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Deliverable 5.1

Description of market mechanisms (regulations, economic incentives and contract structures) which enable active demand participation in the power system

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The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 207643

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D5.1

Programme	FP7 – Cooperation / Energy
Grant agreement number	207643
Project acronym	ADDRESS
Type (distribution level)	Public
Date of delivery	31/05/2011
Report number	**D5.1**
Status and Version	Final, V 1.0
Number of pages	115
WP/Task related	WP5 – T5.3
WP/Task responsible	University of Manchester & EDF SA
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Partners contributing	EDF SA, UNIMAN, ABB, Consentec, ENEL Distrib., RLTec, Univ. P. Comillas, Vattenfall, VITO, VTT
Document ID	ADD-WP5-T5.3-DEL-EDF-D5.1-Contracts Markets Regulation for AD
🖫	ADD-WP5-D5.1-Contracts Markets and Regulation for AD 1.0 FINAL 010311.doc

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Executive Summary

Previous activities of the ADDRESS Project have identified numerous potential – technical, socio-economic, regulatory - barriers against the development of Active Demand (AD). In particular, they have pointed out those dealing with contractual, regulatory and market issues. One of the objectives of the project was to analyse these three last categories of barriers in order to recommend solutions that may be appropriate to eliminate them.

The recommendations proposed in this document take into account assumptions defined earlier in the ADDRESS Project. Notably, we kept in mind throughout the survey that:

- the aggregating entity called "**aggregator**" is considered in the ADDRESS project as an archetypal deregulated player: behind this term, he can then be a pure aggregator, an aggregator-retailer or any other type of unregulated player. Nevertheless, additional comments are proposed by the authors when they consider important to distinguish between the situation of a pure aggregator and that of an aggregator-retailer.
- the "**AD consumer"** is defined as the residential active consumer who accepts to offer his flexibility to the aggregator via a contract.
- the "**AD product buyer**" is considered as a regulated or unregulated player buying AD products supplied by the aggregator.

Recommendations for contractual issues

<u>The contract between the aggregator and the AD consumer</u>

The relationships between the aggregator and the AD consumer are decisive for AD acceptance. That is why the contract defining the relationships between an aggregator and an AD consumer must propose the best balance between transparency and clarity to guarantee the protection of the AD consumer, and sufficient flexibility to permit the development of various business models by aggregators.

Hence several groups of contractual aspects can be clustered according to the following main topics and the following classification is proposed (see Table on page 9):

- Necessary clauses for respecting general legal obligations. They are common whatever the type of product / service exchanged;
- ADDRESS necessary clauses proposed in order to respect ADDRESS assumptions or options retained early in the project (payment for monitored energy – decreased or increased - and not for the right to control directly the appliances; comfort settings...);
- Recommended but not mandatory clauses for guaranteeing a good AD relationship (conditions of delivery, use, maintenance and repair of the E-Box when the aggregator provides it...);
- Optional clauses, not considered as necessary, but can permit an increase in flexibility for each aggregator to adapt his contracts to his own AD business model (payment for the E–Box; penalty for limiting excessive overriding in case of a remuneration partly based on monitored capacity...);
- Clauses depending of the aggregator's status: it is pointed out that several clauses could be simplified or totally eliminated in case of an aggregator-retailer (declaration in case of change of retailer, declaration of new power pricing by the retailer). This distinction appears also relevant for the billing issue. In the case of an integrated aggregator-retailer, the integrated bill is recommended, notably when the retailer also proposes dynamic power pricing; in the case of a pure aggregator, separated bills for the AD remuneration and for the power supply appears

unavoidable in a lot of countries.

- Early-stage elements: it is mentioned that the contents of some clauses or elements of the contract can be specific to each aggregator in the early years but could become common to all aggregators as soon as the AD activity is mature (reminders of AD objectives, description of payment, billing...). Such a normalisation in a second period, could be an efficient way to make aggregators' offers more transparent and comparable, and thus permit a more efficient way to inform AD consumers.

<u>The contract between an aggregator and an AD products buyer on the wholesale electricity market</u>

Even if organised markets become more complex and flexible, the trading of products has to respect some rules: different products exist but some standardisation is necessary. For example, CRP markets do not exist and would be very difficult to implement (cf. chapter 3.2.5.3).

The bilateral contract is a way to trade more specific products: products with more specific technical clauses such as a precise location requirement, limits on energy [energy min & energy max] to represent load shifting, Conditional Re-profiling Products (CRP), CRP at a very short notice, CRP with a range of possible values between [Pmin, Pmax] (Pmin may be a negative value where demand increases), etc.

In organised markets, the seller is committed. The product purchased by a player is automatically considered as delivered. The buyer assumes no risk of non-delivery by the seller. Just as other power system players, an aggregator who sells energy in the market is responsible for the provision of this energy. More accurately, depending on the imbalance settlement rules of the country, the aggregator or its Balancing Responsible Party (BRP) is responsible for the provision of the balance on its perimeter (transactions / AD productions). Concerning the risk of non-delivery, the contract can sometimes allow the sharing of responsibility of delivery between the aggregator and the buyer via the addition of a special cancellation clause: this optional clause may detail the way by which the aggregator declares the non-availability of the demand resource to the buyer and the penalties linked to this.

On the other hand, the way to verify and measure the delivery of energy is not part of the contract between the aggregator and the AD buyer but has to be defined by the System Operator (SO) in the "Balancing mechanism and imbalances settlement" rules. For SOs' acceptance, the SO may require some proof of reliability from the aggregators such as a description of the programme, the type of device, the methods of measurement, etc. Even if the product is not bought directly by the SO, the SO may want the demand resource to be certified. For example, without measurement, there is a major risk of lack of credibility and, as a result, AD product could be excluded from power markets. Therefore, the method of measurement chosen is an important aspect of these rules.

Note that where the aggregator and the retailer are the same player, the action of the aggregator on a consumer is automatically integrated into the retailer's consumption perimeter. Therefore, the measurement of consumption is sufficient to verify the imbalances of the retailer.

<u>Functional requirements of a regulated player buying AD</u>

An important point for regulated players is their non-discriminatory obligation: SO must study offers from power plants, decentralised power plants, large demand resources and AD.

Another important point is the reliability of energy delivery. A SO can apply penalties to an aggregator (just as it does to energy producers) if there is a deviation between the energy product delivered and the energy product sold. But a reliable product may be difficult to achieve by the aggregator when the specified area of delivery is very small, in particular when the DSO is the buyer.

Nevertheless, if a grid emergency should occur, just before load shedding, and if there is no other standard solution, the SO could require the aggregator to activate available AD as a “best effort” attempt to resolve the problem. In this case, no penalty is applied and the aggregator can be remunerated for the energy provided as defined in the technical rules.

For CRP product, as in the contract between the aggregator and a deregulated player, some clauses of availability, penalties and pre-activation may be defined in the contract. The clause of pre-activation may oblige the buyer to pre-activate the delivery at a specify date. If he does not, the reserve is released; therefore the aggregator can sell his AD to other players, thus reducing his opportunity loss.

Recommendations for market issues

Recommendations for the market include all types of commercial transactions that take place in order to exchange the ADDRESS services. These include bilateral contracts, calls for tenders and, of course, organised markets.

The document describes the different types of transactions as well as the current situation. It appears that existing market mechanisms are already flexible and complex. In organised wholesale markets we find hourly, block, linked and time flexible bids. For the services that can not be exchanged on such markets, we have calls for tenders and bilateral contracts available. In the current market, only minor changes and adaptations need to be made to the arrangements in order for an aggregator to provide services. The major market obstacle is the minimum size of the products which can be too large for the aggregators to provide, but would be a very minor change in the market organisation. Such changes do not present much technical challenge. They would result however in increased communication and data storage requirements.

We have also envisioned different types of new markets such as local markets, flexibility markets and CRP markets and we have proposed mechanisms along which these could operate.

Local markets

Local markets would help solve problems due to location, typically network problems. On a very large scale local markets are already implemented by the means of market splitting or market coupling mechanisms between countries or regions. When considering local markets at the distribution level, where currently very limited amount of local flexible resources exist, the best way for the DSO to obtain services is to sign bilateral contracts with the providers of such services. If the liquidity increases, calls for tenders become necessary if we wish local actions to be based on market principles. The splitting of national (or international) markets down to distribution levels is probably very complex when compared with the benefits that it could bring. In addition the DSO would be the single service buyer, making that such a local market would end up yielding the same results as a call for tenders.

Flexibility markets

Flexibility markets would be markets designed especially for pooling flexibility capacities. The owners of several resources could set up such a market in order to make offers on other markets. A flexibility market would be needed only if the individual actors cannot participate directly to the other markets. An example of this would be where small aggregators pool their capacities in order to provide balancing services to the TSO.

A flexibility market could be a very simple bilateral contract between aggregators or a complex organised platform. Flexibility markets would however increase the complexity of the system. They should be considered only if the increase in complexity is balanced by the increase in possible revenues.

We would recommend adapting existing markets in order to allow the aggregators to participate rather than integrating this new layer of complexity.

<u>CRP markets</u>

We describe a possible new form of market designed to exchange CRP contracts. This design requires the exchange of standardised volumes, which may be an issue. Moreover the needs for CRP services are often related to network constraints and present a location aspect. It would therefore be very difficult to obtain matches between demands and offers at all levels.

We do not recommend the implementation of a new CRP market. With an increased level of liquidities however a CRP market would allow a better use of the capabilities of flexible resources and such a market could bring in benefits in a far future.

Recommendations for technical validation

We have considered the issue of technical validation and the mechanisms that a DSO should go through if a strain appears on the network where flexible actors are active. We have based our thinking on the current mechanisms to handle network constraints at the transmission level.

For the technical validation of aggregators AD programme, whether the products are sold to regulated or unregulated players, grid operators need to define areas in the distribution (load area) and transmission networks (macro load areas).

Solving a network constraint has a cost. Should this cost be borne by the DSO or by the actor responsible for the excessive strain? In the long term the DSO can rely on its existing consumption and production predictions, associated with other available resources it would have access to in order to decide if it should reinforce its network or contract more CRP capacity through bilateral contracts, calls for tenders or organise a local market. Using AD and CRP contracts could mean that a DSO would work closer to its operational limits and that the actions of a local actor could make it cross that limit.

In this case we have identified several options. The one taken in ADDRESS so far is to allow the DSO to curtail the local resources without knowing economic information behind it or without knowledge on the economic aspects of the flexibility deployment, which possibly results in putting the cost of solving the constraint on the resource operators.

Inspired by some current practices at the transmission level, a market based alternative method has been investigated in which the DSO would be responsible for re-dispatching the curtailed service into another network area. This market based approach could be designed in such a way that the resource provider would not gain from constraining the network on purpose, but at the same time the cost of this re-dispatching network service would be borne by the DSO. This could be an incentive for the DSO to invest in network reinforcement to prevent network constraints being violated on permanent basis (even if other mechanisms to incentive it to invest in network reinforcement can be envisaged). This proposed new solution might be complex in the current situation to implement for the DSO as they are nowadays not prepared for finding resources on other networks. We would therefore not recommend it unless mechanisms are put in place to provide the DSO with an easy access to other flexible resources as it happens in some countries on TSO level.

Remarks on balancing and measurement

When the aggregator and the retailer are two different players and when the aggregator sells AD products on the market, balancing responsibilities have to be defined for protecting their respective activities. A solution is proposed in the document but even if we do not know at this point how to measure the real AD profile, an agreed methodology to estimate/calculate as accurately as possible the AD deviation at the aggregated level has to be investigated. Measurement is crucial for acceptance of AD and shall be investigated. Let us add that such sophisticated solutions are not necessary for an integrated aggregator - retailer.

Recommendations for regulation

A successful deployment of AD requires careful consideration of regulatory issues: both to address possible obstacles placed by existing rules, and to look for ways in which regulation may be used to promote it. This section has reviewed the major connections between AD business models and regulation, and in particular, has specified the topics that need specific regulatory work.

The objective of this section has been to think of all the possible interactions that may arise, classify them, and provide solutions for those issues which are deemed relevant or which require a specific solution. The issues identified as possibly requiring a regulatory approach are:

- Data and infrastructure ownership;
- Cost recovery of fixed costs: validation, measurement, settlement, information on load areas;
- Incentives (permanent or temporary), allocation of costs and benefits;
- Market rules;
- Regulation of distributed generation;
- Relationship between players: particularly regulated ones;
- Issues regarding consumer switching;
- Consumer protection regarding data privacy;
- Consumer protection against excessive costs; and
- Require TSO/DSO to manage their systems efficiently (including allowing for the recovery in fair terms of AD investments and operational expenditure as compared with grid investments)

Some issues, although very relevant, can (and should) be incorporated into existing rules: this is the case of price controls, consumer protection, or fair competition in the non-regulated elements of the AD business models (basically, those dealing with retailers and/or aggregators). The recovery of the costs incurred by regulated players (DSOs and TSOs) to develop AD programs can also be incorporated into the existing regulation for distribution and transmission activities.

Other topics do need to be addressed specifically, and here we provide the major conclusions about what we would recommend.

Regarding data and infrastructure ownership: whatever the entity responsible for mastering data, the data belongs to the consumer, who must transfer its use to the relevant party: the DSO, the aggregator and/or the retailer. When the aggregator and the retailer are different entities, some data must be transferred to both, and some to only one of them, then separate data channels may be required. As for the infrastructure, we propose that metering should be considered a regulated activity, likely in most cases to be attributed to DSOs, while the interface with the consumer will be a non-regulated part, and therefore its ownership does not need to be defined. However, rules must be defined in two aspects: the contractual terms under which the interface is provided by the retailer/aggregator (to protect consumers, and also to facilitate switching), and also the standardization of the interface (again, to facilitate switching). Finally, aggregators will need to send information to retailers and vice versa in order to guarantee fair competition: the regulator shall then 1/ define which data are necessary to be exchanged free of charge between them or 2/ propose they sign an agreement.

