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Abstract

Nowadays, the European electricity systems are evolving towards a generation mix that is more decentralised, less predictable and less flexible to operate. In this context, additional flexibility is expected to be provided by the demand side. Thus, how to engage consumers to participate in demand response is becoming a pressing issue. In this paper, we provide an analytical framework to assess consumers' potential and willingness to participate in active demand response from a contract perspective. On that basis, we present policy recommendations to empower and protect consumers in their shift to active demand response participants.

Keywords

Electricity system; demand response; contract; energy policy

1. Introduction[*]

Traditionally, electricity systems are operated on the basis that the supply is adjusted to follow the load in real time, meaning that the flexibility to maintain balance between electric power supply and demand is mostly provided by the generation side, which is dominated by centralised, large-scale, flexibly dispatchable (fossil fuel and hydro based) power plants. Nowadays, the European electricity systems are evolving towards a generation mix that is more decentralised, less predictable and less flexible to operate due to the massive integration of renewable and distributed energy sources in order to meet the 20-20-20 targets (EC, 2009a, 2010c). To enable the large-scale integration of these renewables in order to advance the decarbonising of electricity systems without endangering the security of supply, additional flexibility is expected to be provided by the demand side through demand response programmes.

Indeed, demand response is a tool to reduce or postpone other costly investments in network reinforcement and in new flexible fossil fuel based or nuclear generation by shifting demand to times when there is more renewable power available, making (local) balancing easier and reducing overall system costs (De Jonghe et al., 2012; Dietrich et al., 2012; Moura and de Almeida, 2010; Redpoint Energy and Element Energy, 2012; Stadler, 2008). Its value and necessity as a flexibility means has been widely recognised by policy makers in Europe (EC, 2007a, 2010a, 2011a, 2011b, 2012a, 2012b; ENTSO-E, 2012b; ETP SmartGrids, 2012).

In view of this value, there is a massive body of knowledge emerging on smart grids and demand response, both in the academic literature and within the industry.

First, much research is driven by the availability of smart technologies (Smart-A, 2008; 2009b; Sustainability First, 2012a; 2012b; 2012c). Indeed, a recent survey of pilot studies on demand response demonstrates that smart appliances and enabling infrastructure significantly improve the responsiveness of consumers to dynamic price signals (Faruqui et al., 2013). However, two main challenges remain for the deployment of this 'hardware': what is 'smart' technology and how does it get deployed? On the one hand, there is still a lack of standardisation with regard to what this technology should be capable of, as the minimum functionalities of smart meters and smart appliances and the interoperability standards are still under discussion (EC, 2009b, 2010d, 2011c, 2012c). On the other hand, there is a chicken-and-egg problem with regard to deployment of this smart technology: without the infrastructure, smart appliances and demand response cannot be used to their expected potential by the consumers and without demand response through smart appliances, the limited benefits of the enabling infrastructure do not justify the costs of its roll-out (EA Technology, 2011; ETP SmartGrids, 2011; Smart-A, 2009a). The deployment of this hardware is then a process with different speeds across Europe (EC, 2012d).

Second, even if the technology challenges are adequately dealt with, there is an issue of split incentives for the different actors along the value chain (Consumer Focus, 2013a). As a result, there is lively debate within the industry on the role of different incumbent and emergent[1] actors in the organisation of smart grids and demand response (e.g. CEER, 2011a; Ruester et al., 2013b; Smart Grids Task Force, 2013).

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[1] The incumbent actors encompass TSOs, DSOs and suppliers; emergent actors include e.g. aggregators, manufacturers of appliances and devices, retailers in sectors other than electricity or ICT companies.

Besides the technical hurdles and the challenges with regard to the roles of different market players, there is still a third challenge to be resolved to get demand response to take-off: how to activate the consumers. Recent research on consumer price elasticity shows that the demand side, especially the residential and small and medium-sized enterprise (SME) consumers, is not very active nowadays, even when retail price variation through time of use tariffs is present (e.g. Allcott, 2011; Lijesen, 2007; Torriti, 2012). Pilot studies on smart grids do find indications that consumers respond to prices (e.g. CER, 2011; Faruqui and Sergici, 2010; Faruqui et al., 2013; Ivanov et al., 2012; Stromback et al., 2011), but the results of these studies cannot be generalised because of the experiment design or the often limited sample sizes. Yet, consumers making the transition towards activeness are key to the future role of the demand side as a source of flexibility for the electricity system (Bradley et al., 2013). It has been pointed out, e.g. by Olmos et al. (2011), Stromback et al. (2011), Cappers et al. (2012) or Gyamfia and Krumdieck (2012), that the potential of smart meters and smart appliances is significantly limited if the consumer is not engaged to use them. Eurelectric (2011) also expects consumers to be able to manage and adjust their electricity consumption in response to real-time information and changing price signals. The aforementioned literature clearly recognises the importance of active consumers for demand response; there is, however, limited understanding on how to effectively activate consumers to participate in demand response. (Lewis et al., 2012; Delmas et al., 2013) consider that engaging consumers to make the transition from passive to active can be considered a major challenge for successful demand response take-off. Dulleck and Kaufmann (2004) demonstrated that providing customers with more information can affect electricity demand in the long run but not in the short run. Vassileva et al. (2012) point out that to help consumers make better decisions by providing feedback on their energy consumption, a good understanding of consumers is needed in terms of their personal preferences with regard to how to receive this feedback, e.g. consumers without internet want a non-electronic means of communication. This need for understanding consumers is further demonstrated in the empirical work on consumers' selection of tariff programmes by Dütschke and Paetz (2013), who find that consumers prefer simplicity over dynamic programmes and that automation is a (necessary but insufficient) prerequisite for consumer participation in demand response. A comprehensive understanding of consumers' motives to become active demand response participants is thus required. Measures to engage and empower consumers should be based on such understanding.

Therefore, this paper investigates how to engage and empower consumers, in particular small consumers connected to the distribution grid (residential and SME consumers) – including consumers who have self-generation (so-called 'prosumers'), to shift towards active demand response participants. The focus is given to small consumers because industrial consumers, given their size and skills, and facing less market barriers and transaction costs than small consumers, already have the possibility to be active today if they want to; even if industrial demand response is often still limited (Hopper et al., 2006; Sustainability First, 2012c), on the one hand. On the other hand, in the decentralising electricity system, flexibility is needed at a much more local level than in the past; the many small consumers connected to the distribution together make up a large potential for flexibility (ETP SmartGrids, 2011).

The paper adopts a consumer-centred approach, which means that we do not relate consumers' responsiveness only to the potential of financial incentives, as is often the case in pilot studies – but explore a wider set of costs and benefits that consumers would be exposed to from the perspective of contracts and demand response intermediaries. Our analysis reveals the importance of contracts in promoting consumers' participation in active demand response. It is shown that the diversity of contract types as well as of intermediaries is vital if the active demand response is to take off to the benefit of consumers.

This paper is then organised as follows: in Section 2, we focus on the demand response contracts through which consumers are likely to participate in demand response, how these contracts interact with different types of consumers, and how consumers can be empowered to manage the contract selection process. Next, in Section 3, we examine the role of the intermediaries that consumers sign

this contract with, how this intermediary affects consumers' engagement to participate in demand response, and how negative effects for consumers can be limited or avoided. The paper ends with a discussion of the presented recommendations and conclusions on how to engage and empower consumers to make the transition to active participation in demand response.

2. Interaction between contracts and consumers

Residential and SME consumers will participate in demand response through dedicated 'demand response contracts' that are, in principle, distinct from 'electricity supply contracts'. An electricity supply contract arranges the provision of electric power to a consumer by an electricity supplier. A demand response contract, on the other hand, governs the relationship between the consumer, who adapts his consumption in response to a signal, and the demand response intermediary, who is the counterparty that provides this signal.[2] This distinction is necessary, first, to focus on demand response, regardless of whether it is offered separately from or included in a supply contract. Second, in many countries, emerging market players are effectively proposing stand-alone demand response contracts to consumers, providing an alternative to the demand response contracts offered by incumbent suppliers. Hence, our analytical distinction does not necessarily imply that consumers participating in demand response have to manage two separate contracts; they could be merged into one contract.

In this section, we first present a categorisation of contracts according to their technical features and the high levels terms they impose on consumers. Then, by investigating consumer load mix and consumer preferences, we demonstrate the necessity of having diversified demand response contracts to engage different consumers. Furthermore, we identify the challenges of contract selection and put forward recommendations to empower consumers, enabling them to manage their contract selection process.

2.1 Diversity of contract types

Based on the existing literature (e.g. Albadi and El Saadany, 2008; Borenstein, 2005; Braithwait and Krisch, 2006; Brattle, 2011; DOE, 2006), experience from industrial consumers' demand response and practice in recent as well as on-going pilot projects, we distinguish five types of contracts that could be offered in the electricity market: (1) *time of use (TOU) pricing*, (2) *dynamic pricing*, (3) *fixed load capping*, (4) *dynamic load capping*, and (5) *direct load control*. Every conceivable set of contract terms[3] should then belong to either one contract type or a hybrid of these types[4].

We first systematically classify the different contract types with regard to their technical features, being form of signal and volatility of signal; the latter encompasses both notice time and granularity. Next, we discuss for each contract type the high-level terms imposed on customers. These terms are not limited to the financial compensation that can be expected for such a contract, but also include price and volume risk, complexity and loss of autonomy/privacy by the customer of such contract.[5] The technical features and the high-level terms are summarised in Table 1.

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[2] By convention in this paper, when 'contract' is mentioned, we refer to a demand response contract. Whenever we refer to an electricity supply contract, this will be done explicitly as 'supply contract'.

[3] Contract terms include the establishment of time intervals, prices, quantities, termination fees, start and end dates, access to consumer data, et cetera.

