between those who take advantage of the best deals and those who do not. To the extent that vulnerable or lower income households have suffered adverse effects from the market, or have benefited less from the market than others, this may be a distributional concern, though such concerns differ between Member States according both to the development of the market and alternative policy tools to help disadvantaged households.

Research and policy initiatives suggest that there are a variety of reasons for disengagement with the market, so successful attempts to increase activity will need to be multifaceted and focused on specific groups. Given the rather low response to earlier initiatives, 'automating' the process, either through the increasing use of third party intermediaries, or by encouraging competition *for* parts of the market through opt out collective auctions, may be a more effective way to discipline the markets. Any intervention needs to take account of the total costs imposed on consumers, including time, effort and worry involved, as well as potential monetary gains; and introducing new players, such as third party intermediaries, raises questions both about the vertical relationships between such actors and energy suppliers, and of horizontal competition between the players in this 'new' market. These lessons from the retail market have important implications for the evolution of demand management solutions.

Thanks to the development of ICT, thousands, and eventually millions of consumers will have the possibility to play a role in electricity wholesale markets by adjusting their consumption to signals reflecting market prices more or less accurately. Will they do so? Most probably not as direct active players, with the exception of the 0.1% biggest industrial customers. However, medium-sized consumers equipped with electrical heating, air conditioning and storage system could be incentivised to join aggregators, that is remote operators, able to monitor domestic appliances and industrial machines for given duration, at some specific dates where the electric system is stressed by peak load or the need to be rebalanced. Controlling the possibility to disconnect 1 kW at one million locations gives the equivalent capacity of a nuclear generation plant, with the additional advantage of time and spatial flexibility. Unfortunately, this business model is unprofitable as yet, at least as an activity separated from the supply of energy. The future of DSR could be in the bundling of energy supply and load-shedding.

Thanks to smart meters and demand-response programs, large quantities of precise information will be collected from consumption places and processed to be used by energy suppliers and load-shedding aggregators. This raises several intriguing questions. One is that consumers will progressively lose the initial informational advantage on their electricity needs; it is good news for efficiency and bad news for equity, since energy and service suppliers will be able to extract more rents from consumers. Regulators will probably have to intervene to limit the market power of energy and service suppliers, except if we can enter a world of strong competition in retail. Another question is the trading of data collected on consumers' behaviour. Will it be legal to sell data on consumption profiles? Will data on profiles be viewed as an essential facility for new entrants?

Demand-side participation is not possible without investing in the distribution grid. At the same time, the volume of energy transmitted by the distribution infrastructure will decrease because of energy savings, "prosuming" and storage. Clearly, the current payment system to DSOs will need a drastic review.[44]

[44] CERRE has published in December 2016 a report on legal and regulatory adjustments necessary to transform DSOs into neutral market facilitators. http://www.cerre.eu/sites/cerre/files/161108_CERRE_DSOReport_Final.pdf.

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