A second important element is the correct allocation of the costs and benefits of AD programs: this will require an appropriate regulation of electricity distribution, and sometimes transitional regulations for the generation sector (which may encounter unexpected losses due to the introduction of AD programs).

When AD programs are introduced as variable price schemes, regulation must guarantee a fair competition between non-regulated retailing prices. But regulation must also prevent an unfair competition with the regulated default tariff (when there is one). Therefore, the regulated default tariff should probably be designed as a flat tariff, but high enough, so that there is space for retailers or aggregators to develop different business models. When remuneration for AD is paid separately, this will not be an issue.

The coordination between network system operators (TSOs and DSOs) is another issue that must be considered by regulators. AD actions requested by one of them must be validated by the other, to prevent problems in the grid. This validation will also avoid duplicities (when one retailer/aggregator tries to sell the same product – including conditional offers - to both agents). Grid operators will also need to define areas in the distribution and transmission networks (load areas), so that aggregators will have better information on where to sell their services. The purchase of AD products by grid operators must be subject to a specific procedure, which guarantees its transparency and impartiality (e.g., public auctions).

Finally, the regulation of DSOs' revenues is also an important element for facilitating the penetration of AD: if DSOs are not able to materialize the benefits from purchasing AD, they will not be interested in doing so. The way they may materialize these benefits will depend strongly on the characteristics of the regulatory regime, which is highly country-specific. In case remuneration is based on standard grid models, AD services must not be taken into account when setting up the standard grid model. If revenues are regulated through benchmarking processes, then the incentive for using AD is already incorporated. In incentive-based regulatory regimes that treat capital and operating expenditure separately from each other, it can be more difficult to generate appropriate incentives towards the use of AD services. Such a regime can even produce disincentives. If, for example, capital cost are directly passed through to the tariffs, while operating cost are subject to efficiency factors. Therefore, specific regulation may be required.

Of course, the changes and additions to current regulations will depend largely on the degree of penetration of AD. In the early stages, while AD remains a non-relevant part of the system, coordination between grid operators may not need to be enforced strictly, and AD product purchase mechanisms do not need to be regulated in detail. The same applies to the regulation of distribution activities and the compensation to generators. All the remaining issues (data and infrastructure ownership, validation, and incentives for DSOs) are required from the start. Indeed, jump-starting AD programs may also demand the use of temporary incentives for consumers, DSOs and retailers/aggregators to remove non-economic barriers common in the early stages of every new business model.

The role of regulation is thus critical for the deployment of AD in the European power systems, moreover considering the differences in the existing regulatory regimes, which will require a country-specific adaptation of the basic principles described here. However, care should be taken not to develop a heavy-handed approach, which might be contrary to the market liberalization principles of the European energy sector. An additional recommendation is to take into account the social costs and benefits of AD when making regulatory decisions. The important point is that regulators become aware of potential regulatory barriers against AD in their frameworks, and then seek for solutions that are compatible with their general regulatory approach.

Next steps within ADDRESS

Since the electricity markets and regulation in all EU member states are not exactly the same, the conditions may be different for aggregator business concepts and for implementing AD based services, at least under present circumstances. Consequently, there may be markets where certain alterations to the conclusions and recommendations of this document may become necessary taking into account these markets specific requirements. However, in this document it is not possible to cover all market conditions, business concepts or service variations.

The design of contractual, market and regulatory instruments proposed by this document will have to be also combined with and adapted in accordance to the outputs of the other ADDRESS tasks dealing with a better understanding of players' benefits and costs, motivations and AD acceptance. They will contribute to the social welfare metrics of AD.

Specifications for the development of a market simulator will be able to be partly based on the present outputs. Such a simulator is required by the French field tests.

Table: status of contractual clauses between the aggregator and the AD consumer

	Status necessary recommended or optional	**Content** common or specific to each aggregator
Administrative information (company identity, address…)	necessary	common
Reminders of AD objectives	recommended	specific (in a first step)
E-Box provision and use		
• Aggregator as E-Box provider		
○ delivery, installation, maintenance & repair	recommended	common
○ use of the E-Box by the AD consumer	recommended	common
○ payment for the E-Box provision	optional	specific
• AD consumer as E-Box provider		
○ E-Box compatibility	necessary	common
• Initial E-Box programming	recommended	specific
• Continuous connexion of the E-Box and appliances	recommended	specific
• Comfort settings	necessary	specific
Remuneration		
• Clear description of payment for monitored energy	necessary	specific (in a first step)
• Additional capacity payment	optional	specific
AD response. of the AD consumer		
• *Declaration in case of change of retailer (*)*	*recommended*	*common*
• List of appliances if monitored energy	not recommended	-
• Ability to use the override mode	necessary	common
• Training to ensure an efficient response to the signals	recommended	specific
• Penalty for limiting overriding if only monitored energy	not recommended	specific
• Penalty for limiting overriding if also monitored capacity	optional	specific
• Declaration of new appliances		
○ if only monitored energy	not recommended	-
○ if also other energy services	recommended	specific
• *Declaration of new power pricing by the retailer (*)*	*optional*	*specific*
Duration and cases of premature cancellation		
• Exclusive right	recommended	specific
• Duration of the contract, effective date and expiry date	necessary	specific
• Potential renewal of the contract	optional	specific
• Temporary suspension before the expiry date	recommended	specific
• Total cancellation before the expiry date	necessary	specific
• Definition of the notice whatever the cause	necessary	specific
• Non performance due to *force majeure*	necessary	common
• Reminder of law and arbitration	necessary	common
Signals, data access and confidentiality		
• Confidentiality for private data	necessary	common
• If smart *official* meter, energy data access by aggregator	necessary	specific
• If no smart *official* meter		
○ provision / operation of the additional meter	necessary	specific
○ energy data access by aggregator	necessary	specific
• Energy data sent to AD consumer	recommended	specific
• Signals and other relevant aspects	recommended	specific
Billing		
• Billing and / or regular contact with the AD consumer	recommended	specific (in a first step)

(*) clause not necessary in case of an integrated aggregator-retailer

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List of abbreviations

AD	Active Demand
BOA	Balance Obligation Agreement
BRP	Balance Responsible Party
CAPEX	Capital expenditure
CIPU	Coordination of injection by the production units
CRP	Conditional Re-Profiling
DER	Distributed Energy Resource
DOW	Description of Work
DSO	Distribution System Operator
E-Box	Energy box
LV	Low voltage
µCHP	Micro combined heat and power
MV	Medium voltage
NSO	Network system operator
OPEX	Operating expenses
OTC	Over The Counter
SO	System operator
PJM	Pennsylvania, Jersey, Maryland Power Pool
RPM	Reliability Pricing Model
SRP	Scheduled Re-Profiling
ST	Sub task
TSO	Transmission System Operator
WP	Work Package

1. ADDRESS objectives and introduction to Deliverable D5.1

The present document is the ADDRESS Deliverable D5.1. Before describing the contents of this deliverable and the results obtained in the project, it is useful to remind rapidly what the ADDRESS project is. That's why this first section will successively present:

- a brief overview of ADDRESS project targets and objectives
- a short description of Work Package 5 (WP5) in which Deliverable D5.1 has been produced
- a reminder concerning the Task 5.3 'Contracts, Markets and Regulation"
- a brief introduction to Task 5.3 public Deliverable D5.1 (objectives and structure).

1.1. The ADDRESS project : targets and objectives

ADDRESS ("Active Distribution networks with full integration of Demand and distributed energy RESourceS") is a four-year large-scale Research & Development (R&D) European project launched in June 2008. The project coordinator is ENEL Distribuzione SpA and the consortium consists of 25 partners from 11 European countries spanning the entire electricity supply chain, qualified R&D bodies, small and medium enterprises and manufacturers.

More specifically, the ADDRESS European project aims to deliver a comprehensive technical and commercial framework for the development of Active Demand (AD) in the smart grids of the future.

1.2. Brief description of WP5

Besides the other ADDRESS WPs which are mainly technical, the **WP5 "Acceptance and Benefits for the Users"** proposes a better understanding of the potential acceptance and benefits associated with the deployment of an AD-side to small-scale consumers, DSOs, TSOs, aggregators and selected other players (retailers, BRPs…). It is reasonable to assume that most of potential benefits of all players aside from consumers are mainly economically-driven. For instance, DSOs and TSOs seek to optimise their return on infrastructure investments and operation expenditures given regulated revenue streams.

Consumers, on the other hand, are not pure economic agents since they may be driven also by motivations which are social and cultural (including environmental issues) combining with socio-economic backgrounds.

Knowledge will be developed on the mechanisms through which consumers could be led to engage and accept technical and commercial features proposed by ADDRESS. The understanding of consumers' benefits and of their motivations to participate or not to AD programs will drive to the design of contractual, market and regulatory instruments. These instruments are necessary to modulate their behaviour when seeking to exploit optimally the potential benefits of AD. Moreover, non-economic accompanying measures for helping consumers to engage fully with AD principles and technologies will be proposed to complement monetary incentives. This work will run, in parallel with the field testing specification and implementation in another WP of the project. In order to answer to these challenges, the following tasks are parts of the WP5:

- **Task 5.1 - Potential benefits**: this task proposes a better understanding of players' benefits. Its first step consists of the identification through interviews, classification and assessment of potential benefits (social, economic, environmental…) for the different stakeholders (small consumers, DSOs and aggregators, TSOs, wholesale markets, regulators and governments). Its second step consists of the identification of models to quantify monetary and physical benefits for consumers, DSOs, and generators. These models will later enter the construction of the cost/benefit tool specified in Task 5.4 (see below). Its third step consists of the evaluation of quantitative benefits via the compilation of data for different consumers, distribution networks and power generation systems from the countries involved, and of the evaluation of the benefits of AD for these countries. Finally, these outputs will be compared and validated against the outcome of the field tests. This will result in a final assessment of the benefits to be expected for the different stakeholders from AD management.

- **Task 5.2 - Consumer engagement and acceptance**: its objective is to identify and characterise the mechanisms through which consumers may or may not willingly accept and engage with AD principles and technologies. Based on the results of the stakeholder interviews, a questionnaire survey and an interview study be conducted in the case study areas to explore in greater detail initial consumer expectations from the AD field trials; their current energy consumption practices and attitudes; and the technology suites involved in their current consumption. As such, the pre-trial assessment and the interim assessment would consist of both a qualitative and quantitative assessments, including a diary study which will consist of a number of participants filling in a diary for a period of one week. This approach will complement the assessment in terms of the impact AD technologies and principles can have on people's energy consumption in relation to time, their time management of daily practices and activities, and the daily constraints that might hinder or enable interaction with AD. For many of the field trial participants, the trial will be their first experience of more active interaction with their energy supply and of AD technology. Such a qualitative assessment will allow a more detailed exploration of the participant experiences during the trial than would be possible through the questionnaire alone. At the end of the trial, a post-trial quantitative assessment, with some qualitative element, will follow-up on any issues which emerged from the interim assessment, and assess the interaction between consumers and AD over a long time period. Finally, the requirements concerning the information needed in the consumer's role will be defined.

- **Task 5.4 - Business cases for the ADDRESS concepts**: its first objective is to define specification for a cost-benefit analysis tool. The cost-benefit analysis for the business cases implementing the ADDRESS vision will be based on the e3-value methodology. The main focus of such methodology is the assessment of all economic transactions between the different actors taking part in a business model, in order to provide both the whole picture of such business model and the economic implications for each and every actor. Starting from the AD products identified in D1.1[1], one or several business cases will be selected for the assessment of their costs and benefits. Later, the business model(s) will be applied to the four different locations envisaged in the scenarios described in D1.2[2].

  Then the next step will perform the second stage of the e3-value methodology, i.e. the economic analysis of the business models. For that purpose, a cost-benefit analysis tool will be developed

[1] ADDRESS Deliverable Report D1.1 - Technical and Commercial Conceptual Architectures, Core document – May 2010
[2] ADDRESS Deliverable Report D1.2 - Application of the ADDRESS conceptual architecture in four specific scenarios – May 2010

on the grounds of the specification set up in the first step.

1.3. Presentation of Task 5.3

Price and volume signals as defined by ADDRESS are meaningless unless they can be interpreted by a consumer with complete confidence as part of a contractual agreement with an aggregator. Likewise, market mechanisms and contractual models for trading of *packaged* demand-based services between aggregators, system operators and other players must be clarified. At the same time, the course of the evolution of the regulatory framework must sometimes be altered to foster the development of a more AD-side.

The objective of the **Task 5.3 "Contractual, market and regulatory schemes for Active Demand"** is to propose elements for designing the contractual, market and regulatory instruments: these ones are necessary to allow and to improve the interactions relevant to AD between consumers, aggregators, regulated players and other power system players. Moreover, the instruments will be designed with the objective of optimising benefits of consumers, aggregators, system operators and other players individually as well as for the power system as a whole.

The proposed schemes have to try to favour win-win outcomes between consumers, system operators and aggregators and market-based solutions with minimal regulatory intervention. They must be as simple, predictable and transparent as possible. They focus on:

- contractual regimes of variable complexity between the aggregator and the AD consumer.
- contractual regimes between the aggregator and the AD product buyer (regulated or unregulated).
- formal and informal markets – and their relevant adaptations when necessary - for trading the demand-side products specified in Deliverable D1.1 between aggregators, DSOs, TSOs and other players;
- remaining issues which are not solved by market mechanisms and contractual regimes and then need temporary / permanent regulatory instruments.