[4] Hybrids of multiple contract types are conceivable, e.g. direct load control added to TOU pricing or TOU/ dynamic pricing added to fixed load capping. Critical peak pricing (CPP) is a special case of dynamic pricing with very high prices during critical events when demand exceeds supply; CPP is thus a price signal that is superimposed on the normal price signal and could thus also be considered a hybrid.

[5] It is worth noting that this selection of criteria is not aiming at an exhaustive evaluation; instead, we intended to focus on criteria that could discern the impact of different contracts on consumers.

2.1.1 Technical features: signal form and volatility

The form of the demand response signal is either price or volume:

- *Price-based* contracts: use a tariff for electricity as the signal form to trigger a change in the consumption;
- *Volume-based* contracts: constrain the load, i.e. the instant electric power consumption, to a contractually defined floor and/or cap;

For either of those contracts, the signal volatility can be low (static) or high (dynamic):

- *Static* contracts: the signal is established with long notice for a number of predefined, relatively extended intervals; volatility of the signal is low;
- *Dynamic* contracts: the signal is established with short notice and for shorter intervals that better reflect wholesale market trading intervals; volatility of the signal is high.

We further distinguish a *control-based* contract in which the consumer cedes control over specific appliances to the counterparty in the contract. The consumers are therefore not expected to react to any signals themselves.

Time of use pricing is then a static price-based contract, with *dynamic pricing* the dynamic as its counterpart. *Fixed load capping* and *dynamic load capping* are the respective static and dynamic volume-based contract types. Finally, the *direct load control contract* is the control-based contract type.

2.1.2 High-level terms imposed on consumers

The contract types implicitly or explicitly impose high-level terms on the customers of these contracts. These terms are financial – price risk and financial compensation, and non-financial – volume risk, complexity, loss of autonomy and loss of privacy.

- *Price risk* reflects the uncertainty of the price for the consumer. It is only present in price-based contracts and it is higher for the dynamic contract type (dynamic pricing) than for the static variant (time of use pricing). Due to this price risk, in some contracts, the consumer might end up with a higher bill than expected if he does not respond to the price signals.
- *Volume risk* reflects the uncertainty of the power that will be available to the consumer and is only present in volume-based contracts. In other words, with certain contracts the consumer might have access to less power (equivalent to being curtailed) than is needed for all wanted end-use services, or he might have to consume more than expected (or at least pay for this unconsumed energy) if his current consumption does not meet his floor restriction. Volume risk is higher for dynamic load capping contracts than for fixed load capping contracts.
- *Complexity* refers to the difficulties consumers could have with understanding what is expected from them, e.g. having to deal with signal volatility, or learning the impact of different appliances on power consumption. Complexity is higher in dynamic contracts than in their static counterparts; it is also higher for volume-based contracts as consumers have come to grips with the load impact of different appliances. Direct load control is a fairly simple contract for consumers because all control decisions are outsourced.
- Some contracts affect the degree of freedom in consuming power by limiting the total load or controlling the individual appliances– in other words, consumers experience a *loss of autonomy*; the consumer is then also expected to reveal some personal information with regard to, e.g. what appliances he has and when he prefers to use them, resulting in a *loss of privacy*. Autonomy (being in control) and privacy (non-disclosure of personal information) are distinct issues that are, however, closely related. Loss of autonomy/privacy is absent in price-based contracts, limited for volume-based contracts (as power can be curtailed, consumers cannot always have all end-use

services they want) and high for the direct load control contract that signs away all control for part of the load to a third party.

- Financial compensation: the contracts include financial compensation, directly or indirectly, that should correspond to the imposed terms in the contract. Dynamic contracts typically have a higher compensation potential than static contracts. For direct load control, the compensation is related to the size of the load that is part of the contract.

An overview of all these features can be found in Table 1.

Table 1. Diverse contract types: technical features and high-level terms imposed on customers

Contract type	Technical features		High-level terms				
	Signal form	Signal volatility	Price risk	Volume risk	Complexity	Autonomy/ Privacy loss	Financial compensation
Time of Use pricing	Price-based	Static	Low	None	Low	None	Limited
Dynamic pricing	Price-based	Dynamic	High	None	High	None	High potential
Fixed load capping	Volume-based	Static	None	Low	High	Limited	Limited
Dynamic load capping	Volume-based	Dynamic	None	High	High	Limited	High potential
Direct load control	Control-based	Predefined	None	None	None	High	Limited/ High potential

2.2 Consumer classification 1: Consumer load mix

The first justification for the existence of diversified contracts lies in the fact that the ability of consumers to participate in demand response can be associated with their 'load mix'; and there are as many load mixes as there are consumers. The classification of consumers according to their load mix would then help to distinguish consumers in terms of the flexibility of their load and, consequently, how responsive they can be to the different signals provided by the different types of contracts.

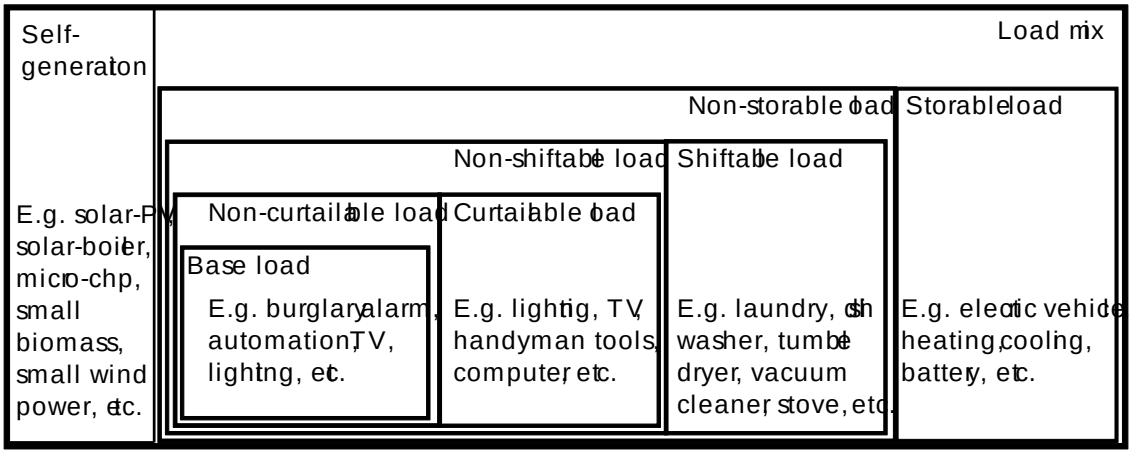
In this section, we first define consumer load mix. Second, we demonstrate how the appropriateness of a contract for a consumer depends on the match between his load mix and the technical features of the contracts.

2.2.1 Consumer load mix

There are many studies trying to classify load in an attempt to derive its potential to participate in demand response. Wood and Newborough (2011) classifies load into 'unpredictable', 'moderately predictable' and 'predictable' loads. But the correlation between 'predictability' and 'flexibility' of load is not straightforward; being predictable doesn't necessarily mean that such load could be more easily shed or postponed. And such predictability of energy consumption is much related to consumer behaviours, which are not supposed to be fully rigid. Another way to categorise consumers' load is by the appliances of the household, such as in Smart-A (2008). It offers very detailed information about consumers' technical capacity to be responsive, but does not allow taking into account the behavioural aspect, and moreover, it is hard to generalize for SME consumers. We recognize that there are different degrees of flexibility that one can expect from consumer load, analogue to a generation mix. Therefore, we classify consumer load into five load types that together make up the consumer *load*

mix: (1) storable load, (2) shiftable load, (3) curtailable load, (4) base load, and (5) self-generation (Figure 1). This way, how appliances are used to provide end-use services is also reflected in the load characterisation, allowing consumer behaviour to be taken into account in the estimation of the consumer's potential to participate in demand response.

Figure 1. Load mix made up of different proportions of storable load, shiftable load, curtailable load, base load and corrected for self-generation (examples serve an illustrative purpose)



Consumer load, i.e. the power consumption from the electricity grid, can first be segmented in *storable load* and non-storable load.

1. **Storable load**: the power consumption and the end-use service are decoupled by storage that can be in the form of (electrochemical) batteries or thermal inertia.

Next, non-storable load can be further segmented in *shiftable load* and non-shiftable load.

2. **Shiftable load**: power consumption can be moved in time without affecting the end-use service. Shiftable load often involves a non-interruptible process like a laundry cycle and thus involves some planning.

Non-shiftable load then is further segmented in *curtailable load* and non-curtailable load.

3. **Curtailable load**: power consumption cannot be shifted without affecting the end-use service, but the service can be interrupted instantly.

The remaining non-curtailable load can be classified as *base load*.

4. **Base load**: the end-use service needs instant power and cannot be interrupted or shifted in time.

The load refers to net electric power consumption from the grid and is thus equal to the total power consumption corrected for *self-generated* power by the prosumer.

5. **Self-generation**: power generation on the premises of a consumer, reducing the net load. Dispatchable self-generation can be used as back-up power.

Together, the different proportions of these load types make up the consumer load mix; this load mix could then be qualified by its dominant load type: e.g. a 'curtailable load mix' then has a dominant share of curtailable load. Consequently, consumers with a dominant share of base load can be seen as the least flexible, while consumers with a dominant share of storable load can be considered the most flexible.

Finally, it is important to note that the load mix of consumers is not static but can change over time. Indeed, taking into account that the load mix depends not only on the appliances but also on the lifestyle of the occupants of the house, there are several circumstances that can lead to a significant

change of the consumer's load mix; the acquisition of new appliances with new functionalities (as an electric vehicle) and the job switching by one of the occupants are examples of such circumstances.

2.2.2 Matching the contract to load mix

As the load mix defines the potential of a consumer to participate in demand response, the right contract is needed to valorise that potential. In this section, we associate the load mixes to the static or dynamic nature of the demand response signal in the different contracts.