1.4. Introduction to Deliverable D5.1

1.4.1. Main objectives

The Deliverable D5.1 – i.e. the present document - is the final document produced by the Task 5.3. Its main objective is to propose options dealing with contracts, market mechanisms and / or regulation permitting to overcome barriers to the AD development.

The document is expected to be self-sufficient and to provide a condensed description of the most important results obtained. It comprises the following sections:

Section 1 gives an rapid overview of the main objectives assigned to the WP5 "Acceptance and Benefits for the Users" and more particularly to the Task 5.3 "Contractual, market and regulatory schemes for AD" which produces the present document. Several assumptions retained in previous ADDRESS documents are reminded.

Section 2 proposes a series of recommendations dealing with the contractual frame defining the relationships between the aggregator and 1/ the AD consumer, 2/ a unregulated player as a AD product buyer and 3/ a regulated player as a AD product buyer.

Section 3 is devoted to the description of market mechanisms – existing or new – with elements able to push and favour the AD development and the place of AD services in these markets.

Section 4 deals with balancing, technical validation and settlement & billing issues and proposes ideas and solutions.

Section 5 then presents what we think to be the minimal regulatory intervention necessary for the AD development as a complement of the market-based propositions.

Section 6 presents conclusions of the document.

Since the electricity markets and regulation in all EU member states are not exactly the same, the conditions for implementing AD based services may be different, at least under present circumstances. Consequently, there may be markets where certain alterations to the conclusions of this document may become necessary taking into account these markets specific requirements. However, in this document it is not possible to cover all market conditions and service variations.

1.4.2. Reminders of key assumptions and inputs from other WPs

It is important to keep in mind assumptions and results from ADDRESS WPs which may have significant impacts on the contractual issues :

1.4.2.1 Inputs from ADDRESS WP2

Real time signals sent by the aggregator to the consumer (to the E-Box)

Concerning volume and price signals, a number of alternatives could be used:

- • Exchange price and volume signals independently
- • Use volume modification signals. In this case, a reference baseline is needed in order to assess the fulfilment of the aggregator's request. The reference baseline could be calculated for each household by the E-Box or the aggregator. The consumption profile associated to the group to which the consumer belongs could also be used for calculating this reference baseline.
- • Use several price signals depending on volume bands or consider a single price for the whole consumption.

In order to simplify, standardise and make transparent the relationship between the aggregator and the consumer, ADDRESS will use only one signal: **combined price / volume signal.** This signal will give an incentive (€ as a function of kW actually consumed) with no reference to the absolute values (no reference based on forecasted consumption is used). This will be the ADDRESS standard message for AD request between aggregators and consumers.

Table 1 from WP2 shows an example of the details of the information sent to the consumer. This information can be very complex (as it is the case in the example) or very simple, considering for example one level of power where the price would be as previously stated in the contract.

Table 1: Details on standardised AD request from aggregator to consumer

Average power demanded (5 minutes period)	Energy Price (*)
Less than 0,6 kW	Incentive of X (€)
0,6 kW ≤ Power < 0,9 kW	Incentive of Y (€)
0,9 kW ≤ Power < 1,2 kW	Incentive of Z (€)
More than 1,2 kW	Incentive of W (€)

(*) These signals can be used as an incentive or discouragement to consumption (positive or negative).

Comment: the adopted price signal aggregator – consumer in ADDRESS, with incentives without baseline is very useful for avoiding reclamations or non efficient behaviour by the consumer. But a real residential load curve is very erratic. Due to the way the consumer's response is assessed (on the consumption and not on the actual reaction to AD signals), the AD consumer might be sometimes remunerated for a consumption considered as responding to AD signal but in fact due to another behaviour: that is why the aggregator's ability to well correlate his AD signals and load profiles is crucial for his activities.

Moreover, if the aggregator sells to the market a deviation of consumption in relation to a reference (or baseline), this deviation has to be measured. This point is not an issue in the contract with the buyer but for the whole ADDRESS project.

Daily report sent by the E-Box to the aggregator

It is assumed that the E-Box will receive periodically metering information. This information is received by the E-Box either from the meter itself if smart enough, or from an additional equipment installed. As a reference on the frequency for receiving this information, it is proposed by WP2 to consider **5 minutes** periods. The E-Box records consumption each 5 minutes and it sends daily reports with the real time consumption to the aggregator.

As recommended by the WP2, for the metering information, it is needed to register consumer profile on **15 minutes** basis so that it will be used for consumer assessment and settlement. This information will be sent by the metering responsible to players that need it like aggregators and retailers.

1.4.2.2 Assumptions and inputs from other WPs

- We must keep in mind throughout the document that **the aggregating entity called "aggregator" is considered in the ADDRESS project as a archetypal deregulated player : behind this term, he can be then a pure aggregator, an aggregator-retailer or any other type of player[3].** Nevertheless, additional comments are proposed each time the authors consider important to distinguish the situation with a pure aggregator from the one with an aggregator-retailer.
- The **AD consumer** is defined as the residential active consumer who accepts to offer his flexibility to the aggregator via a contract.

[3] In Deliverable D1.1 / ADDRESS technical and commercial conceptual architectures (p. 20) : "*For the purpose of ADDRESS, in order to have a clear and more easily understandable view, we consider here "**archetypal" players** with clearly separated roles and functions. However, in "real" life, a given company may have several of the roles as defined in this section*".
See also in 1.1 Appendices / F.1.9. : Considerations when the aggregator is also a retailer

- the **AD product buyer** is considered as a regulated or unregulated player buying AD products proposed by the aggregator.
- Emergency situations are out of the scope of the ADDRESS project and therefore will not be considered in this document.
- There is no direct load control of devices by the aggregator: that is the AD consumer - or his E-Box - who decides to follow or not signals sent by the aggregator.
- The consumer is theoretically not obliged to use an E-Box: the smart appliances could directly react to the price / volume signals sent by the aggregator. But the ADDRESS project only studies the case with an E-Box.
- The aggregator must pay the consumer for the monitored AD actions in order to make possible the use of dynamic pricing. This option is clearly analyzed by ADDRESS. But it could be complement by a payment for the right to control premises.
- The minimum duration of the price and volume signals sent to the energy boxes will be of fifteen minutes with starting intervals at 0´, 15´, 30´ and 45´ possibly in each hour of the day.
- Each consumer is assumed to have a smart meter (or a new additional device). The metering company will inform the aggregator about metered consumer profiles with 15 minutes time intervals (time resolution).
- The aggregator measures the total consumption of the AD consumer's house: it is an easier way than to measure reactions to AD signals. In case of load reduction signal, if consumption is lower than expected, there is a payment to the AD consumer ; if higher than expected, no payment to the AD consumer (see the section below).
- Identifiers of AD consumers are their point of supply code and load area code managed by the DSO. They are useful for local AD products if necessary and also for verifying the AD products provided by the aggregator.
- In the project, we speak about load areas for DSO and macro load areas for TSO.

1.4.2.3 Remarks on European projects concerning the protection of consumers

Relationships between the aggregator and contractual options must be compatible with European rules, and notably with the EC efforts for improving the protection of consumers (and of energy consumers) reinforced since 5th of July 2007 by the document «Towards a European Charter on the Rights of Energy Consumers»[4]. Even if AD is not directly mentioned by these debates, it could be indirectly influenced by them.

- IMCO [5] draft Report on the Consumer Rights Directive currently debated (plenary debates on 25th of February 2011 and 23rd of March 2011), as a result of the project of EC Directive proposed in October 2008 for reinforcing contractual rights of consumers. The Draft Directive aims at establishing an updated, clear and more uniform set of rules concerning consumer rights when purchasing goods and services.
- Conclusions on "An energy policy for Consumers" by the Council of the European Union, 3rd December 2010, which insist on the necessity to provide to all consumers good information,

[4] Key goal : 1/ assist in establishing schemes to help the most vulnerable EU citizens deal with increases in energy price ; 2/ improve the minimum level of information available to citizens to help them choose between suppliers and supply options ; 3/ reduce paperwork when consumers change supplier ; 4/ protect consumers from unfair selling practices. It is particularly mentioned that : "*European consumers of electricity and gas services must have the right to transparent, comparable and enforceable contract structures*" (see appendice B of the Charter for details). Note that the full harmonisation of all consumer rights in the EU is no longer an option retained by the Commission (cf Viviane Reding, 17th March 2010).

[5] Internal Market and Consumer Protection Committee

transparent and easy to understand, guaranteeing confidentiality.

- Recommendations by the London Forum for discussing how to increase the right of energy consumers. For instance, in Sept. 2009, recommendations for improving electricity billing (clear information concerning switching rules…) were proposed.
- Public Consultation Questionnaire concerning the "Harmonised methodology for classifying and reporting consumer complaints and enquiries" (Oct. 2009)…

1.5. Acknowledgment

The following table gives the names and affiliations of the project participants who contributed at different levels to the work leading to the results described in this deliverable. Their contributions are gratefully acknowledged.

Partners	Contributors
ENEL Distribuzione	Valentina Alagna & Marina Lombardi
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The careful and thorough reviews made by Carlos Madina (Tecnalia) and Peter Lang (UK Power Networks) are also gratefully acknowledged. Their comments have significantly contributed to improve the text.

2. Structure of contracts

A contract is a framework that defines a product or service, the conditions of its exchange and the remuneration between the two parties. In terms of the conditions of the exchange, it defines the timing of the exchange, the mode of payment, the potential cases in which it may be annulled, the measures in place in cases of dispute, etc.

This document takes into account the responsibilities of main AD players outlined in other ADDRESS work packages, and discusses types of contracts, in particular:

1. The contract between the aggregator and the AD consumer
2. The contract between the aggregator and a unregulated player as an AD product buyer
3. The contract between the aggregator and a regulated player (DSO or TSO) as an AD product buyer

The different exchanges of information between the aggregator, DSO, TSO and the balancing responsible party of the active consumers are dependent on the regulatory framework (the mechanisms for which are not necessary implemented by the regulator). The same is the case for the AD product measurement. These relationships are imposed on players as obligations included in their supply licences or in their DSO/TSO licences (and not by contractual clauses). They are addressed in Chapters 3 and 5.

2.1. Contract between the aggregator and the AD consumer

In order to enable market rules to operate as effectively as possible, commercial contracts should in theory be as non-normative as possible. In this way, they can offer several options, depending on the strategy of each aggregator[6]. The aggregator can choose among different types of contract. This freedom creates competition between aggregators, notably in relation to their portfolios of AD consumers.

However, as the aggregator is engaged in the mass market, he requires his own contract standards in order to optimise the contract portfolio.

This also means that when the AD contract is signed, it must be adapted to context, taking into account location in terms of grid constraints, regulation, competition, pricing control, market design and so on. As these factors change continuously, the framework of the contract must also be adapted to these evolutions.

Contracts should also encourage customer participation. For instance, the customer must see that the expected reduction in his electricity bill via AD more than compensates for the costs (including the transaction cost induced by the contract itself – negotiation and management of the relationship with the aggregator – and possibly the cost of potential loss of comfort).

On the other hand, it might be necessary to have some contract models in order to guarantee clear information for AD consumers and easier switching between aggregators. In addition, some questions (framework of the contract, data ownership and exchange, etc.) must be standardised. For instance, customers are not used to estimating the impact of the reduction of their heating set-point temperature.

[6] Example: in Florida, the utility FPL proposes to his AD consumers a remuneration depending on the type of control (more or less right to control appliances).

This means that contracts must be as simple and transparent as possible, and provide clear incentives for AD consumers.

2.1.1. Preamble: one or two contracts for AD and power supply?

We can distinguish two situations:

I. In the case of a pure aggregator, the question of a contract combining AD involvement and power supply is not relevant: the aggregator signs a contract with the AD consumer and the supplier signs a contract for supplying power to the consumer. Each of them is held responsible for his own contract.

II. In the case of an aggregator-retailer, two options can be envisaged by the operator depending on his strategy, that is to say a single contract or two separated contracts. Two comments can be added:

   - If he proposes a dynamic pricing for the power supply, a single contract combining AD and power supply might be easier to manage (reduced transaction costs, etc.), since AD signals and dynamic pricing are strongly linked. This scenario involving dynamic pricing is not analysed in detail by the project.
   - Whatever the pricing proposed for the power supply (dynamic pricing or flat tariff), if the aggregator-retailer chooses the single contract, he should ensure that the contract is flexible enough for managing some potential risks due to changing situations during the contractual duration. For instance:
     - the consumer suddenly switches to another power supplier: what does happen for the AD relationships?
     - the aggregator wants to optimise his AD portfolio by removing an AD consumer he deems insufficiently reactive to AD signals: what does happen for the power supply?

2.1.2. First contact, AD pre-contract and AD contract

The aggregator must respect the general rights of consumers, which include a decision based on full knowledge of the facts, whatever the mode of contact (e.g. door-to-door contact; telecontact; contact away from customer premises, for example by attempting to sign up new AD consumers in supermarkets).

At the first contact or visit and before the signature of the contract, the aggregator tries to assess the consumer's potential flexibility by questioning him on his energy behaviour (e.g. smart shiftable appliances; HVAC premises with thermal inertia; power contracted with the retailer and its pricing; electric vehicles, dispatchable generation sources, storage systems; timing of use). The aggregator then tries to assess the potential sensitivity of the AD consumer to price variations (and his ability to react to signals that are: very short [a few minutes]; short [intra-day]; or long [a few months or a year]).

> **Comment**: the first contact could be made via the aggregator's website. However, direct contact with a representative from the aggregator seems preferable, even essential.