- A *curtailable load mix* can interrupt load instantly and is thus particularly able to respond to dynamic signals. Dynamic pricing and dynamic load capping can be appropriate contracts for this consumer category.
- A *shiftable load mix* needs some planning of load and thus benefits from static signals that are notified well in advance and are less volatile within the day. TOU pricing and fixed load capping fit well for this class of consumers.
- *Storable load* allows using load so flexibly that it can respond to both static and dynamic contracts. Furthermore, the decoupling of power consumption and end-use services makes this load suitable for a contract with third-party control. A direct load control contract, as well as all other contracts might then be appropriate.
- Finally, some consumers might have a base load mix, which has limited flexibility and is not suitable for participation in demand response. This consumer class might not find a contract that is appropriate for their load mix.

So, a consumer's potential to participate in demand response will be maximised if the technical features of the contract match the flexibility of the load mix. If a consumer cannot find a contract that allows his demand response potential to be valorised, he might choose not to participate at all.

2.3 Consumer classification 2: Variety of consumer preferences

Besides the technical ability, the engagement of a consumer to participate in demand response depends on his individual 'preferences' regarding the costs and benefits that he associates with his participation.

- *Costs* refer to what the consumer perceives as something asked from him by the counterparty.
- *Benefits* refer to what the consumer perceives as compensation in return for his participation.

Such costs and benefits are associated with consumer related criteria such as altruism and prosocial motivation (Delmas et al., 2013), price risk, volume risk, complexity, loss of autonomy/privacy, and financial compensation. These criteria have been used to differentiate the contract types (Table 1), except for altruism and prosocial motivation, which are intrinsic to consumers and thus independent from all contracts.

Consumers make an individual evaluation of these criteria. For instance, loss of autonomy can be a cost for one consumer whilst a benefit for another; and different consumers might attribute different value to the same criterion. So, depending on the individual consumer's preferences, different contracts might then be appropriate to increase or maximise the willingness of a consumer to participate in demand response; illustrated here for two possible consumers.

- A well-educated consumer who is risk seeking in order to increase his financial compensation, but is also concerned about his privacy.
    - Benefits: high potential for financial compensation, high price risk, no loss of privacy;
    - Costs: complexity and autonomy.

  Dynamic pricing might be the most appropriate contract for consumer classes with similar preferences.

- A less-educated consumer who is not used to complexity and is more willing to outsource the handling of complex technology, even at a small cost.
    - Benefits: low complexity, high loss of autonomy, low price risk;
    - Costs: volume uncertainty, limited financial compensation.

  Direct load control, TOU pricing and fixed load capping might be appropriate contracts for the class of consumers with similar preferences.

If a consumer cannot find a contract reflecting his preferences, he might refrain from participating in demand response. The contracts must therefore be diversified enough to increase participation rates, providing a second justification for needing a set of diversified contracts.

Similarly to what has been discussed for the consumer load mix, also the preferences should not be considered static over time. The way consumers valorise the different contract terms may change over time.

2.4 Challenges and recommendations for contract selection

We have now demonstrated that existence of diverse contract types is needed to reflect different load mixes and consumer preferences. We have also demonstrated and illustrated in the previous sections that the five contract types discussed in this paper make up such a diversity that is able to match different consumers. However, consumers might still find it difficult to select, first, the right contract type for them from a set of diversified contracts, and next, find the best contract terms for that contract type. First, we identify the challenges in contract selection; second, we discuss how to empower consumers to manage the selection process.

2.4.1 Challenges in contract selection

The contract selection process for consumers can be broken down into four steps, including: (1) qualifying their load mix, (2) recognising their preferences, (3) selecting an appropriate contract type, and (4) finding the best contract terms. Each of these steps can be a challenge for a consumer.

1. Qualifying the load mix: consumers might not be aware of how their use of appliances affects their ability to participate in demand response (e.g. just considering all load as base load); they might also not be aware of the possibilities of their load to be used more flexibly; or they might lack the skills to tap into the flexibility potential (e.g. they do not know how to programme their washing machine).
2. Recognising consumer preferences: consumers might not be aware of costs and benefits that are implicitly present in the contracts; they might not reveal their preferences; they might also lack the skills to properly evaluate costs and benefits.
3. Selecting an appropriate contract type: a consumer's load mix might not be aligned with his preferences regarding the costs and benefits related to his participation in demand response (e.g. a consumer with a curtailable load mix – dynamic contracts, who prefers low uncertainty and low complexity – static contracts). In the light of consumer rights in Europe, it should be clear that the consumer makes the final decision in this regard and he cannot be forced to enter a specific contract type (EC, 2007b, 2010b).
4. Selecting the best contract terms: contract types are generic forms of contracts; the consumer will still need to find an actual implementation of it; lack of comparability in contract design might then prevent a consumer from identifying the best contract terms; the variation in contract terms might become too large to be able to choose.

2.4.2 Empowering consumers for contract selection

Here we present recommendations on a toolkit to empower consumers, enabling them to overcome the challenges in contract selection.

Furthermore, the presented tools do not only remedy specific issues, but they contribute to the gradual building of consumers' trust in demand response.

2.4.2.1 Consumer profiling

Consumer profiling, is an instrument that helps a consumer in making explicit (1) his load mix, (2) his preferences and (3) how the contract types can be associated to load mix and preferences; thus dealing with the first three aforementioned challenges in contract selection. Moreover, the unique features of consumers in terms of load mix and preferences are sufficient to evaluate the potential responsiveness of different consumers. Thus, the categorisation of consumers according to these features may be considered as an accurate classification of consumers. Moreover, the market players offering the demand response contracts have an interest in consumer profiling too for their customer segmentation.

In practice, load profiling comes down to surveying the consumer on his load mix using the typology of load types introduced in Section 2.2.1, and on his preferences by including criteria like the high-level terms that are explicitly or implicitly imposed on consumers through the contract types, as summarised in Table 1.

Consumer profiling then helps consumers (1) by facilitating contract selection through the recognition of the consumer's load mix and preferences, (2) by educating consumers on their load mix and preferences, and (3) by correcting/adjusting past choices based on regular profiling.

Since demand response is a market activity, the intermediaries who propose the contracts would also have an interest in providing a proper consumer profiling, as it provides them accurate information to build their customer segmentation. However, to avoid excessive intrusion and facilitate market supervision, high level guidelines on the profiling methodology needs to be provided by national authorities. It is stressed that consumer profiling needs to be conducted in full transparency with the consumer and can only be started with the consent of the consumer.

2.4.2.2 Contract comparison tools

Consumer profiling helps a consumer to select an appropriate contract type, but there could exist many different sets of contract terms for this contract type. A contract comparison tool, then, directly addresses the aforementioned fourth challenge in contract selection by raising consumer awareness and facilitating comparison.

To fulfil its function, a contract comparison tool, like a price comparison tool, has to satisfy a number of requirements (CEER, 2012a; Consumer Focus, 2013b; Ofgem, 2013). The main requirements are as follows. First, the provider must be certified and highly trustworthy, thus an independent actor is best placed to provide this service. Second, the methodology for comparing contracts should be transparent and clearly defined by the regulator. Third, contracts should include those contract terms that are most relevant for contract comparison; the establishment of a minimum set of contract terms to be defined in each contract could be useful in this regard. Fourth, consumers must be able to compare the performance of their contract ex post to the expected performance of their current contract terms and other contract terms offered on the market.

2.4.2.3 Optimising the range of contracts

One standard contract will not allow all consumers to participate in demand response, whereas having too many contracts might make it impossible to compare and choose the best contract, even with tools to assist in contract selection. Thus, an adequately large range of contracts involves a trade-off

between having the market offer unlimited tailored contracts adapted to individual needs (one extreme) and having only one standard contract for all consumers (another extreme). The national regulatory authorities could play a role in optimising the range of contracts for consumers' interest (Ofgem, 2012). Some harmonisation of contract design is necessary to allow the regulators to efficiently monitor the range of existing contracts before trying to reduce or increase the range.

Therefore, the national regulatory authority could impose a notification requirement for every contract that is going to be offered on the market. This notification should include the signal type and volatility (see Table 1) allowing the regulator to connect the new contract to one of the contract types. Such harmonisation can also help directly reducing transaction costs for consumers, e.g. by reducing complexity and facilitating comparison, thus lowering searching costs.

2.4.2.4 Protection of personal information

To participate in demand response, the consumer is required to reveal personal information: first, to facilitate the contract selection process (revealing load mix and preferences), and second, to comply with the contract terms with regard to the sharing of data and personal information. Furthermore, we have illustrated that volume-based and control-based contracts imply a loss of privacy to different degrees: limited for the load capping contracts and high for direct load control contracts.

The consumer must be confident that personal information and data will only be used for clearly consented purposes. Adequate data protection rules should therefore be implemented to overcome challenges one to four (Article 29 Data Protection Working Party, 2013; EC, 1995). The starting principle must be that the consumer is in control: a party requesting access to information should be explicit about what information is needed and with what frequency, and the requested data must only become available after explicit consent to the request by the consumer (CEER, 2011b).

2.4.2.5 Protection of vulnerable consumers

In the light of the on-going work in the Citizen's Energy Forum's Vulnerable Consumer Working Group and of the development of an energy policy for consumers, we can observe here that additional assistance and protection for vulnerable consumers is justified; in fact, a basis already exists in the framework of the internal market for electricity (EC, 2009c, 2010a). Other measures could also be considered at the Member State level, such as protecting vulnerable customers through social welfare systems.

2.4.2.6 Promotion and dissemination of pilot projects

The contract selection represents a new challenge for consumers as well as for policy makers, intermediaries, etc. Therefore, the development of the contracts as well as of the supporting contract selection tools will be a learning process for all stakeholders. The pilot projects on demand response, which currently aim at testing the acceptability of the new technology and related commercial arrangements with consumers, could be of great added value to this process.

Nowadays, there is already a significant number of pilot studies on demand response, some still on-going (ADDRESS, 2010; Frontier Economics and Sustainability First, 2012; Stromback et al., 2011). Despite the number of existing studies, the lessons learned concerning the consumer and the contracts from the existing set of studies are limited and insufficient to feed the debate on how to engage and empower consumer to participate in demand response. There remains a need to promote more contract-oriented pilot projects in the future in order to reach a consensus on the understanding of consumers' engagement. Additionally, consumers should also be made aware of the output of these studies to show them the potential benefits for society and for themselves.