If the aggregator is also the retailer, he already knows the customer's load profiles. If not, for more accurate information the customer could either provide metered information on his consumption if available independently or could allow his meter operator (if able to do so) to provide information on the daily load curves of the past year to the aggregator.

The location of the potential AD consumer is also important, in order to harmonise AD products with the local needs of the grid.

Taking into account this information, the aggregator retains the right to refuse a new subscription if the technical profile of the house is inadequate (for example, no appropriate meter, insufficient flexibility due to the existing electrical appliances, etc.).

> **Comment**: The aggregator is not allowed to oblige the customer to buy new smart appliances (if he or she does not have them). This would involve a risk for the customer because it is difficult to assess the benefits deriving from the AD contract and from the renewal of his premises. However, the aggregator could advise the customer to buy a (cheaper) electronic device (for example, a smart thermostat for heating/air-conditioning).

If the aggregator concludes that the AD potential of the customer is adequate, it proposes a contract. At this stage, the future AD consumer must be given the following information:

- Administrative information (company identity, address, phone number, e-mail, etc.)
- Specific/technical information on the AD offer (see details below)
- Possibilities and conditions of premature cancellation; measures in cases of dispute with the aggregator and possibility of amicable settlement, etc.
- Duration of the offer.

If the AD consumer and the aggregator are in agreement, they sign the contract.

2.1.3. Reminders of AD objectives in the contract

The customer's reasons for participating in an AD programme may be various: economic, behavioural, cultural, etc. That is why the overall impacts of AD must be reiterated at the beginning of the contract, even if the information is purely qualitative:

- In the short term: a reduction of the electricity bill for the AD consumer thanks to better information about his consumption complemented by adapted AD remuneration (if there is any);
- In the medium term: a reduction in power system costs due to reduced peak loads, reduced balancing costs, reduced grid constraints and so on, leading to reduced bills for all customers (or at least to an increase of the bills not as much as it would without AD);
- In the long term: a contribution to sustainable development.

At first, in order to foster the development of the aggregator's activities, calculation and presentation of these issues can remain specific to each aggregator. Later, when their activities become mature, they might be standardised in order to facilitate comparison between aggregators' offers and to provide clear information to the AD consumer on these issues.

2.1.4. E-Box ownership and initial programming of the E-Box

Two separate scenarios can be identified:

- **The aggregator is the E-Box provider:** the aggregator provides the E-Box to the consumer in order to optimise his consumption.
  - <u>Clauses and conditions on delivery, installation and maintenance of the E-Box</u> must be specified. The E-Box's software is the responsibility of the aggregator (or of a technical operator contracted by the aggregator). The aggregator is also responsible for ensuring the

technical operation of the E-Box. A phone number for maintenance and advice on utilisation can be given in the contract. In return, the AD consumer agrees to provide the aggregator's representatives with safe and reliable access at reasonable times.

During the period covered by the contract, the aggregator must inform the AD consumer about any important modification of or update to the E-Box or the services it proposes to the AD consumer: in some countries, a major alteration might result in a premature cancellation of the contract by the AD consumer without any compensation (see later, "Duration of the contract").

- Clause on reliability and liability linked to E-Box operation; conditions of repair or replacement of a defective E-Box and conditions of restitution are clearly outlined, notably in cases of premature cancellation (see later).
- Clause on the use on the E-Box by the AD consumer : the AD consumer is not authorised to "touch" the E-Box (to dismantle or tamper, etc.) and is responsible for any damage caused to the E-Box by his own actions or by a third party. He is also responsible for any fraud caused by deliberately dishonest use of the E-Box (including its theft). He must guarantee that the E-Box will be kept in an adapted environment. The AD consumer is obliged to keep the E-Box (i.e. not authorised to loan or sell it, etc.).
- Clause on the total or partial payment for provision of the E-Box must be included in the contract if the business model implemented by the aggregator includes such a payment. However, this clause must remain as open as possible for the aggregator: all options should exist without any standardised clauses in order to enable different aggregator strategies (a freE-Box or the customer to pay X% of the price of the E-Box when signing the contract, with reimbursement if the customer keeps the contract for at least two years, etc.).

- **The aggregator is not the E-Box provider:** in this case, the customer – or a third party – owns the E-Box.
  - Clause stating that the E-Box installed must be compatible with norms/standards;
  - Clause for the replacement of the E-Box: the AD consumer is responsible for the repair and maintenance of the E-Box. Should the AD consumer replace the E-Box, the clause must state that the new E-Box be compatible with relevant standards;
  - In both cases, the aggregator is authorised to verify that the E-Box has a standardised mode of communication, with the possibility of prematurely cancelling the contract (including a fixed fee for recovering the costs of cancellation) if the E-Box is not compatible or it is not used appropriately.

Additional clauses would be needed, whatever the type of E-Box ownership:

- **Commitment on the continuous connection of E-Box and appliances:** the AD consumer gives a firm commitment that his smart devices and E-Box will remain connected. In particular, devices must remain available for the E-Box to monitor except in cases of overriding. Where this commitment is not respected, a premature cancellation could result (see later).
- **Clause on E-Box programming:** whoever its owner, the E-Box must be programmed with the objective of optimising home consumption and managing its flexibility. The contract mentions who programmes the E-Box (aggregator or AD consumer):
  - ➢ Scenario 1: the customer programmes key parameters (pricing, feed-in tariff, etc.). The E-Box interface must be very simple;
  - ➢ Scenario 2: a third party programmes the E-Box;

- Scenario 3: the aggregator programmes the E-Box. The aggregator gathers information during the initial contact/visit about the customer's key parameters in detail (information from the contract with the retailer, including: hourly pricing; power; feed-in tariff in the case of renewables; information about the appliances and devices if they are not plug-and-play, etc.);

- **Clause on comfort settings:** whatever the nature of E-Box ownership, some settings must remain available to the AD consumer. The customer must be able to configure his or her preferences and priorities in relation to comfort level (e.g. maximum/minimum comfort temperature; desired operation time frame), and be able to add or remove appliances, etc. This is configured directly at appliance- or at E-Box-level. For this reason, the E-Box should provide an adapted and easy interface.

Comment: even if this requirement is not included in the contract, the aggregator could be encouraged to give free advice to the AD consumer to ensure optimal understanding and use of the E-Box, devices, etc. Where given, such advice could help prevent ineffective utilisation, thus avoiding inefficient programming of the E-Box and/or a loss of comfort and thus reducing the risk of disappointment and discouragement on the part of the AD consumer. This necessarily entails: the use of appropriate and easy-to-use information technologies; a precise hour of departure/latest hour authorised/minimum set-point of temperature authorised; different choices for the comfort programme (free automatic management, management with comfort, exemption of some devices, etc.); and the impact of each programme on appliances (for example the maximum reduction of heating set-point temperature by 3°C over two hours corresponding to "medium comfort").

2.1.5. Description of the type of remuneration

2.1.5.1 Clause describing clearly the payment for monitored energy (ADDRESS assumption)

The ADDRESS project recommends that payment for monitored energy (decreased or increased) must be offered. The contract must clearly state that remuneration to the AD consumer is based on the price/volume signals described above.

Comment: Where only monitored energy is eligible for payment, if the AD consumer is not called upon, his relationship with the aggregator might not prove very attractive. In addition, there is a management cost for having an AD consumer in the portfolio even if he is not called upon.

The contract could also mention whether the aggregator will be expected to provide a "best endeavour" commitment (the company must provide the means to reach the results) or whether he will be subject to a "performance obligation" (the company must reach the result required by law or by its commitment, with a risk of punitive compensation if the set objectives are not met).

Comment: in the case of a performance obligation for energy services with contractual objectives for reducing the power bill, the aggregator would need to directly control the appliances and devices. This example is beyond the scope of ADDRESS and will not be considered here.

2.1.5.2 Another option for remuneration: capacity pricing vs energy pricing

A system of remuneration combining both fixed and variable parts could also be imagined. If we consider that the AD consumer could also be partially remunerated for monitored capacity and the right to monitor appliances, several types of payment could be envisaged as a complement to the payment for monitored energy:

- €X per year or €X per hour of smart appliances connected. For the aggregator, the advantage of this system is that it would guarantee high response. of AD consumers (dispatchable devices, high acceptance of AD signals, few overriding responses, etc.)
- €Y at subscription plus €Z per year depending on connected appliances
- Free services for the customer, such as detailed breakdown of consumption, information and advice about the possibilities of improving energy consumption and emissions.

If the consumer accepts a signal with very short notice (e.g. <1h or <12h), the aggregator could propose a fixed premium or bonus for this flexibility.

As regards product provision in the market, it can be assumed that demand response would be perceptible at an aggregated level and if those AD products are then communicated to the system operator (by, for example, a BRP), there would be a system for technical validation and control of delivery. We will discuss this issue in Chapter 5.

It would be much more difficult to assess service provision at the lowest level (i.e. a household). Moreover, while respecting transparency and fairness in billing the end customer, it might be difficult to put an accurate mechanism in place without huge demand (and thus costs) for technical equipment and local intelligence.

This problem has, however, been avoided under ADDRESS through the selection of the type of price and volume signals, and hence of rewards, presented in *Table 2*. The following discussion is presented for the sake of covering other possible options.

The possibility of not taking actual changes to the load as a basis for pricing, but rather the volumes that are kept available for use, is a possibility. This approach could be called “capacity-oriented” pricing instead of “energy-oriented” pricing. Capacity-oriented pricing would allow a more straightforward and “easy-to-understand” approach for the end consumer. As long as there is no (unapproved) loss of comfort for the end consumer, he will not be interested in the exact time and volume of use of certain appliances connected to the E-Box. The price offered by the aggregator to a single consumer could then be based on the number, technology and even maybe some of the characteristics of the appliances that are connected to the E-Box. In this case, the end user will still have the power to overrule the requests of the E-Box; limits on this override option could then be agreed upon between the end consumer and aggregator. Assuming that the aggregator is perfectly aware of the general flexibility of his portfolio at any given moment, he could then statistically derive the number of customer to address and the characteristics of the price/volume signals to be sent in order to obtain the requested demand response. Based on the returns in the market, the aggregator could derive the level of remuneration for the capacity made available by its end consumers.

Table 2: Pros and cons for capacity-oriented pricing versus energy-oriented pricing

Pros	***Cons***
Ease of settlement and billing	Potentially more complicated[7] for aggregator to translate market prices to remuneration for the customer
Transparent for end consumer (comparability, billing, expected returns, risk management)	Agreement needed between aggregator and consumer on potential overrule possibilities
Easy for monitoring service provision (connected or not? overruled or not?): total response measured on aggregated level	Limited to the use of AD service itself, no link to increased or decreased energy consumption resulting from AD

Capacity-oriented pricing at market level between aggregator and interested market players could even be considered. However, it should be noted that keeping available capacity and selling this on the market could be subject to misuse. This problem could be countered by agreeing on heavy penalties when the buyer of AD requests the capacity to be activated and the service cannot be delivered (as happens nowadays at transmission level with switchable loads). The problem, however, remains that, if service provision is only monitored on aggregated level with a rather limited level of accuracy, such penalties might be hard to enforce.

> **Comment**: the consumer can pay his electricity via a dynamic pricing offered by his retailer. In the case of a pure aggregator, and whatever the type of remuneration for AD, the system must then guarantee that there is no double remuneration for the AD consumer (remuneration by the aggregator and by the retailer) (see §4.3).

2.1.6. Possible clauses for guaranteeing high AD consumer response

2.1.6.1 Optional clause for limiting overriding

The contract must include the provision that the AD consumer can use the override mode of the E-Box. The question of potential compensation depends on the type of remuneration.

- <u>If there is remuneration for monitored energy only</u>, there is no reason for the contract to mention a penalty for low AD response. (underperforming during an event). The entity in charge of aggregation must develop his own tools for forecasting the behaviour of his AD consumers when price/volume signals are delivered: the AD consumer is paid for his responses to AD signals and the aggregator supports the risks of his business. A clause could nevertheless mention that a too-frequent use of the override button – a use judged not "reasonable" – would provide justification for premature cancellation of the contract by the aggregator without any compensation for the AD consumer. The aggregator could then demand compensation to recover the costs of cancellation. However, the contract must clearly define the meaning of "reasonable use". In order to avoid such situations, the aggregator could verify whether the cases of overriding are intentional or unintentional. In order to avoid such a situation from the beginning, in the contract the aggregator could offer an initial test phase with the AD consumer to ensure that he is ready to respond to AD signals.

[7] Although it should be kept in mind that the use-oriented approach and thus service provision monitoring itself is complicated, as is clear from this report.

- If part of the remuneration combines payment for monitored energy and annual fixed remuneration, especially for monitored capacities, the aggregator can decide to add a fee and then include a clause in the contract explaining its mechanism (what is penalised, frequency of overriding, etc.). For instance, the contract can then define an overriding threshold (overriding freely possible a given number of times in the year). Over this threshold, the AD consumer pays the fee or receives reduced remuneration.

In both cases, such conditions do not appear attractive for the potential AD consumer who may be opposed to this mechanism since it would be difficult for him to forecast the gains generated by the AD contract. Instead of – or alongside – a fee, the aggregator could offer a premium if response over the year is very high. In this case, the annual fixed remuneration should be lower, and the premium for performance would pay for the difference.

2.1.6.2 Clauses on potential changes to the AD consumer's *response.*

The fact that the AD consumer can, on a permanent basis, change his energy behaviour is an element of the business risk taken on by the aggregator: the AD consumer must retain the right to change his behaviour and the aggregator must anticipate this risk. The aggregator is presumed to be able to forecast the behaviour of the AD consumer when price/volume signals are delivered and to verify if he has responded as expected:

- Clause on updated knowledge of the retailer's name: if the aggregator is the retailer, the contract does not need such a clause. If the AD aggregator is not the retailer, relationships between the aggregator and the retailer are more complex. The contract may contain an obligation to the AD consumer to keep the aggregator updated on the name of his retailer throughout the duration of the contract. However, the name of the retailer must not be cited in the contract: if the retailer is named in the contract and the AD consumer switches, the AD contract should be re-signed.
- In the case of an entirely plug-and-play system, no clause on the declaration of new appliances: as assumed by the ADDRESS project, in the future, appliances will be plug-and-play (i.e. automatically recognised by the system – and notably by the E-Box as soon as it is plugged in – with information on power, physic particularities, efficiency, etc.). This also applies to the pricing provided by the retailer, which will be automatically loaded via a dedicated interface. These data will be then instantaneously transferred to the E-Box, which will be then able to reprogram and update itself to provide optimal performance. In this scenario, standards need only guarantee that data will be accurately transferred to relevant parties.
- In the case of manually-typed data, no clause on the declaration of new appliances except with regard to combined payment for both monitored energy and monitored capacities: no current devices and sets are able to communicate with the E-Box and their physical characteristics must be typed in manually.
    - Inclusion in the contract of the list of appliances monitored by the E-Box at the effective date is not recommended: such a description of premises is made by the aggregator at the first visit/contact
    - In the case of payment for monitored energy only, the inclusion of a clause obliging the AD consumer to declare all changes of appliances during the contractual period is not recommended. The aggregator must be able to manage this risk. This is also the case for new usages of electricity. For instance, for the customer who rents his home, the choice of heating is the responsibility of the homeowner. The aggregator has to take into account this change in his business risk and must not penalise the customer. Moreover, with the daily report, the aggregator will be able to detect the new AD consumers' flexibility

  - In the case of combined payment for both monitored energy and monitored capacities guaranteeing more flexibility, the contract should detail the types and the number of devices monitored (heating, water heaters, appliances, etc., as well as small-scale production units like µCHP or local storage), the duration of each switch-off, the duration between each switch-off, the total duration of switch-off during a day or during a defined period, etc. All these values can vary according to the season or to the appliance. The aggregator could also decide to add a clause obliging the AD consumer to declare any change to his devices.
- <u>No clause on the pricing of power by the retailer</u>: should the AD consumer mention any change of his power pricing offered by his retail supplier (or any new feed-in tariffs for renewables) ? This question also relates to E-Box reprogramming. Whoever the actor responsible for reconfiguration (AD consumer, aggregator, third party), the E-Box is assigned to optimise the customer’s consumption by considering in its calculation not only price/volume signals sent by the aggregator and comfort settings, but also – if possible – updated power pricing. But an obligation to declare such a change is not recommended: 1/ The consumer must retain the right to choose any tariff offered by his retailer without difficulty; in other words, the aggregator cannot restrict the customer’s rights. 2/ The AD consumer will modify his energy behaviour in order to take into account the new power pricing in force. It devolves to the risk accepted by the aggregator to detect and manage such a behavioural change in his AD consumers. Note that where an aggregator-retailer is concerned, this risk is lower (and totally disappears if the aggregator-retailer re-programmes the E-Box himself).

  Comment: in the case of a contracted monitored capacity and/or a performance obligation, such a clause could be recommended in order to provide the aggregator with information about any pricing change offered by the retailer.

2.1.7. Clauses on the duration of the contract and possible cases of suspension and premature cancellation

The framework of the contract between the AD consumer and the aggregator must include the following clauses:

2.1.7.1 Clause on exclusive right

The aggregator needs exclusive rights to the flexibility of the AD consumer: that is to say, the AD consumer cannot sign an AD contract with another aggregator over the same period for monitoring the same appliances. It makes no sense for a E-Box to submit a control signal to an appliance where there is a possibility that another device will submit the opposite control signal at the same time.

2.1.7.2 Clause on the duration of the contract and its expiry date

- Participation in the AD programme is based on the effective date. The contract must define the effective date: for example, the day when the aggregator confirms participation by a letter (meaning that he accepts the customer in his portfolio) or the day that the E-Box provided by the aggregator is installed.
- The duration of the contract requires a balance between a sufficient period for the aggregator to recover his costs (i.e. door-to-door contact; estimation of the customer’s flexibility; contract; advice on programming E-Box where relevant; provision, installation and programming of the E-Box where relevant) and a period sufficiently short 1/ to allow the aggregator to re-optimise his portfolio

of AD consumer in relation to changing contexts and 2/ to not restrict possibilities of switching.

This issue should be as free as possible for the aggregator but with a limited duration in order to ensure both market competition and the AD consumer's acceptance (see T5.2). From the customer's point of view, it is not necessary to have a contract that lasts less than one year. From the regulator's point of view, two or three years would seem to be the maximum in order to permit a high rate of switching.

2.1.7.3 Clause for a potential renewal of the contract

There could be a clause to enable an easy renewal of the AD contract at the expiry date, if the two parties are satisfied with their AD relationship.

In order to protect the AD consumer and to permit the renegotiation of some clauses (new information, new services, etc.), a direct contact could be planned for the expiry date.

2.1.7.4 Clause of temporary suspension before the expiry date

Relative contractual flexibility is an interesting possibility. For instance, if the AD consumer carries out renovations to his house for several weeks, he could then disconnect the E-Box. Conversely, should the aggregator need to carry out maintenance on the AD system over a given area, the resulting suspension of activity would make AD response neither possible nor useful.

For this reason, temporary suspension without any compensation should be anticipated in the contract. The party asking for suspension should inform the counterparty as to the reason for and duration of the suspension. The notice period would be defined in the contract (e.g. deadline for the advance notice, for instance one or three months; form of the notification, such as a registered letter). The duration of the suspension can be capped in the contract (for instance, two or three months maximum).

2.1.7.5 Clause of total cancellation before the expiry date

The cancellation clauses must be as fair as possible for both parties. Different situations could justify a premature cancellation: for example, moving house, desire on the part of the aggregator to optimise his portfolio of AD consumers... Several periods can be then distinguished:

- In some countries, a first period ("retraction run") is imposed by national consumer protection laws. In France, such a pull-out clause is imposed for all contracts, whatever the product or service. The customer possesses the right to cancel the contract within seven days of signature, without any compensation to pay.
- A second period ("trial run") during which each party can better test and estimate the expected gain and interest from the AD contract and can then cancel the contract without any fee (for instance one month after the contract comes into force).
- A third period during which each party may cancel the contract, but with a fixed sum to pay as compensation. Both the period and the fixed sum must be mentioned in the contract.
- After this third period, if both parties are in agreement, the cancellation of the contract is possible without any fee. This could pertain in instances where there is a sudden important alteration in the AD consumer's flexibility inducing very low remuneration for the monitored energy and low flexibility for the aggregator.
- The aggregator may change, modify, add or remove portions of the contract at any time. As mentioned above, he can also largely modify/update the E-Box (if he is the provider) and the services it proposes. But whatever the modification, he must then notify the AD consumer of any

such changes (on his website, via e-mail or post). Continuation of the contract requires the agreement of the AD consumer. If the AD consumer does not agree to these modifications, he may request termination of the contract by notifying the aggregator.

In all these cases, the notice period of cancellation must be defined in the contract (deadline for advance notice, for instance three months; form of notification, such as registered letter, etc.).

In each case, if the aggregator owns and provides the E-Box, conditions imposed on the AD consumer to send back the E-Box and all relevant equipment are mentioned and detailed (deadline after the notification of cancellation, possible fee if the deadline is not respected, etc.).

It seems also recommended to add in the contract:

- a clause of non-performance due to *force majeure*
- the reiteration of governing law and arbitration.

2.1.8. Clauses on signals, data access and data confidentiality

2.1.8.1 Clause on confidentiality for private data

Data protection is crucial [8]. The contract must state that the aggregator is obliged to protect private data in line with regulatory obligations.

Proper security measures must be applied (for example, https protocol, data encryption).

The AD consumer must retain the right to direct access to his private data and to correct them if necessary.

The AD consumer also retains the right to forbid any commercial use of his personal data. The national law must be stated (for instance, the French Law 78-17 dated 6 January 1978 on private data confidentiality modified by the Law dated 6 August 2004). Without an explicit agreement on the part of the AD consumer, the aggregator – or any subcontractor involved in his AD activities – is not authorised to sell or provide the AD consumer's name, address, or any other information to any entity except those directly involved in its AD activity (and under the same obligation as for private data).

2.1.8.2 Clause on energy data access

The aggregator is presumed to be able to forecast the behaviour of the AD consumer when price/volume signals are delivered and to verify if the AD consumer has responded as expected. Some of the necessary information falls under the total responsibility of the aggregator (surveys, polls, loads driven by weather conditions, physical or statistical modelling, etc.). Other information is collected by other players, particularly the metering company:

- Metered data:
    - **If the "official" meter** is smart enough, it sends relevant data to the E-Box. Such data are available for the AD consumer via the E-Box interface, notably information about the total consumption used for daily load reports (also necessary to the aggregator for settlement).
    - **If the "official" meter is not smart enough** or can not communicate to the E-Box for another reason, an additional meter is envisaged by ADDRESS for the unique purpose of reporting total home consumption. A clause must then be added in order to set out conditions relating to installation, operation and ownership.

[8] This aspect is decisive. The ERGEG Guidelines of Good Practice for smart metering published on 8 February 2011 affirms data protection as the top priority: "Customer control of metering data: it is always the customer that chooses in which way metering data shall be used and by whom, with the exception of metering data required to fulfil regulated duties and within the national market model."

  - If the aggregator is not the retailer, the AD consumer must also authorise the metering entity to inform the aggregator via the E-Box about customer profiles with relevant time intervals. He might also authorise the meter operator to provide his historical load curves to the aggregator.

- Information sent to the AD consumer: DER equipment and sensors in the house are continuously monitored by the E-Box. The E-Box can therefore provide the customer with information about his consumption/production, status of the DER devices, energy and money saved, etc. With this consumption information and the price/volume signals sent to the E-Box beforehand, the E-Box estimates the remuneration owed to the customer for each AD activation, for each day and for the month. The aggregator can provide information about other AD impacts (prevention of blackouts and brownouts, stabilisation of energy prices, reduction of CO_2 emissions, contribution to a green future, etc.). The contract must describe access conditions to these data (free or not, etc.).

2.1.8.3 Clause describing signals and related aspects

The E-Box is the interface between the AD consumer, his aggregator and appliances. Technical description of signals sent to the E-Box is defined by a technical agreement and/or by regulation, and hence not described by the contract. However, the contract must oblige the aggregator to respect data standards (as a part of the provision of best endeavour).

The description and conditions of delivery for the real-time signals sent to the E-Box must be specified, notably for the combined price/volume signals, as assumed by ADDRESS:

- The frequency of the signals (how many times per day can the aggregator modify his signals?). In order to make the AD signals clear and comprehensible for the AD consumer, the aggregator should limit intraday alterations. If the “official” meter is smart enough, it can provide the E-Box with extremely frequent power information (minute by minute): optimisation by the E-Box is then possible on an hourly, half-hourly, 15 minute basis, etc. Where this is not the case, an additional power meter is necessary;
- The notice (one day ahead, 15 minutes ahead, etc.) and the duration of the aggregator’s signals sent to E-Box (15 minutes);
- In the case of extreme prices and in addition to the usual signals sent to the E-Box, the aggregator can offer the AD consumer additional direct messages (e-mail, SMS, etc.).

2.1.9. Billing

Once the contract is signed, as for electricity/gas supply, it is important that the aggregator keeps in contact with the AD consumer, particularly in the case of a pure aggregator (in the case of an aggregator-retailer, the link with the AD consumer already exists and contact is regular via the electricity bill).

2.1.9.1 Elements to include in the bill

For the reason cited above, the bill, whatever its format (paper bill, e-bill, SMS, etc.), is a regular means of providing AD consumers with relevant information. It could be one of the few opportunities for AD consumers to consider concretely and thoroughly the overall deviation of their consumption patterns and the gains accrued from their AD behaviours. That is why the AD bill must be transparent and comprehensible[9].

However, in the first phase of the project, the billing process must remain flexible (i.e. adapted to each aggregator's business model) and not excessively standardised; this will foster the development of AD and facilitate a fast-growing emergence of aggregator activity. Billing by the aggregator need only respect various key provisions imposed by legislation in terms of information, transparency, clarity and consumer protection.

With regard to AD provided during the billing period, the bill could mention:

- The date and time of AD signals;
- An estimate of the customer's response: the AD consumer's load curves (hour by hour, every 15 minutes, etc.) and the associated price/volume signals;
- Remuneration to the AD consumer resulting from his response to AD signals. Obviously, information must be adapted to the type of remuneration chosen (with penalties if there are too many cases of overriding);
- Taxes and charges, where relevant;
- The short/long-run objectives and interest of AD participation could be clearly outlined in the bill (reduced electricity bill, prevention of blackouts and brownouts, stabilisation of energy prices, contribution to a green energy future, etc.), in order to maintain the AD consumer's motivation.

Where there are too many AD events over the billing period, an e-bill can be offered in place of a paper bill in order to reduce the billing costs. For this, the aggregator must ask for the customer's agreement.

In the second phase, when AD is more mature, comparison of information between bills will be useful in order to facilitate the choice of aggregator by AD consumers (possibly resulting in switching). Such reinforced comparability would also ensure that AD consumers are treated fairly. Standards could cover the billing process, the billing frequency, the form of billing, the presentation of prices, the impacts on CO2 emissions and networks, etc. This evolution will also depend on the types of potential complaint. The role of the regulator will be then important.