It is also noted that, due to the local character of demand response, pilot projects are mostly conducted in a decentralised way; and so is the dissemination of their output. The resulting lack of

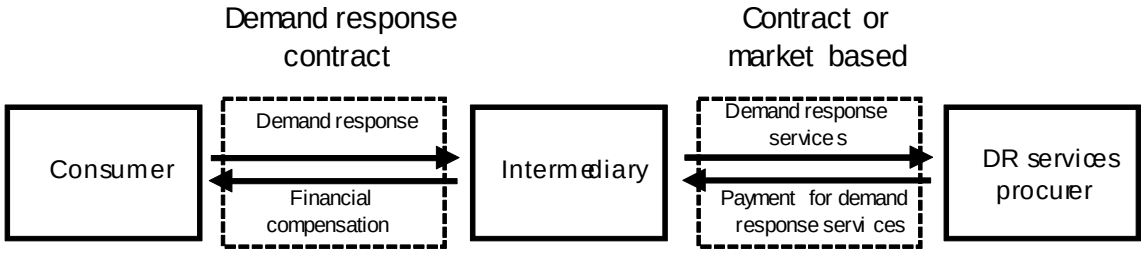
coordination between different projects, as well as the limited dissemination of results prevents different stakeholders from sharing their experiences and improving the understanding of consumers' engagement. Currently, reporting in pilot studies is mostly focused on technological developments, while it should also be oriented around providing output to feed into the consumer-focused policy making (Lewis et al., 2012). Indeed, information relevant for the development of decision-making tools, such as consumer profiling and contract comparison tools, could be tested in pilot projects and the results could be compared across the projects. Therefore, in order to extract the most value from these projects, there is a need to establish reporting guidelines so that the output can be easily disseminated and benchmarked.

3. Variety of intermediaries and their impact on consumers

Even if in principle consumers can offer their demand response services without the intervention of an intermediary, residential consumers and SMEs face certain barriers to directly participate in the energy markets such as market rules defining too high thresholds, and the transaction costs and risks that are too high if managed at individual level. The first set of barriers could be removed by changing the market rules, while the second set of barriers still remains. That is why there is a need for intermediaries to facilitate the residential and SME consumers to deliver demand response.

Intermediaries (also referred as 'aggregators' in the literature) are then entities that facilitate the demand response transaction between consumers, who provide flexibility, and demand response procurers, who use flexibility to optimise their businesses, through contracts as the ones discussed in the previous section (Figure 2). Very different entities can play the role of intermediary for demand response, and different entities may have a different impact on consumers. Due to such differences, we argue in this section for the need for a variety of intermediaries (Sections 3.2 and 3.3). Moreover, we also discuss the factors that could hinder the emergence of a variety of intermediaries for demand response (Section 3.4) and provide recommendations on how to overcome these barriers (Section 3.5).

Figure 2. Interaction between consumers, intermediaries and procurers of demand response services



3.1 Variety of intermediaries

Before discussing how different intermediaries may impact consumers, it is necessary to categorise the potential intermediaries for demand response. For analytical purposes, the large variety of entities that may play this role in the future is reduced to three representative intermediaries:

- **Supplier**, which refers to the entities that, besides being an intermediary for demand response services, also provide supply services to the consumer. This then includes any company or legal person that sells electricity to final customers, including integrated suppliers-DSOs.
- **Third-party**, corresponding to a for-profit entity having the provision of demand response services as its core business within the electricity sector without being a procurer of demand response services. ESCOs, for instance, are a potential third-party intermediary.

- **Consumer cooperative**, which refers to a non-profit entity composed by an aggregation of consumers. These entities are typically small and localised, e.g. organised at the neighbourhood level or by consumer associations.

3.2 First reason: Intermediary preferences for the demand response contracts

An intermediary's preferences towards certain demand response contracts would be primarily related to the services that these contracts would enable, hereafter called demand response services. Since different demand response services may have different requirements in terms of consumer responsiveness, the interest of a certain intermediary in certain demand response services can make him inclined towards certain contracts.

In this section, we first present the typology of demand response services. Second, we discuss the interest of each intermediary in different demand response services by looking at his incentive-based business model. Then, we discuss the matching between the technical features of each demand response service and the features of each demand response contract. The outcome of this analysis will then reveal the possible preferences of certain intermediaries over certain contracts.

3.2.1 Typology of demand response services

Demand response as a means of flexibility can have an impact both in the short term, for efficient and reliable operation of the total electricity system, and in the long term, for adequacy optimisation of this electricity system. Indeed, it can offer a diverse set of services to the electricity system. Within this section, we present a typology of demand response services, including a discussion on their specific technical requirements and on their procurers.

We consider that demand response can offer five different types of services[6] to the electricity system:

1. Portfolio optimisation, which is used by market players to meet their load obligations at minimum costs by arbitrating between generation and demand response on different time horizons. This service is procured by suppliers and other wholesale actors.
2. Structural congestion management, which aims at solving congestion in the transmission system '*that can be unambiguously defined; is predictable; is geographically stable over time; and is frequently reoccurring under common circumstances*' (ENTSO-E, 2012a). This service is procured by TSOs and DSOs.
3. Occasional physical congestion management, which aims at solving physical congestion which is unpredictable and occasional, e.g. caused by distributed generation and renewable energy sources. This service is procured by TSOs and DSOs.
4. Balancing of electricity system, which refers to the '*procurement of balancing reserves (capacity) and balancing energy by the TSO to perform balancing, meaning all actions and processes, on all timescales, through which TSOs ensure, in a continuous way, to maintain the system frequency within a predefined stability range*' (ENTSO-E, 2013). In other words, the TSO balances demand and supply by procuring fast sources of flexibility. This service is procured by TSOs and in the future potentially also by DSOs.
5. Ancillary services, which refer to '*a range of functions which TSOs contract so that they can guarantee system security. These include black start capability, frequency response, fast reserve,*

[6] The demand response services discussed in this paper are a selection of possible services that have been discussed in the literature (e.g. DOE, 2006; Ofgem, 2010a; Frontier Economics, 2012). This is not meant to be an exhaustive list of flexibility services that could be offered now or in the future through active demand response.

the provision of reactive power and various other services' (ENTSO-E, 2012c). This service is procured by TSOs.

As these services help resolve different problems in the electricity system, they have different requirements in terms of reaction time (how fast flexibility can respond to the activation signal ranging from minutes, e.g. to balance wind unpredictability, to hours for predictable events like structural congestion management services), duration (the timespan of the perturbation to be covered can last seconds, e.g. for ancillary services, minutes or even hours, e.g. for structural congestion management services) and firmness (the level of guaranteed delivery of the service). Non-compliance to firm commitments in a contract is subject to contractual penalties. These penalties could be severe as firmness of services like ancillary services, balancing services or occasional congestion management services is critical for the electricity system.[7] The technical requirements of the different demand response services are summarised in Table 2.

Table 2. Technical requirements of different demand response services in terms of reaction time, duration, and firmness

Service type	Reaction time	Duration	Firmness
Structural congestion management	Slow	Long	Low
Portfolio optimisation	Slow	Long or short	Low
Occasional congestion management	Fast	Short	High
Balancing services	Fast	Short	High
Ancillary services	Very fast	Short	Very high

3.2.2 Interaction between demand response services and demand response contracts

We have discussed in the previous section that in order to provide different services, demand response needs to fulfil different technical requirements. We have also discussed in Section 2.1 that different demand response contracts have different technical features. Then, it is expected that there is a relation between the contract types and the demand response services. Indeed, the requirements of the demand response services need to be adequately reflected in the contract features to ensure technical requirements are met by the consumer's demand response. Table 3 offers an overview of the plausible matching.

[7] A more detailed analysis of reaction time, duration and firmness in the context of demand response can be found in Grünewald and Torriti (2012, 2013)

Table 3. Matching between demand response services and demand response contracts based on technical features of contracts and technical requirements of demand response services*

Contract type	Structural congestion management	Portfolio optimisation	Occasional congestion management	Balancing services	Ancillary services
Time of Use (TOU) pricing					
Fixed load capping					
Dynamic pricing					
Dynamic load capping					
Direct load control					

*Blank spots in the table indicate that requirements of demand response service are not sufficiently reflected in demand response contract features

Some general insights of matching the demand response services to the contracts can be drawn from the table above (Table 3):

- Demand response services that require firmness match with volume-based contracts and in particular with direct load control contracts if, additionally, the response should be fast and available at very short notice.
- Demand response services which require less firmness could be met by price-based contracts.
- The optimisation of structural electricity system issues can be handled by static contracts that match with the need for a persistent signal over a longer interval, whereas services that need to be fast and variable are better embodied by dynamic contracts.

3.2.3 Business model: intermediary preference towards demand response services

One might expect that any intermediary would always offer all demand response services in order to maximise the overall value of demand response. This expectation, however, may not be materialised because in reality, intermediaries can have divergent business objectives which make them attribute less or more value to certain services. Moreover, these services can differ in terms of risk, which might be perceived differently by different intermediaries. Hence, the business model of the intermediaries, i.e. making profit out of selected demand response services, can differ. This sub-section then discusses how the interest in demand response services can differ for different intermediaries by first analysing the intermediary's core business and second their risk preferences.[8]

[8] Note that this paper does not aim to provide an exhaustive overview of intermediary incentives, but instead focuses on two incentive issues that show a potentially biased relationship between the demand response intermediary and certain demand response services. More information on intermediary incentives can be found in reports discussing the value of demand response (e.g. DOE, 2006; Frontier Economics, 2012; Ofgem, 2010a).