2.1.9.2 AD versus power supply: one or two bills?

Once an aggregator provides incentives to a AD consumer, the latter can decide whether or not to respond to the price/volume signals.

If the AD consumer does not respond, there will be no change from the current situation and billing will occur as it does today without AD.

If the AD consumer does respond to the price/volume signals, he will alter his behaviour (directly or indirectly via the E-Box) and thus as a logical result there will be a (potential) change to his energy bill (e.g. shift in consumption from day to night hours or a total energy consumption increase or decrease resulting from the presence or absence of payback effect, etc.).

The billing of the end customer can be carried out via one integrated energy bill for both the energy component (and possibly other components, such as network tariffs or taxes) and the AD component, or it can be kept totally separate, so that the AD consumer receives two separate bills, potentially at

9 This issue also exists for the electricity bill. The Second Citizens' Energy Forum – designed especially to enforce consumer rights in the EU energy market – endorsed a number of recommendations on billing which were developed on the basis of good practices already existing in some EU countries, and which contain a specific list of items to be included in bills. See also "Implementation of EC good practice guidance for billing", ERGEG, 08/09/2010

different times.

Potential structure of an integrated energy and AD bill

If the bill contains both the energy and AD components, it would be logical to separate the energy bill into two, to improve transparency: one part would cover normal energy consumption/production without AD (energy component) and the other would cover the results of AD actions[10] (AD component); see *Table 3*.

Table 3: Simple example of a bill with energy consumption decrease

(Illustrative example not based on expected or realistic values)

Description		Quantity	Price	Total
Energy (energy supplier)		1000 kWh	€0.20/kWh	€200
Active Demand (aggregator)	Increased/decreased electricity consumption	-50 kWh	€0.20/kWh	-€10
	AD remuneration		€30	-€30
Total				€160

The first part would consist of a specific indication of the total (increased/decreased) energy consumption and the resulting total costs/revenues. It is possible that AD actions would cause the total energy consumption to increase and thus also the end customer's total expenditure on energy. As the end customer will be only interested in a positive return on his AD actions (i.e. offered flexibility, which is the second part on the energy bill), this loss of revenue (or additional cost) should be neutralised and even turned into a positive return through remuneration for specific AD actions; see *Table 4*. Otherwise, the end customer would cease to offer flexibility or would choose another aggregator and/or supplier.

Table 4: Simple example of a bill with energy consumption increase and neutralising AD remuneration
(Illustrative example not based on expected or realistic values)

Description		Quantity	Price	Total
Energy (energy supplier)		1000 kWh	€0.20/kWh	€200
Active demand (aggregator)	Increased/decreased electricity consumption	+50 kWh	€0.20/kWh	€10
	AD remuneration		€30	-€30
Total				€180

By presenting the different components of the energy bill in a transparent way, it would still be possible for the end customer to assess the quality and price of the delivery of services by his energy supplier and aggregator, helping him to decide whether it would be in his interest to change his preferred energy supplier and/or aggregator.

[10] Note also that environmental information, or other information of interest to the end consumer, could be shown on the energy bill; however, such matters are beyond the scope of the analysis in this report.

However, we should note that final billing must be based on measured data and the only quantity that can be measured is total consumption. The effect of the aggregator's signals on energy consumption can only be an estimate. If such bills are presented to customers, it should be made clear to them what is actually measured and used for billing and what aspects are for information purposes only.

A second option would be to present only energy and AD components without any indication on the increase/decrease of consumption due to AD actions.

Table 5: Simple example of a bill with energy consumption and neutralising AD remuneration without notification of consumption increase

(Illustrative example not based on expected or realistic values)

Description		***Quantity***	***Price***	***Total***
Energy (energy supplier)		1050 kWh	€0.20/kWh	€210
Active demand (aggregator)	AD remuneration		€30	-€30
Total				€180

A final option for an integrated bill would be to present only energy consumption, with any remuneration or compensation for offering flexibility to the market already incorporated in the final energy price on the bill (e.g. by a percentage reduction on the energy price). This approach is less transparent and should only be taken into consideration when both the retailer and the aggregator for that particular customer are the same actor (see subsection on billing responsibility).

Table 6: Simple example of a bill with energy consumption increase and neutralising AD remuneration without splitting the components

(Illustrative example not based on expected or realistic values)

Description		***Quantity***	***Price***	***Total***
Energy (energy supplier)		1050 kWh	€0.17/kWh	€179
Total				€179

Potential structure of a separate energy and AD bill

Under this quite logical option the retailer will be only responsible for billing the energy component (and perhaps other non-AD related components) and the aggregator for the AD component. The retailer will only show total consumption linked to the energy price, while the aggregator will simply represent remuneration for the AD actions. Any increase/decrease of energy consumption will not be indicated in the energy bill (comparable to *Table 5* and *Table 6*) and remuneration of AD will be totally independent of the energy bill.

Billing responsibility

In the interests of transparency and simplicity, the best billing option might be an integrated method carried out by one entity, e.g. the retailer. In practice, this is likely only to be practical when the aggregator and retailer are the same entity. **Where the retailer and aggregator are different entities, they have different interests and it might be problematic for a customer to be billed by one of those two competing companies** (e.g. the retailer). A major drawback of this approach is that the energy supplier has power over the final billing:[11] where different parties are responsible for energy supply and aggregator activities, the supplier will therefore have insight into the results of the actions of another deregulated market player (the aggregator). Therefore, this approach seems unworkable in practice, meaning that either the retailer and aggregator should be the same market player or separate billing should be implemented.

Separate billing has the advantage of retaining the division between the businesses of deregulated players. However, some major disadvantages can be identified: the aggregator would probably be not aware of the price agreements in force between the AD consumer and energy supplier,[12] with the result that the AD consumer would be obliged to calculate the net effect of energy consumption/production increase/decrease himself or that this, as indicated in the previous section, would simply not be taken into account. In addition, the AD consumer would receive two different bills, probably covering different time periods and sent out at different times. One method of implementing a system of two transparent and separate bills involves another pricing and remuneration method for AD, and is discussed further in this document. However, this system does not take into account changes in energy consumption.

2.2. Contract between the aggregator and a deregulated player as an AD product buyer

2.2.1. The AD product sold by the aggregator on the markets: inputs from ADDRESS Deliverable D1.1

The business of the ADDRESS aggregator is to make a profit by selling power profile modifications in the form of SRP (Scheduled Re-Profiling) and CRP (Conditional Re-Profiling) products to the players interested in them, as defined in D1.1. SRP involves an obligation to provide a specified demand modification (reduction or increase) at a given time to the service buyer, while CRP engages the aggregator to possess the capacity to provide a specified demand modification during a given period when the delivery is called upon by the buyer (similar to a reserve service).

Figure 1 represents a SRP/CRP product. The parameters defining CRP and SRP products are described in Table 7.

[11] Note that this is already the case in some European countries, where one final energy bill is sent by the energy supplier to the end customer. Alongside the price of energy, the bill also includes “cascaded” costs, such as for example transmission and distribution tariffs, taxes and contributions, etc. This, however, only covers regulated activities, which is different to the theoretical case in which two deregulated activities (energy supply and AD) would have to be integrated.

[12] Unless contractually agreed or imposed by regulation. For further discussion on this topic, consult the internal report of subtask 5.3.3.

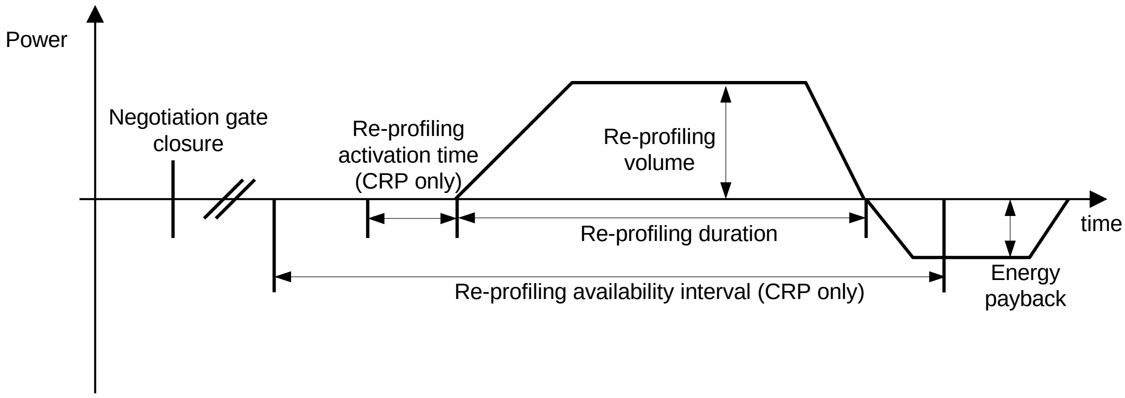

Figure 1 - AD product power delivery template

Table 7: Parameter description for CRP and SRP products

Parameter	Description
Re-profiling volume	The AD product volume or volume range. It may be positive or negative (or even be bidirectional – see above). Instead of a volume an envelope may also be specified (minimum and maximum, MW) to provide upper and lower bounds on the product delivery (i.e. a tolerance between the agreed product volume and the volume delivered)
Energy payback	*Energy payback* is a tolerance specifying an admissible energy payback effect that may occur after the delivery of the AD product. We note that the energy payback tolerance could be an extension of the service delivery envelope. Moreover, if energy payback is explicitly considered in the product delivery, it may happen prior to the "main" product delivery (e.g. by charging thermal or chemical storage) as well as partly before and partly after
Re-profiling duration	The deployment duration associated with the product power shape.
Re-profiling availability interval (T_{ser})	The *re-profiling availability interval* (for CRP only) is the time interval over which the conditional power delivery associated with the product may be called upon by the buyer
Re-profiling activation time (T_{act})	The *re-profiling activation time* (for CRP only) is the time between activation call by the buyer and the effective start of the power delivery by the aggregator

2.2.2. The contract: a means of sharing the responsibilities between the aggregator and the AD product buyer

We should distinguish between organised markets and bilateral contracts:

- In organised markets, the same rules are defined for everybody and no special contract modifies the responsibilities of any player. The product purchased by a player is automatically considered as delivered. The buyer takes on no risk for non-delivery by the aggregator. If the aggregator is not able to provide the AD, the aggregator is held responsible. More accurately, in the energy market, the aggregator or his balancing responsible party is responsible for the provision of the balance on his perimeter (transactions/AD productions). The verification of delivery is not made product by product but on the whole perimeter of the player or the BRP.

- In bilateral contracts, the players can share the responsibility of non-delivery. For example, clauses may be defined in the contract in order to share the risk between the buyer and the aggregator. In such contracts, the aggregator remains the programming responsible (the actor who sends the AD schedule to the SO), but the aggregator may transfer part of the risk of imbalance to the buyer. To do this, the aggregator can declare the unavailability of the demand resource and pay a penalty to the buyer.

Example of optional clauses in the contract which can allow the aggregator and the AD buyer to share some of the risks:

- Cancellation clause and penalties for SRP or CRP contracts
- Pre-activation notice for CRP contracts.

2.2.3. The framework of the contract between an aggregator and a deregulated player

2.2.3.1 General clauses

- Delivery and acceptance
- Remedies for failure to deliver and accept
- Suspension of delivery
- Term and termination rights
- Delivery point: the delivery point may be a market zone, such as for example Belgium or Centro-Nord in Italy, or a more precise location.
- Volume profile, including the allowed payback effect
- Time periods
- Non-performance due to *force majeure: w*here there is a curtailment due to a network incident or load shedding of the aggregator's consumers, the AD product cannot be delivered. Special clauses can be defined if the time before the delivery is very short or if the quasi-totality of AD consumers are affected: in such cases the system operators, and not the aggregator, are held responsible.
- Confidentiality obligations
- Governing law and arbitration

2.2.3.2 Specific clauses for a Scheduled Re-Profiling Product (SRP)

- The date of delivery
- Examples of more specific technical clauses for specific SRP products:
  - An SRP with a more complex profile (Pi at period Ti)
  - An SRP with a parameter for energy (E) and an energy minimum and maximum to represent load shifting (a supply of P1 power during T1 hours beginning at date t1 and then a consumption of P2 power during T2 hours beginning at date t2 with E = P1xT1 - P2xT2)
  - An SRP with a precise location requirement: not necessary a market zone – potentially a precise area in the network.
- Cancellation clause and penalties

The contract can allow the aggregator to transfer its balancing risk to the AD buyer thanks to the addition of a particular cancellation clause. This optional clause may detail:

- A minimum notice period for cancellation
- A practical method of cancelling
- A penalty associated with this cancellation.

<u>Example: French SOs' rules illustrating how to transfer some responsibility from the aggregator to the AD buyer</u>

Assumptions of the example:

- The aggregator and the buyer do not belong to the same BRP
- Every sale between BRPs is declared to RTE (the French TSO).

Declaration to the TSO after the use of the cancellation clause by the aggregator:

Any cancellation of sale by the aggregator is declared to the TSO: the aggregator is no longer held responsible for providing AD and the buyer can no longer include the AD product in his perimeter. Therefore, the buyer must find energy in order to balance his perimeter.

- Invoicing and payment

The payment (in €/MWh) can be invoiced at the signature of the contract or at the date of delivery.

If the contract contains a cancellation clause and the aggregator cancels the sale, the penalty is invoiced at the date of cancellation.