Core business

Out of the three considered entities, one has another core business in the electricity system -- the supplier (selling energy) -- while the other two (third-party and consumer cooperatives) could establish their business only with demand response. If the core business of the actor is not demand response intermediation, the incentives for being an intermediary could somehow be affected by the incentive in their core business. Here we discuss two cases:

1. In the case that certain demand response services can be for self-use, the intermediary might have a higher incentive to procure those services.
   - Supplier: might focus on self-optimisation of its portfolio of generation and demand;
2. In case certain demand response services are in conflict with the intermediary's core business, he might have a preference for not procuring it.
   - Supplier: core business is to sell energy, whereas demand response may be used to reduce the consumer's load. Demand response can thus be competing with supplying more energy.

The two effects discussed above could explain the possible preferences of the supplier towards a limited number of demand response services.

Business risk preferences

The risk preference is another factor to explain why an intermediary could incline to certain contracts. Intermediaries that are more risk averse might turn away from those demand response services whose business risk is perceived as too large.

These business risk preferences can be attributed to limited skills with concern to trading in different energy markets. Or the limited size of the demand response business can turn away the intermediary from markets with large exposure due to volatility. For instance, the balancing market is often smaller in size, less liquid and more volatile than the day-ahead spot market. In some electricity systems, procurement of ancillary services and congestion management tools might be non-market based and thus less transparent, increasing business risk for market players.

Risk averseness might potentially be higher for those intermediaries that have no vested business in the electricity system. Indeed, these actors are more likely to lack a robust core business that provides a financial cushion. Out of the considered actors in this paper, the commercial third party and the consumer cooperative fit this profile, but suppliers could also be less or more risk averse.

The intermediary's risk preferences can thus further narrow down his preferences towards demand response contracts.

Concluding, different intermediaries may have incentives to target specific demand response services and, consequently, to prefer specific types of demand response contracts. As seen in Section 2, the existence of diverse contract types is necessary in order to better fit different consumers' load mixes and preferences. The intermediaries' preferences towards demand response contracts could then affect consumers by reducing the diversity of contracts available.

Nonetheless, intermediaries' differing preferences towards demand response contracts are not necessarily an issue for consumers. In fact, even if not all the contracts are offered by a single intermediary, they could still be available if different intermediaries coexist. Thus, a range of diverse contracts matching different consumers' preferences would still be available, but it would be offered by different intermediaries.

3.3 Second reason: Intermediary impact on consumers' surplus

Another reason for why a variety of intermediaries is necessary lies in the fact that different intermediaries may affect consumers' benefits differently, i.e. the financial compensation that consumers receive from their participation in demand response. This financial compensation is related to the value of the flexibility services that the intermediaries procure from consumers via the contracts. Consumers' surplus discussed in this section refers to the value of the financial compensation that consumers receive by participating in demand response.

The impact of intermediaries on consumers' surplus can be twofold: first, the overall profit captured from demand response may differ depending on the entity that plays the role of intermediary; and second, different entities may split the profit with the consumer differently. In what follows, we present an analysis of the twofold impact, then summarised by Table 4.

The overall profit

The overall surplus (*the size of the cake*) that can be captured by different types of intermediaries can be associated with (1) the openness of the intermediary towards the different services and (2) the costs of trade for this intermediary in providing different demand response services.

The *openness towards the provision of different demand response services* can be hindered by the misaligned incentives with the core business of each entity and by his risk-averseness. Within the previous section, we have already assessed this issue by looking at the preferences towards the provision of certain services. Indeed, if the intermediary does not have the incentives to provide all demand response services, the maximisation of the benefit extracted from demand response might be impeded. However, it is also shown in the last section that it is not clear which intermediary would be able to capture the most value from demand response, since none of the entities would be fully open towards all the services that can be provided through demand response.

The costs of trade refer to the costs different entities need to bear to play the role of intermediary, and this is strongly linked to both the skills of each entity and the economies of scale that can be achieved by the different entities. A supplier should have the necessary skills and, consequently, have a low cost of trade compared to a third-party and a consumer cooperative. It seems more difficult for the third-party to achieve high economies of scale due to higher costs to acquire customers, which is a typical problem for the new market players. However, commercial third-parties may have other businesses that, even if not energy related, already have a customer base which may reduce the costs related to customer acquisition. The consumer cooperative might be the model with the highest costs of trade, not only because the consumer cooperatives are usually extremely local (e.g. neighbourhood level), but also because they are commonly formed by customers who do not have specific training or experience in the sector. It is worth noticing that the economies of scale achieved by each of these entities could be very different; indeed, there are suppliers with a relatively low number of customers and there could be third-party intermediaries with a relatively high number of customers.[9]

Profit sharing with consumers

Different entities share the captured surplus with consumers (*the slice of the cake*) differently; how they share can be associated with (3) their business orientation and (4) the competitive pressure they are facing.

The *business orientation* refers to whether an entity is profit-based and, consequently, willing to maximise its own profit or not. This has implications for the incentives of different entities to share the profit from demand response with consumers. Being profit-based, suppliers and third-parties have the

[9] For example, we could consider the case where a large telecommunications provider would offer demand response services to its customers (see Section 3.4.1 for a more detailed analysis of this case).

main goal of maximising their own profit. This may imply that as intermediaries they would, on the one hand, try to increase the overall profit from demand response, but, on the other hand, also reduce the customers' share of the profit. Nonetheless, it is worth noting that this effect may be reduced by the presence of high competition pressure, as discussed by the following criterion. The consumer cooperative is a non-profit entity, and so the whole profit is to be shared between the consumers.

Finally, the sharing of profits with the consumers is also related to the competitive pressure each entity is faced with. Indeed, when an entity is profit-based, the higher the competition, the fairer the distribution of profits with the consumers might be. When the competition level is high, an entity would be willing to reduce its own profit share in order to attract more customers, while in the absence of competition, a customer's choice would be reduced and so there would be no need for the intermediary to provide more attractive incentives. Even if this issue could also apply to a consumer cooperative, it is mainly relevant when assessing how supplier and third-party would share the profit with consumers. Currently, it is recognised that in some countries, although in theory the retail market is liberalised, in practice there may still be only one supplier and a consequent lack of choice for consumers (EC, 2010a).

Table 4. Possible impact of intermediaries on consumers due to their entity

Intermediary	Openness to different services	Costs of trade	Business orientation	Competition pressure
Supplier	Low: conflict with core business	Low	Profit-based	Limited
Third-party	High	Medium	Profit-based	Variable
Consumer cooperative	Medium: averse to high risk services	High	Non-profit	Variable

The above analysis shows that different intermediaries can indeed have a different impact on consumers' benefit, while there is not a clear best. There seems to be a trade-off between the preference for specific demand response services and the costs of trade, so that the intermediary that maximises the overall profit from demand response may vary, e.g. depending on the most profitable services. Moreover, we have also discussed the fact that the coexistence of different intermediaries will increase the competition level, leading to a fairer distribution of profits and, consequently, higher consumers' benefit. It seems therefore necessary to ensure an adequate range of intermediaries and proper competition in order to safeguard consumers' benefit from demand response participation.

3.4 What may hinder emergence of a variety of intermediaries

In the previous two sections, we have already discussed the importance of ensuring a range of intermediaries. However, the existence of such a range of intermediaries may be inhibited by (1) market power issues and (2) the existing market rules and regulations for the provision of different demand response services. Within this section, we then explain how these conditions may limit the emergence of a variety of intermediaries.

3.4.1 Market power issues

The potential abuse of market power by a dominant intermediary may inhibit other intermediaries from participating in the demand response market, which may have negative implications for the consumers (as referred to in Sections 3.2 and 3.3). Indeed, this dominance in the demand response

market by a single entity may not only lead to an absence of an adequately large range of contracts and services provided, but it may also imply reduced incentives for the intermediary to fairly share the demand response benefits with the consumer.

In this section, we present three distinct situations where the dominance[10] in the demand response market by a single intermediary is likely to happen, namely: (1) high concentration in the supply market; (2) existence of integrated supplier-DSO; and (3) existence of an integrated business model for demand response and the deployment of smart appliances and/or enabling infrastructure.

Dominant supplier

Market power in the supply market may be transferred to the demand response market, due to the established large customer base and customers' familiarity with the supplier. Indeed, while this horizontal integration of businesses would lower customer acquisition costs for the supplier to enter the demand response market, it would simultaneously increase those costs for the new demand response intermediaries that would neither have an established customer base, nor the confidence from the consumers. Moreover, since a supplier would provide bundling of services, it would be difficult for the consumer to distinguish between the costs associated with the supply of electricity and the benefits resulting from the participation in demand response. The potential ambiguity regarding the actual benefits resulting from demand response participation, would make it difficult for consumers to evaluate the demand response offers of other intermediaries against the bundled one provided by the dominant supplier.

Hence, due to the already established contractual arrangements, a dominant supplier for domestic consumers and SMEs has a high probability of becoming the dominant intermediary in the market for demand response.

Integrated supplier-DSO

In certain regions, a DSO may integrate other businesses besides the operation of the distribution network. Indeed, there are situations where the DSO is also a supplier, a producer, a trader, or a vertically integrated supplier/producer/trader. If we consider the latter, the supplier-DSO (being vertically integrated) would have more information about the regulated demand response services as well as about the load profile of consumers than any other intermediary. Moreover, similarly to a dominant supplier, he would also benefit from the established large customer base and customers' familiarity and the provision of a bundle of services (misleading the assessment of other intermediaries' offers).

Thus, due to the already established contractual arrangements and the advantage of data access, there is a high probability that an integrated supplier-DSO would become a dominant intermediary in the market for demand response.