2.2.3.3 Specific clauses for a Conditional Re-Profiling Product (CRP)

- Exercise of the option and deadline:
    - The time period in which the CRP can be activated by the product buyer (Tser), and possibly a period within Tser when the product is unavailable,
    - Notice of delivery (Tact).
- Pre-activation notice

One specificity of CRP is that within the Tser period the AD buyer can activate the product at any time. In order to alleviate this risk for the aggregator, the contract may include a pre-activation notice clause. Under this clause, the buyer would be engaged to inform the aggregator at a specific date whether he intends to exercise the right to activate the product.

For example:

- Date(s) of pre-activation: for example, 25 March 2011 at 10:00 AM, or, for example, every day at 3:00 PM for a possible activation the day after.
- Number of pre-activations authorised during the time period in which the CRP can be activated (typically when this time period is relatively long, for example one month).

When the buyer does not pre-activate the product, the aggregator can decide to use his AD capacity to sell energy on the market, thus reducing his opportunity loss.

- Cancellation clauses and penalties

This optional cancellation clause may allow the aggregator to transfer some of the risk to the AD buyer; for example, the risk of non-delivery and therefore of imbalance with regard to the system operator. In this scenario, and respecting certain conditions defined in the contract, the aggregator can make his product temporarily unavailable or even halt activation of the CRP product.

For example:

- Authorisation for x declarations of non-availability in a year with at least one week's notice. Where there is non-availability with shorter notice, a penalty of €X/MW applies
- In the case of non-availability once the product has been activated by the buyer, a larger penalty of €Y/MW applies (for instance: Y=50% of the CRP price and 100% for the second instance of non-availability)
- Or, there is an obligation to provide the product a certain minimum number of times per year (or during the period of the contract). This is the system chosen by RTE in France for the experimental model with big industry consumers and their aggregators: in order to receive the fixed remuneration for the capacity of demand response, on at least ten occasions each year, at the request of RTE, the industry consumer has to offer a demand response programme for the following day
- A limit on the number of activations authorised for the buyer during the period of the contract.

Once activated by the buyer and declared available by the aggregator, the CRP becomes an SRP, and if there is no additional cancellation clause in the contract, the aggregator is then responsible for providing the product.

On the other hand, if the aggregator fails to deliver the product and declares its unavailability, the aggregator pays a penalty to the buyer as set out in the contract. The buyer may then go to the market to make up the energy shortfall.

- More specific technical clauses for specific CRP products include:
  - CRP at very short notice (<30 minutes)
  - CRP with location requirement
  - CRP with no fixed P value but a range of possible values between [Pmin, Pmax]. Pmin may be a negative value (i.e. where demand increases).
- Invoicing and payment
  - Premium for the availability of energy: the buyer pays the aggregator the premium on or before the premium payment date.

    Part of the payment in €/MW could be invoiced at the signature of the contract and another at the end of the period during which the buyer may activate the product (Tser).
  - Loss of the premium when there are too many cancellations

    When the aggregator declares X non-availabilities, the fixed part of the payment due at the end of the period would not be paid by the buyer. If the aggregator declares Y non-availabilities, the aggregator would have to reimburse the buyer for the first part.
  - Energy payment

    The payment in €/MWh could be invoiced at the activation date or at the date of delivery.

2.2.3.4 Contracts for selling capacity credits (in countries where capacity markets exist)

A capacity market is a market with an obligation on retailers to possess or purchase a certain number of capacity credits. Capacity credits are allocated to generation means that qualify or to proven demand response capabilities. Producers and aggregators can sell these capacity credits to retailers who need them. From a long-term perspective, this scheme serves to ensure that sufficient capacity from generation or demand response is installed to supply the load under one or several representative peak situations.

The capacity market is not linked to the energy market: the buyer of capacity credits does not buy the right to activate the energy.

An aggregator could sign a contract with another player to sell him a volume of capacity credits certified (often certified by the SO) for a given period.

2.2.4. Reliability and measurement of AD to define in the SOs' rules

The SO may require some proof of reliability from the aggregators, such as a description of the programme, the type of device, the methods of measurement, etc. Even if the product is not bought directly by the SO, it may want the demand resource to be certified.

The AD certification method is currently being discussed in France (certification coordinated by the TSO with the participation of the DSO). These rules will be integrated into the “balancing mechanism and imbalances settlement” rules.

Measurement is a key factor in ensuring the TSO's confidence with regard to AD activity. Without measurement, there is a major risk of lack of credibility and, as a result, AD products could be excluded from power markets. Therefore, the method of measurement chosen is an important aspect of these rules.

With regard to other transactions in the electricity market, measurement and verification of the AD energy delivered is an issue for the system operator and not for the AD product buyer. Verification of AD energy delivery relates to the technical rules defined by the SOs and not to the contracts between the aggregator and the AD buyer.

Where the aggregator and the retailer are the same player, the action of the aggregator on a customer is automatically integrated into the retailer's consumption perimeter. Therefore, the measurement of consumption is sufficient to verify the imbalances of the retailer.

2.3. Contract between the aggregator and a regulated player as an AD product buyer

Non-discriminatory obligation is an important issue for regulated players. The SO must study offers from both power plants and decentralised power plants, and AD.

Another important issue is the **reliability of energy delivery.** As for any other generation power plant or large demand resources, the SO can apply penalties with regard to the aggregator, if there is a deviation between the energy product delivered and the energy product that is sold to the SO.

If a grid emergency should occur, just before load shedding and if there is no other standard solution, the system operator could require the aggregator to activate available AD as a “best effort” attempt to resolve the problem. In this case, no penalty is applied and the aggregator can be remunerated for the energy provided, as defined in the technical rules.

For CRP product, as in the contract between the aggregator and a deregulated player, some rules of availability and penalties must be defined in the contract.

2.3.1. The DSO as the AD product buyer

Before the contract, as a first step, the DSO can make an upstream call for tender for AD products in order to attract aggregators in the local area, involving some kind of commitment to buy a given volume of AD products, typically CRP products.

The framework of the contract must include the following clauses:

- Type of AD products (firm or optional, then notice of exercise):
    - SRP
    - CRP
    - CRP, but with a clause to release the reserve a week or a day ahead. This clause could attract aggregators in the local area of the DSO, as the aggregator earns the CRP DSO product and also can sell the SRP on short-term markets thanks to the energy not used by the DSO.
- Volume and other parameters defined in §2.3
- Specified location
- Conditions of delivery: reinforced due to network security issues; however, if the AD is required over a very small area, reliability is difficult to achieve
- Invoicing and payment
- Measurement
- Penalties for failure to deliver (reinforced due to network security issues)

  Since SOs might resort to AD products to cope with network operation constraints violations, the failure (total or partial) of AD products could harm the continuity of supply and power quality, with all resulting implications (e.g. worsening of the rewards/penalties index, etc.). Penalties should be established for the aggregators in cases of delivery failure:
    - The difficulty with distribution network constraints at MV and above all at LV is that network simulation cannot provide adequate statistics because of the low number of active consumers in the load area. So the DSO cannot work with probability of demand response but must have an accurate picture of how much kW will be provided by demand response
    - With the small area size, the aggregator cannot be sure of the accurate volume of demand response provided because the aggregator works with statistics
    - Thus, the DSO and the aggregator could come to an agreement: for securing delivery, the aggregator sells only X% of his potential. If the delivery is less than X, the aggregator is heavily penalised.
- Non-performance due to *force majeure*
- Duration (AD services can allow the deferral of some DSO investments, local congestions, and so on, by limiting/shifting load peak => duration is then important: over one year?)
- Confidentiality obligations
- Governing law and arbitration.

2.3.2. The TSO as the AD product buyer

For network congestion issues, the TSO could buy a CRP product with a clause to release the reserve a day ahead. This clause could attract aggregators in the local area of the TSO as the aggregator earns the CRP TSO product and can also sell an SRP in short-term markets thanks to the energy not used by the TSO.

This could provide a good opportunity for the aggregators to start up. The TSO's local area is greater than the DSO's, improving the potential for AD flexibilities; the aggregator can begin activity with fewer customers than would be required in the energy market, because the remuneration is greater.

The framework of the contract must include the following clauses:

- Type of AD products (firm or optional then notice of exercise)
- Volume and other parameters defined in §2.3
- Specified location if necessary
- Conditions of delivery (reinforced due to network security issues)
- Invoicing and payment
- Measurement and control of the product delivered to the TSO (if the product is a CRP, the TSO can test the availability of the product by activating it as a test)
- Penalties in cases of failure to deliver (reinforced due to network security issues)

  The rules must be similar to those for generators. The player has to deliver the product bought by the TSO and the TSO can apply penalties to the aggregator if there is a deviation

  For CRP, some rules of availability and penalties must be defined in the contract, as they are for deregulated players
- Non-performance due to *force majeure*
- Duration
- Confidentiality obligations
- Governing law and arbitration.

3. Place of AD products in markets

The objective of this section is to give an overview of the current market situation in Europe and to propose solutions, focusing on market based options, to issues that are pending within the ADDRESS project.

The first part describes the existing markets, including basic information about different exchange types. We follow with a review of the ADDRESS services, we assess which existing markets they would fit better in and we give ideas for possible new markets.

3.1. Markets

3.1.1. Existing markets

3.1.1.1 Day-ahead energy markets

We will here describe Elspot, the NordPool day-ahead market. There are some variations in different countries such as the volumes, format and number of bids or the time scale. The principles however are very similar all around Europe.

Every day before noon, all the actors wishing to exchange electricity over the NordPool area (Norway, Sweden, Finland, Estonia and Denmark) send their bids for the next day.

The bids can be either production bids (supply bids) or consumption bids (demand bids). They can be simple hourly bids, block bids, linked block bids or flexible hourly bids. The granularity for the bids' volume is 0,1 MWh.

Hourly bids

Hourly bids are bids for a single hour. The bidder can set up to 62 price steps in addition to a minimum and a maximum price set by Nordpool. An example of an hourly bid is showed hereunder (see Figure 2).

	0	**20**	**20,1**	**22**	**22,1**	**25**	**25,1**	**2000**
10	50	50	0	0	-10	-10	-30	-30

Hour of the day

Volume traded for each price specified above

Figure 2 - Example of an hourly bid on the Elspot market.

In this example, the market participant is willing, during the hour number 10 (between 9 and 10 am), to consume 50MWh of electricity if the market price is under 20 €/MWh or to produce respectively 10 or 30 MWh/h if the price is above 22 or 25 €/MWh.

If the settlement price is not a submitted price step, the volume traded will be set by a linear interpolation of the volumes between the adjacent price steps. In our example, a market price of 22,05 €/MWh would engage the participant to produce 5MWh of electricity during that hour.

Block bid

A block bid covers a block of several consecutive hours with a fixed price and a fixed volume. Block bids are particularly useful in cases when the costs for starting or stopping the power production or consumption is very high. A block bid must be accepted in its entirety. If it is accepted, the participant will be bound for the specified volume at each hour comprised in the block. A block bid is accepted if the bid price of a sales/purchase block is lower/higher that the average market price during the hours to which the bid applies.

Each participant may put up to fifty block bids per delivery day.

The fact that a block bid must be accepted in its entirety is the reason why it is common practise to find block bids that extend over only one period of time. It offers the guarantee of an "all or nothing" situation and protects against a partial acceptance of the bid.

On the other hand some actors (mainly producers) have an agreement with the market operator saying that their block bids can be converted into hourly bids in case of a technical need arising in the network.

Linked block bids

Linked block bids are simple block bids where the acceptance of one block bid (daughter block) is dependent on the acceptance of another block bid (mother block). It is possible to link up to three blocks. The third one is then dependent on the acceptance of both the first and second bid. Linked block bids must be either only sales or purchase blocks and they must be connected to one bidding portfolio in one bidding area.

Flexible hourly bid

A flexible hourly bid has a fixed price and volume, but the hour of the day is not specified. It will be accepted in the hour with the highest price in the calculation if it is higher than the limit set in the bid's specification.

Price calculation

The calculation of the price is made in steps. The first step takes in all the supply and demand bids and puts them together to form the aggregate supply (sale) curve and the aggregate demand (purchase) curve (see Figure 3). Only hourly bids are included in this first calculation. This step is conducted for each hour of the day.

In the second step the flexible hourly bids and the block bids are included[13]. The cheapest sale bids and the most expensive purchase ones are included one by one. If the average clearing price over the bid's duration allows for the block bid to be accepted, it is added to the relevant (sale or purchase) curve and the clearing price is recalculated. The new situation should then be checked. The recalculated price may make it so that the average price over the bid's duration would become such that the block bid should not be accepted anymore. In that case, the block bid is rejected. Linked block bids are evaluated only if the mother bid has been accepted.

[13] This paragraph describes the way block bids are handled in Belpex. The information about the Nord Pool calculations was not readily available.

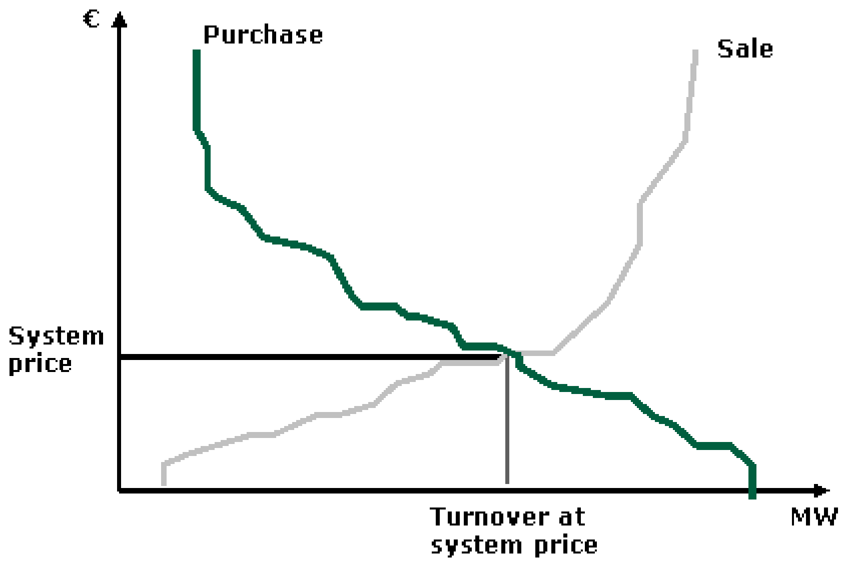

Figure 3 - Determination of the system price based and of the traded volume on the Elspot market.