Dominance related to the deployment of smart appliances and/or enabling infrastructure

The deployment of smart appliances (or enabling infrastructure) may be financially supported by a demand response intermediary who is interested in enabling demand response to increase his intermediation business. However, as a prerequisite for the support provision, the intermediary would probably require the ownership and/or the right to control the appliances acquired (or the developed infrastructure). In either case, this deployment activity would provide an advantage to this intermediary in relation to the others, leading to the existence of a dominant intermediary. Indeed, within this situation, the appliances/infrastructure deploying intermediary could have privileged access

[10] To avoid any misunderstanding, we only claim that the market distorting effects by abuse of a dominant position must be avoided or corrected.

to consumers' information, and in some cases he could even impede the data access for other intermediaries. Moreover, this may also lead to a lock-in effect, since the intermediary investing in the appliances/infrastructure may impede (or make difficult) the switching of intermediaries by consumers. Indeed, when investing in appliances/infrastructure, the intermediary would either claim the ownership of the acquired goods or at least require a long-term contract in order to ensure the payback of his investment.

Accordingly, an intermediary that would support the deployment of smart appliances and/or enabling infrastructure would likely have a dominant position in the demand response market, mostly due to the uneven access to data compared to other intermediaries and the lock-in effect.

Concluding, we can say that this dominance in the demand response market by a single entity may emerge mainly due to four main factors:

- The **familiarity** of existing entities with whom consumers already have a contractual arrangement provide an advantage to entities who have other business in the power sector;
- The **bundling of services** and the respective billing may make it difficult for consumers to compare the offers made by different intermediaries;
- The **preferential or discriminatory access to data**, either due to the bundling of services or to the ownership/control of the enabling infrastructure, hampers all intermediaries to be on equal footing;
- The **lock-in of consumers** to a certain intermediary may also be seen as a potential barrier to the emergence of a wide range of intermediaries.

3.4.2 Market rules and regulation for the provision of demand response services

Market rules

The markets where flexibility services are currently offered, namely the spot market and the balancing market, have strict rules and commitment requirements that need to be fulfilled by the actors willing to participate. Some of these requirements may impede some of the demand response business models presented in this section to take place. For instance, in France, residential demand response is not allowed to participate in the spot market, even when several consumers are aggregated. Here, the main barriers seem to be related to the firmness and marginal impact of demand response in the spot market, which are currently under the investigation of the French regulator (CRE, 2007; 2010). Similarly, the balancing market may also not be effectively open to the residential demand response in some countries, due to the very strict requirements such as minimum bidding volume, minimum bid duration and binding up and down bids (Ruester et al., 2012b).

Even though some of the existing market rules make the participation of demand response intermediaries difficult, one should recall that these rules were designed to ensure the proper functioning of the different markets at a time when demand response was not yet considered a means of flexibility. Thus, it would be advisable to revisit the existing rules in a context where demand response is present, while assessing which rules are strictly necessary to ensure the proper functioning of the markets.

Regulation

The procurement of congestion management services and ancillary services is often not fully market based, but managed through bilateral contracts, tenders with generators and even mandatory provisions. Moreover, existing regulation does not always incentivise the procurers of these services (TSO and DSO) to consider demand response on equal footing with other flexibility sources. For instance, regulatory incentives for grid operators at the transmission and distribution levels often focus

on capital expenses (expansion of the grid). As congestion management through demand response implies an increase of operational expenses instead of capital expenses, a DSO or TSO might prefer grid investments that can be added to the regulatory asset base. Such an element of traditional rate of return regulation would hinder the deployment of innovative solutions that are less capital intensive (Prüggler and Bremberger, 2011). If the regulatory framework in place does not provide a level playing field between demand response and other sources of flexibility, intermediaries' business models that target regulated flexibility services might be seen as infeasible as the procurers of these particular services, i.e. DSO and TSO, might not show interest in demand response. Hence, also for the services whose procurement is not market based, there is a need to adapt regulation in order to allow for demand response to compete with other flexibility sources, so that a variety of intermediaries may emerge.

Furthermore, the definition of network tariffs may also need to be revisited. Network tariffs should provide correct signals to the market players regarding network constraints so that the demand response could be optimised to deliver the highest value for the overall electricity system. In the past, network congestion often has been positively correlated with high electricity prices as they both have been occurring during the peak load periods. On such occasions demand response could serve both purposes at the same time: reducing the local congestion and electricity generation costs. Nowadays, with more renewables in the generation mix, the electricity price could be low when power generation from renewable sources is abundantly available. In that case, demand response incentives are consistent with shifting load to periods of low price, causing, instead of mitigating, constraints in the local network. To resolve this challenging situation, it is important that the network tariff also send signals about the network constraints so that the network users, including the demand response intermediaries, can assess all incentives related to the grid **and** the commodity. This way, the individual decisions of market players could work towards the overall interest of the power system. The network design is beyond the scope of this paper, though it has been discussed in detail in CEER (2011a), Ruester et al. (2012a, 2013b) and Eurelectric (2013).

3.5 Recommendations to achieve a variety of intermediaries

In the previous section we have identified which conditions may hinder the emergence of a variety of intermediaries, including the presence of a dominant intermediary (who uses his market power to impede new entry), and the market rules and regulation that limit the role of intermediaries in providing different flexibility services through demand response. Thus, it is necessary to avoid the development of dominant intermediaries, on the one hand and on the other, the regulatory framework must also be corrected to ensure non-discrimination of demand response over other flexibility sources.

First, in order to allow for different intermediaries to emerge, there is a need to leverage the advantages of the incumbents and facilitate the market entry for new market players.

To do so, the following actions could be considered:

1. The development of a **licensing scheme** specific for demand response intermediaries helps to increase the confidence of consumers in new entrants in the electricity sector. Such license then ensures that the entity fulfils the necessary conditions to provide this service. In some EU countries, there is already a similar scheme for suppliers so that any actor willing to provide supply services must fulfil certain predefined conditions, which are recognised by the attribution of a license. Furthermore, licenses can help regulators to impose conditions like a maximum period to complete a customer switching process or a minimum set of contract terms to be defined in the proposed contracts. The experiences with such supplier licences should be further analysed with regard to the benefits for consumers, the compliance of suppliers with the license terms, the administration costs, etc.
2. The obligation to provide **disaggregated billing information** frequently enough for intermediaries who provide a bundle of services may facilitate the comparison of offers from

different intermediaries. Indeed, this would facilitate the use of comparison tools, as described in Section 2.4.2, helping consumers to find the best contract for them and, consequently, the best intermediary. We have seen in the previous section that the bundling of services, and respective billing, may make the assessment of different offers very difficult, due to the aggregation of the different services' costs into a single bill. The EU directive for end-use efficiency and energy services (EC, 2006) already requires informative billing to be provided to consumers. Nonetheless, the mandate is mostly aiming at the recognition of actual energy costs by the consumers. Thus, it may be necessary to require that the financial compensation of consumers' flexibility is also made explicit in the bills. Additionally, as discussed in Section 2.4.2, the consumer should have the right to get information on his consumption and costs (commodity and network related costs) with a frequency – that can be higher than the billing frequency – and through a communication channel of his choice.

3. Moreover, there is a need to ensure **non-discriminatory access to data** for the different intermediaries. For instance, regulation should prohibit the information transfer from the regulated activity to the deregulated activity, so that an integrated supplier-DSO would not have an information advantage compared to other intermediaries. Any data sharing then requires prior consent by the consumer with the exception of metering data required for the regulated activities.
4. Finally, in order to counteract the potential switching difficulties caused by the integration of demand response with smart appliances (or enabling infrastructure) deployment, one could consider extending and promoting the existing **independent dispute resolution mechanisms** (CEER, 2012b; ERGEG, 2010). In general, switching costs from one intermediary to another should be as low as possible to increase competition between intermediaries. Nevertheless, termination fees representing upfront investments made by the intermediaries could exist in which case they should be reasonable and clearly established in the contract terms.

Regarding the existing market rules and regulation on the provision of flexibility services, change may be necessary to avoid discriminatory treatment of demand over other flexibility resources. Nonetheless, it is important to stress that the call for a non-discriminatory treatment for demand response does not imply an artificial bias towards procurement of demand response as compared to other flexibility means. A level playing field does not guarantee that all demand response services will be offered, but it should guarantee that the value of demand response can be monetised if it is a competitive solution.

In what refers to market rules, there is a need to revisit them in a context with demand response to understand whether all the commitment requirements are still valid in such contexts. For instance, there are already some on-going regulatory efforts to open the balancing market to demand response. In France, there is a demonstration project to test the possibility of allowing a third-party intermediary aggregating residential demand response to participate in the balancing market. The European FP7 project Ecogrid EU presents another innovative way to allow participation of demand response in real-time markets: it tests a bid-less real-time market where residential consumers will be able to respond to prices reflecting the real-time electricity system imbalance either directly, or through an intermediary, without any restriction to size (Ecogrid EU, 2011).

Moreover, regarding the procurement which is not market based (including congestion management and ancillary services), output-based regulation may be considered so that all flexibility means can be equally considered. For instance, in the UK, Ofgem's RIIO[11]-regulation rewards companies that innovate and run their networks efficiently by offering incentives focused on delivering 'results' without focusing on particular means to achieve those results (Ofgem, 2010b). Indeed, since 2010, networks have been regulated on a TOTEX basis, i.e. their revenue is based on a combination of capital and operation expenses. In Italy, the regulator AEEG has started to adopt

[11] RIIO stands for Revenue = Incentives + Innovation + Outputs.

output-based regulation for certain services of DSOs[12] (Lo Schiavo et al, 2013). The Orkney Islands represents an interesting case in which innovative regulation allowed the DSO to consider all flexibility means (the 'innovation') on equal terms, including curtailment of wind power, in order to deal with congestion (main target), avoiding building an expensive submarine cable to the Scottish mainland (the 'conservative' approach), while allowing further connection of distributed wind power (other benefits) to the local distribution grid (Meeus and Saguan, 2011; SSEPD, 2012). Such regulation allows a level playing field to be established for demand response. It is noteworthy that such output-based regulation also implies significant operational challenges for the regulated actors. TSOs/DSOs not only need to verify the technical viability of new flexibility sources, but also need to ensure the coordination and communication with flexibility services providers so that these services are provided timely and with the anticipated quality. It could then be anticipated that the business model as well as the competences of the regulated actors would evolve with such regulation innovation (Ruester et al., 2013b).

4. Summary of policy implications

This paper investigates how to proactively prepare consumers to engage in active demand response as soon as the hardware is in place. To this aim, we adopt a consumer-centred approach, assessing a wide set of costs and benefits that consumers would be exposed to from the perspective of contracts and the counterparty – the demand response intermediaries.

This paper proposes a consumer profiling method that is both useful for the consumers, as well as for the intermediaries, to have an accurate estimation of their potential to participate in active demand response. The profiling consists of two parts: the consumer's technical abilities, on the one hand, and his preferences on high level terms of the contracts, on the other hand. The technical abilities of consumers are related to their load mixes, which represent their appliances and how these appliances are used, with, e.g. TV being perfectly curtailable at one time (re-run of a TV series) but base load at another time (football world cup final) for the same consumer. The willingness of consumers depends on their preferences regarding criteria such as price risk, volume risk, complexity, and loss of autonomy or privacy which are implicitly or explicitly part of the high level terms of a contract. For consumers to be engaged, both their load mix and their preferences must be met by the contract terms.

Our analysis shows that the diversity of contract types is necessary for demand response to be appealing to a variety of consumers. There is a balance to strike between simplicity and tailored contracts. Such a balance can vary depending on the profile of the consumer, which is revealed by the profiling method we propose. Indeed, consumers might still experience difficulties in finding the most appropriate contract among a range of contracts. There is a need to establish tools and mechanisms, such as a price comparison tool, some harmonisation of contract design or data protection measures to further empower consumers in making their deliberate choices.

It is also demonstrated in the paper that a single intermediary might not have the incentive to provide diverse contract types to consumers but would select the ones that are in line with its core business. However, the presence of these intermediary preferences does not mean that regulation should intervene and correct the business incentive of the intermediary. We demonstrate that diverse contract types can be provided through market forces if diversified demand response intermediaries enter the market. Therefore, the regulatory effort should focus on how to ensure adequate competition in demand response. We propose a series of measures that aim, on the one hand, at leveraging the advantages of the (incumbent) players, and on the other hand, at establishing a level playing field for the provision of flexibility services. The first set of measures includes development of a licensing scheme for intermediaries, disaggregated billing, non-discriminatory access to data, and formation of

[12] This output regulation applies to the investments for the purpose of service quality and distributed generation connection, while incentives to reduce energy losses and to improve security of supply/congestion management are still input-based.

independent dispute resolution mechanisms. The second set of measures is related to market rules and regulation: the wholesale energy markets should be gradually opened to demand side bids so that the value of demand response could be monetised if it is a competitive solution; regarding the procurement of flexibility services which are not yet market-based (including congestion management and ancillary services), output-based regulation could allow all flexibility means, including active demand response, to be equally considered.

Finally, the measures we recommend in this paper can benefit from pilot studies and experimental research, which are excellent opportunities to test and improve, e.g. different contract designs, consumer profiling, contract comparison or disaggregated billing. Pilot studies must thus not only focus on technology – as is often the case nowadays, but also include the contracts that are very important to engage consumers. Our analysis shows that without considering the contract, pushing technology is ineffective because it cannot ensure that consumers become active (Ruester et al., 2013a). Results of these studies should also be reported and disseminated in a more structured way than is currently the case, allowing lessons to be learnt through meta-studies of several small- and large-scale projects and fostering the EU wide promotion of benefits for society and individual consumers. We highlight that empowering consumers is also about educating consumers, e.g. in using data from their smart meters or in using the empowerment toolkit in order to have engaged and empowered consumers as soon as the hardware is in place.

References

ADDRESS, 2010. Application of the ADDRESS conceptual architecture in four specific scenarios, http://www.addressfp7.org/config/files/ADD-WP1_ADDRESS_scenarios-v1.0.pdf, last accessed 3 May 2013.

Albadi, M.H., El-Saadany, E.F., 2008. A summary of demand response in electricity markets. Electric Power Systems Research 78 (2008) 1989–1996.

Allcott, H., 2011. Rethinking real-time electricity pricing. Resource and Energy Economics 33 (2011) 820–842.

Article 29 Data Protection Working Party, 2013. Opinion 04/2013 on the Data Protection Impact Assessment Template for Smart Grid and Smart Metering Systems ('DPIA Template') prepared by Expert Group 2 of the Commission's Smart Grid Task Force.

Borenstein, S., 2005. Time-varying retail electricity prices: Theory and practice. James Griffin, Steven Puller, eds. Electricity Deregulation: Where to from Here? University of Chicago Press, Chicago, IL, pp. 317–357.

Bradley, P., Leach, M., Torriti, J., 2013. A review of the costs and benefits of demand response for electricity in the UK. Energy Policy 52: 312–327.

Braithwait, S. and Kirsch, L., 2006. Incentives and Rate Designs for Efficiency and Demand Response. Demand Response Research Center, Lawrence Berkeley National Laboratory. http://drrc.lbl.gov, last accessed 16 April 2013.

Brattle, 2011. Demand Response Review (presentation). http://www.brattle.com, last accessed 16 April 2013.

Cappers, P., Mills, A., Goldman, C., Wiser, R., Eto, J.H., 2012. An assessment of the role mass market demand response could play in contributing to the management of variable generation integration issues. Energy Policy 48: 420-429.

CEER, 2011a. CEER Advice on the take-off of a demand-response electricity market with smart meters. C11-RMF-36-03. http://www.energy-regulators.eu, last accessed 3 June 2013.

CEER, 2011b. Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas. E10-RMF-29-05. http://www.energy-regulators.eu, last accessed 3 June 2013.

CEER, 2012a. Guidelines of Good Practice on Price Comparison Tools. C12-CEM-54-03. http://www.energy-regulators.eu, last accessed 16 April 2013.

CEER, 2012b. CEER Position Paper on the Commission proposal Directive on Consumer ADR, COM(2011) 793. C12-CEM-49-05. http://www.energy-regulators.eu, last accessed 3 June 2013.

CER, 2011. Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report. Commission for Energy Regulation. CER11080a.

Consumer Focus, 2013a. Smart Grids and Consumer Issues position paper - Final draft. http://www.consumerfutures.org.uk, last accessed 23 May 2013.

Consumer Focus, 2013b. Comparing comparison sites – Price comparison website mystery shopping report. http://www.consumerfutures.org.uk, last accessed 23 May 2013.

CRE, 2007. Décision de la Commission de régulation de l'énergie du 5 décembre 2007 relative aux règles transitoires de mise en œuvre des effacements diffus.

CRE, 2010. Délibération de la Commission de régulation de l'énergie du 28 octobre 2010 portant approbation de la prolongation des règles transitoires de mise en œuvre de l'expérimentation relative aux ajustements diffus.

De Jonghe, C., Hobbs, B.F., Belmans, R., 2012. Optimal Generation Mix with Short-Term Demand Response and Wind Penetration. IEEE Transactions on Power Systems 27(2): 830-839.

Delmas, M.A., Fischlein, M., Asensio, O.I., 2013. Information Strategies and Energy Conservation Behavior: A Meta-Analysis of Experimental Studies From 1975 to 2012. UC Center for Energy and Environmental Economics Working Paper Series. E3 WP-061. www.uce3.berkeley.edu, last accessed 23 May 2013.

Dietrich, K., Latorre, J.M., Olmos, L., Ramos, A., 2012. Demand Response in an Isolated System with High Wind Integration. IEEE Transactions on Power Systems 27(1): 20-29.

DOE, 2006. Benefits of demand response in electricity markets and recommendations for achieving them. http://eetd.lbl.gov/ea/ems/reports/congress-1252d.pdf, last accessed 16 April 2013.

Dulleck, U., Kaufmann, S., 2004. Do customer information programs reduce household electricity demand?—the Irish program. Energy Policy 32 (2004) 1025–1032.

Dütschke, E., Paetz, A-G., 2013. Dynamic electricity pricing – Which programs do consumers prefer? Energy Policy, http://dx.doi.org/10.1016/j.enpol.2013.03.025.

EA Technology, 2011. Delivering the Benefits of Smart Appliances. A research report completed for the Department for Environment, Food and Rural Affairs. September 2011. efficient-products.defra.gov.uk/spm/download/document/id/996, last accessed 30 April 2013.

EC, 1995. Directive 95/46/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data.

EC, 2006. Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

EC, 2007a. Communication from the Commission to the Council, the European parliament, the European Economic and Social Committee and the Committee of the Regions: A European Strategic Energy Technology plan (set-plan) – 'Towards a low carbon future'. Brussels, 22.11.2007 COM(2007) 723 final.

EC, 2007b. Communication from the Commission to the Council, the European Parliament and the European Economic and Social Committee: EU Consumer Policy Strategy 2007-2013: Empowering consumers, enhancing their welfare, effectively protecting them. Brussels, 13.03.2007 COM(2007) 99 final.

EC, 2009a. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

EC, 2009b. M/441 EN. Standardisation mandate to CEN, CENELEC and ETSI in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability.

EC, 2009c. Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC.

EC, 2010a. Commission staff working paper: an energy policy for consumers. http://ec.europa.eu/energy/gas_electricity/forum_citizen_energy_en.htm, last accessed 16 April 2013.

EC, 2010b. Document by the services of the Commission: European energy consumer checklist. http://ec.europa.eu/energy/agathe_power/pdf/Energy_Consumers_CheckList.pdf, last accessed on 16 April 2013.

EC, 2010c Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage. Brussels, 26.05.2010 COM(2010) 650 final.

EC, 2010d. Standardisation mandate to CEN, CENELEC and ETSI concerning the charging of electric vehicles. Brussels, 4th June 2010 M/468.

EC, 2011a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Energy Roadmap 2050. COM/2011/0885.

EC, 2011b. European Task Force for the implementation of smart grids into the European internal market - Mission and work programme. http://ec.europa.eu/energy/gas_ electricity/ smartgrids/taskforce_en.htm, last accessed 30 April 2013.

EC, 2011c. Smart Grid Mandate Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment. Brussels 1st March 2011 M/490.

EC, 2012a. Communication from the Commission to the European Parliament, the Council, the European economic and social committee and the committee of the regions: Making the internal market work. Brussels, 15.11.2012 COM(2012) 663 final.

EC, 2012b. Directive 2012/27/EU of the European parliament and of the council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

EC, 2012c. Commission Recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems. 2012/148/EU. OJ L 73/9.

EC, 2012d. Smart metering as a first step towards smart grids (Presentation). London Forum, 13-14 November 2012.

Ecogrid EU, 2011. European FP7 project, http://www.eu-ecogrid.net, last accessed 16 April 2013.

ENTSO-E, 2012a. ENTSO-E Network Code on Capacity Allocation and Congestion Management. 27 September 2012.

ENTSO-E, 2012b. ENTSO-E Network Code on Demand Connection. 21 December 2012.

ENTSO-E, 2012c. Definition of ancillary services. https://www.entsoe.eu/about-entso-e/working-committees/market/balancing-and-ancillary-services-markets, last accessed 23 May 2013.

ENTSO-E, 2013. ENTSO-E Network Code on Electricity Balancing v1.19 (draft 24 April 2013).

ERGEG, 2010. GGP on Customer Complaint Handling, Reporting and Classification. E10-CEM-33-05, 10 June 2010. http://www.energy-regulators.eu, last accessed 16 April 2013.

ETP SmartGrids, 2011. Energy Retailers' Perspective on the Deployment of Smart Grids in Europe. http://www.smartgrids.eu, last accessed 30 April 2013.

ETP SmartGrids, 2012. SmartGrids SRA 2035 Strategic Research Agenda Update of the SmartGrids SRA 2007 for the needs by the year 2035. http://www.smartgrids.eu, last accessed 30 April 2013.

Eurelectric, 2011. Eurelectric views on Demand-Side Participation. http://www.eurelectric.org/media/61240/dsp_report_0810-02_simple_page_final-2011-030-0638-01-e.pdf, last accessed 12 September 2013.

Eurelectric, 2013. Network tariff structure for a smart energy system. Dépôt légal: D/2013/12.105/24. http://www.eurelectric.org, last accessed 30 May 2013.

Faruqui, A., Sergici, S., 2010. Household response to dynamic pricing of electricity: A survey of 15 experiments. Journal of Regulatory Economics 38(2): 193-225.

Faruqui, A., Sergici, S., Shultz, E., 2013. Consistency of Results in Dynamic Pricing Experiments – Toward a Meta Analysis. Proceedings of DistribuTECH Conference, San Diego, CA, January 29, 2013.

Frontier Economics, 2012. Domestic and SME tariff development for the Customer-Led Network Revolution. A report prepared for Northern Powergrid. http://www.networkrevolution.co.uk/industryzone/projectlibrary, last accessed 16 April 2013.

Frontier Economics and Sustainability First, 2012. Demand Side Response in the domestic sector- a literature review of major trials. http://www.frontier-economics.com, last accessed 23 May 2013.

Grünewald, P., Torriti, J., 2012. Demand response—a different form of distributed storage? Proceedings of IEEE International Conference on Smart Grid Technology, Economics and Policies. Nuremberg, 3-4 December 2012.

Grünewald, P., Torriti, J., 2013. Demand response from the non-domestic sector: Early UK experiences and future opportunities. Energy Policy 61, pp. 423-429.

Gyamfia, S., Krumdieck, S., 2012. Scenario analysis of residential demand response at network peak periods. Electric Power Systems Research 93 (2012) 32-38.

Hopper, N., Goldman, C., Bharvirkar, R., Neenan, B., 2006. Customer response to day-ahead market hourly pricing: Choices and performance. Utilities Policy 14 (2): 126-134.

Ivanov, C., Getachew, L., Fenrick, S.A., Vittetoe, B., 2012. Enabling technologies and energy savings: The case of EnergyWise Smart Meter Pilot of Connexus Energy. Utilities Policy, in press, http://dx.doi.org/10.1016/j.jup.2012.10.001.

Lewis, Ph. E., Dromacque, C., Stromback, J., Kennedy, D., 2012. Empower Demand 2: Energy Efficiency through Information and Communication Technology – Best Practice Examples and Guidance. VaasaETT Global Energy Think Tank. http://www.esmig.eu/filestor/Final_Empower%202_Demand_Report_FINAL_Distr2.pdf, last accessed 30 May 2013.

Lijesen, M.G., 2007. The real-time price elasticity of electricity. Energy Economics 29 (2007) 249–258.

Lo Schiavo, L., Delfanti, M., Fumagalli, E., Olivieri, V., 2013. Changing the regulation for regulating the change: Innovation-driven regulatory developments for smart grids, smart metering and e-mobility in Italy. Energy Policy 57, pp. 506-517.

Meeus, L., Saguan, M., 2011. Innovating grid regulation to regulate grid innovation: From the Orkney Isles to Kriegers Flak via Italy. Renewable Energy 36, pp. 1761-1765.

Moura, P.S., de Almeida, A.T., 2010. Multi-objective optimization of a mixed renewable system with demand-side management. Renewable and Sustainable Energy Reviews 14 (2010) 1461–1468.

Ofgem, 2010a. Demand Side Response: A Discussion Paper. Ref: 82/10.

Ofgem, 2010b. RIIO - a new way to regulate energy networks. Factsheet 93 4.10.10.

Ofgem, 2012. Ofgem publishes plans to deliver a simpler, clearer and fairer energy market for consumers. Press Release 19 October 2012.

Ofgem, 2013. Updated household energy bills explained. Factsheet 98 16.01.13.

Olmos L, Ruester S, Liong S-J, Glachant J-M., 2011. Energy efficiency actions related to the rollout of smart meters for small consumers, application to the Austrian system. Energy 2011; 36(7): 4396-409.

Prüggler, N., Bremberger, C., 2011. Grid regulation in Austria: smart grids incentives or disincentives? e & i Elektrotechnik und Informationstechnik. 128 (10), pp. 336-341.

Redpoint Energy, Element Energy, 2012. Electricity System Analysis – future system benefits from selected DSR scenarios (presentation). Prepared for DECC. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48551/5759-electricity-system-analysis--future-system-benefit.pdf, last accessed 16 April 2013.

Ruester, S., von Hirschhausen, C., Marcantonini, C., He, X., Egerer, J., Glachant, J.M., 2012a. EU Involvement in Electricity and Natural Gas Transmission Grid Tarification. Final report of the EU FP7 Funded Research project THINK (Topic n° 6/12: http://think.eui.eu). ISBN: 978-92-9084-076-3.

Ruester, S., Vasconcelos, J., He, X., Chong, E., Glachant, J.M., 2012b. Electricity Storage: How to Facilitate its Deployment and Operation in the EU. Final report of the EU FP7 Funded Research project THINK (Topic n° 8/12: http://think.eui.eu). ISBN: 978-92-9084-087-9.

Ruester, S., Finger, M., Schwenen, S., Lassource, A., Glachant, J.M., 2013a. A New EU Energy Technology Policy towards 2050: Which Way to Go? Final report of the EU FP7 Funded Research project THINK (Topic n° 9/12: http://think.eui.eu). ISBN: 978-92-9084-114-2.

Ruester, S., Pérez-Arriaga, I., Schwenen, S., Batlle, C., Glachant, J.M., 2013b. From distribution networks to smart distribution systems: Rethinking the regulation of European DSOs. Final report of the EU FP7 Funded Research project THINK (Topic n° 12/12: http://think.eui.eu) ISBN: 978-92-9084-144-9.

Smart-A, 2008. Synergy Potential of Smart Appliances. A report prepared as part of the EIE project "Smart domestic Appliances in Sustainable Energy Systems (Smart-A)".

Smart-A, 2009a. Case Studies: Results and Conclusions D6.2 of WP 6 from the Smart-A project - A report prepared as part of the EIE project „Smart Domestic Appliances in Sustainable Energy Systems (Smart-A)".

Smart-A, 2009b. Costs and Benefits of Smart Appliances in Europe. D 7.2 of WP 7 from the Smart-A project - A report prepared as part of the EIE project „Smart Domestic Appliances in Sustainable Energy Systems (Smart-A)".

Smart Grids Task Force, 2013. EG3 First Year Report: Options on handling Smart Grids Data. http://ec.europa.eu/energy/gas_electricity/smartgrids/taskforce_en.htm, last accessed 16 April 2013.

SSEPD, 2012. LCNF Tier 1 Close-Down Report - Orkney Energy Storage Park. SSET1007. http://www.ssepd.co.uk, last accessed 16 April 2013.

Stadler, I., 2008. Power grid balancing of energy systems with high renewable energy penetration by demand response. Utilities Policy 16(2): 90-98.

Stromback, J., Dromaque, C., Yassin, M.Z., 2011. The potential of smart meter enabled programs to increase energy and systems efficiency: a mass pilot comparison. VaasaETT Global Energy Think Tank. http://www.esmig.eu/press/filestor/empower-demand-report.pdf, last accessed 23 May 2013.

Sustainability First, 2012a. Paper 3: What demand side services could household customers offer? April 2012.

Sustainability First, 2012b. Paper 4: What Demand-Side Services Can Provide Value to the Electricity Sector ? June 2012.

Sustainability First, 2012c. Paper 3: What Demand Side Services Could Customers Offer? Industry Electricity Demand. September 2012.

Torriti, J., 2012. Price-based demand side management: Assessing the impacts of time-of-use tariffs on residential electricity demand and peak shifting in Northern Italy. Energy 44 (2012) 576–583.

Vassileva, I., Wallin, F., Dahlquist, E., 2012. Understanding energy consumption behavior for future demand response strategy development. Energy 46 (2012) 94-100.

Wood, G., Newborough, M., 2003. Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design. Energy and Buildings 35(8) 821-841.

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