The third step considers the interconnections between different network areas of the Nordpool market. If the system price leads to overflows over some of the interconnections, the Nordic system is split into two or more areas. The price will be recalculated separately for the different areas including a price independent purchase on the surplus area market and a price independent sale on the deficit area market (see Figure 4). These price independent transactions result in a parallel shifting of the purchase or sale curves and in changes in the market price between the two areas.

Sometimes a congestion is discovered between bidding areas within the already found surplus and/or deficit area. In that case, the procedure is repeated in the same manner.

In NordPool, the system we just described to handle congestions is called "market splitting" where the equilibrium is first calculated neglecting the congestions and then split in case of congestion. Another method is the "market coupling" where the zones susceptible of suffering from congestion are calculated separately and, once the different equilibriums are calculated, the possible flows between markets are calculated by the TSO and taken into account on both sides to recalculate new equilibriums. The NordPool market is coupled with the German spot market.

We should note that the steps two and three require some degree of iteration. It is unclear for us in which order they are evaluated, but it shouldn't impact the results of the algorithms.

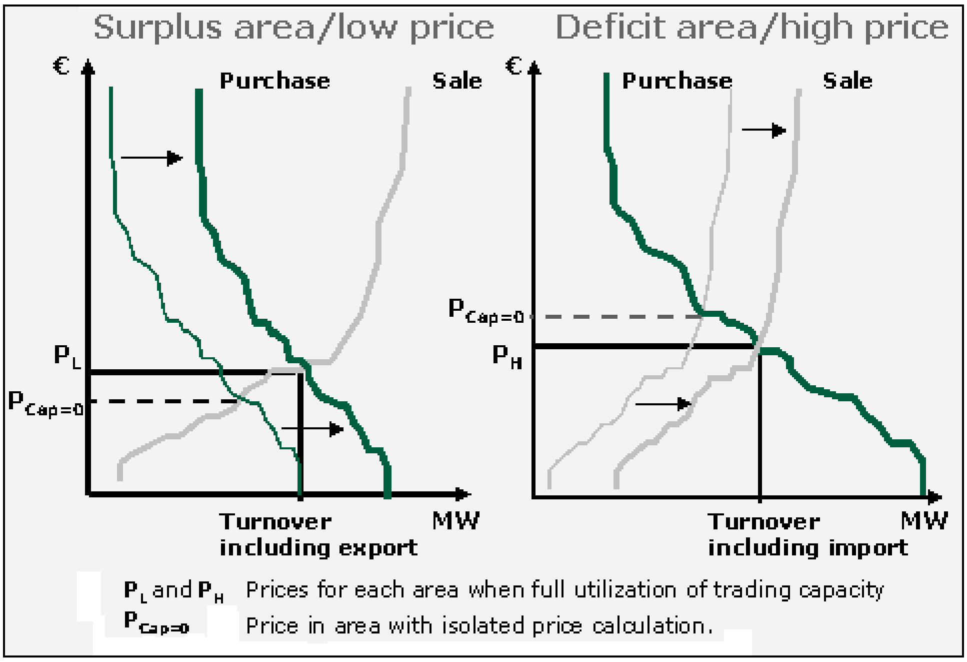

Figure 4 - Illustration of the effect of interconnection trading capacity on the area markets.

3.1.1.2 Intra-day energy markets

Intra-day markets give a chance to the participants to adjust their position between the day-ahead predictions and the time of the delivery, thus allowing them to reduce their imbalances. They usually allow for hourly bids and block bids. In some countries (Spain for example) the intra-day market gate closures happen at a set of different times within the day. In some others, such as in the NordPool area, there is no gate closure, the bids are taken as they come and accepted when possible. There is however always a certain delay between the time the last bids are taken in and the delivery (1 hour in NordPool).

3.1.1.3 Balancing markets

There are differences between the intra-day market positions and the actual energy delivery or consumption. Since electricity is stored with great difficulty and costs, the balance between production and consumption must be kept at each instant. That is the responsibility of the TSO. The TSO purchases balancing services from the balancing market and finances it by charging imbalance fees to the BRPs. The BRPs in turn may charge the costs of their imbalance to the other actors that have a balancing contract with them. More detailed information about the balancing mechanisms can be found in the chapter 4.1.

3.1.1.4 Tertiary reserves

Tertiary reserves are called upon in the process of frequency control to restore the control margins. The TSO has the responsibility of having a determined volume of capacity available at all times. The TSO has to contract tertiary reserves from other actors. In some countries, it can own generators for a part of this capacity, probably under very strict conditions as regards the use of such capacities. It is however not the case in all the EU countries.

3.1.2. Other exchange types

3.1.2.1 Financial over-the-counter energy markets

Over-The-Counter (OTC) energy markets are non-organised markets for derivatives where the underlying good is the price of electricity. Signing these financial contracts allow different agents to hedge the risks associated to price volatility. Several types of derivatives can be traded, such as options, puts, collars, etc. In the end, they all imply a payment from one player to another depending on the physical energy market results. Direct relationships between aggregators and deregulated players through physical bilateral contracts will be dealt with further on.

Aggregators may decide to take part in financial contracts. However, this would not be AD as defined within ADDRESS strictly speaking, i.e. they would not be providing a service to another agent but speculating with the energy price. Therefore, this will not be considered hereafter.

3.1.2.2 Bilateral contracts

Aggregators could sign bilateral contracts, which may be standardised for the sake of simplicity, with the other actors. This addresses possible contracts that aggregators could offer to different deregulated players. The product offered will always consist of AD, either an increase or a decrease in consumption. Nonetheless, according to the needs of each agent, different time scales could be established, SRP or CRP products can be sold, etc. In case a CRP AD product is sold, aggregators should carefully consider, either through their own forecasts or by establishing specific clauses in the contracts, the flexibilities of their portfolio of customers as well as the volume of AD traded in other markets or contracts.

Some of the former contracts ought to be included into existing markets in a similar way as physical bilateral contracts are taken into account in day-ahead markets clearing processes.

Depending on the needs of each deregulated player, a wide variety of AD contracts could be designed. Nevertheless, most probably these contracts could be broadly included in one of the following main categories:

- CRP-2 or a CRP product contracted on a medium to long-term basis and settled before day-ahead markets. Thermal generators or intermittent generators could be interested in a CRP product. They would resort to AD in case they forecast to be shut down or curtailed in next day's energy market due to a high wind production in valley hours. Additionally, retailers could be willing to buy a CRP-2 AD product to compensate for deviations in their long-term contracts. Finally, producers may be willing to purchase AD at the other side of the congestion in order to avoid being constrained off. In these cases, the contracts would be included in the day-ahead market. This process is only possible, or at least it is much simpler, in single-node markets.
- CRP-2 or a CRP product contracted on a medium to long-term basis and settled after day-ahead markets. Retailers could be willing to buy this AD product to compensate for deviations in their energy purchases. Furthermore, other agents (BRPs, production aggregators, generators, etc.) could contract this AD product to hedge their risks in intra-daily markets or to avoid being penalised in the balancing mechanism run by the system operator. Nonetheless, aggregation of production and consumption must be permitted, which is not the case nowadays in several countries. Additionally, if allowed by system operators, some generators could contract AD in order to comply with the obligation to comply tertiary reserves. If the purchasers make use of AD, the system operator and/or the market operator ought to be informed.
- SRP contracted in the short-term (less than a week). A number of players may be

interested in buying AD in a short-term scale for various reasons:

- Large consumers or retailers that see their energy needs modified at short notice may contract AD to reduce their energy purchase costs.
- Production aggregators or generators that due to a contingency are not able to comply with the conditions set in a bilateral contract may resort to AD.
- Any player willing to maximise their profits by shifting electricity consumption may purchase AD products. For instance, generators and production aggregators would be interested in increasing consumption at periods with high market prices, whereas retailers or consumers would rather do the opposite.
- A large producer whose participation in an energy market is systematically constrained due to a congested element may be willing to purchase AD in the other side of the congestion.

3.1.2.3 Call for tenders

Call for bids or call for tenders or invitation to tender is a special procedure for generating competing offers from different bidders looking to obtain an award of business activity in works, supply, or service contracts. They are usually preceded by a pre-qualification questionnaire.

Open tenders, open calls for tenders, or advertised tenders are open to all vendors or contractors who can guarantee performance. Restricted tenders, restricted calls for tenders, or invited tenders are only open to selected prequalified vendors or contractors. This may be a two-stage process, the first stage of which produces a short list of suitable vendors. The reasons for restricted tenders differ in scope and purpose. They are called because:

- There is essentially only one suitable supplier of the services or product
- There are confidentiality issues such as military contracts
- There are reasons for expedience such as emergency situations
- There is a need to weed out tenders who do not have the financial or technical capabilities to fulfil the requirements.

A call for tenders procedure should:

- Allow for the participation of all interested suppliers by issuing an adequate framework;
- Grant equal treatment to all source of supply, unless the call for tenders provides for all or part of the needs to be met, for a particular course of supply, with a block of energy determined by regulation;
- Favour the awarding of contracts on the basis of the lowest price for the conditions and services required;
- Specify if a bid can be partially accepted to fulfil the exact need.

The call for tenders and contact award procedure for contracts generally comprises following four steps:

1. Issuing the call: The call should contain all the information required for potential service suppliers to submit a bid. It should include a statement on the purpose of the call for tenders, a description of the product or services requested, the delivery period instructions to the bidders including the process schedule and bid forms. It also includes a description of the monetary criteria taken into account the bid evaluation process.

2. Bid submission: Bid must be submitted before the deadline in the form specified in the call.
3. Bid selection: Accepted bids are selected based on the criteria defined in the call.
4. Transaction confirmation: the issuer of the call contacts the accepted bidders to sign a transaction confirmation.

3.1.3. Particular mechanisms for managing network constraints

3.1.3.1 Market coupling and market splitting

By market coupling, purchase bids in one country are matched up with sales bids in another country (Figure 5). The purchase/sales bids made in both countries are pooled and then matched up by financial merit order. This way, less expensive energy produced in one country (in this case market A) can be used to meet high demand in another country (in this case market B). This can only be done when both countries are physically interconnected and within the limits of the interconnection capacity.

If there are no cross-border capacity constraints, the market coupling mechanism would result in a single price for all countries involved in the market coupling and thus improve energy market liquidity.

In the example of Figure 5, market A is supposed to have an excess of cheap electricity and a certain available amount of interconnection capacity, resulting in a shift of the purchase curve in market A and sales curve in market B. The end result is prices that are converging. In case there are no interconnection capacity constraints, prices will be equal. The difference between the two options is the starting point. Market splitting starts with the global equilibrium solution and splits towards the regional markets situation. Market coupling starts with regional equilibrium solutions and organizes exchanges between them in order to go towards the global solution.

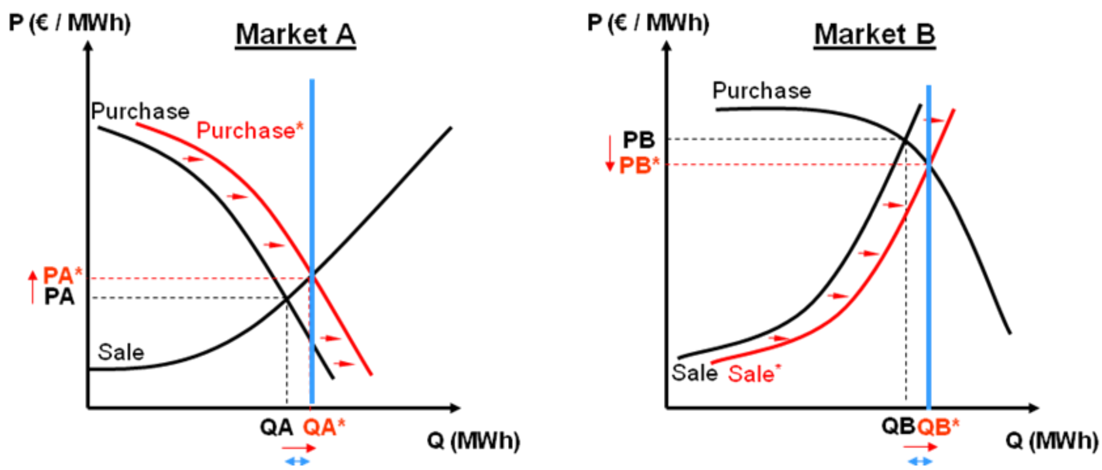

Figure 5 - Market coupling example (source Belpex)

Market splitting and market coupling are two variations of what is called implicit auctions. Implicit stands for the fact the interconnection limitations are taken into account implicitly in the markets clearing and is opposed to explicit auctions as described below.

When market splitting is used, the implicit auction is performed within the day-ahead electricity auction by one single power exchange. Market splitting is a simplification of nodal pricing and the transmission capacity is handled implicitly in the price and bid calculation performed at the power exchange. At times when the transmission capacity is not sufficient to get price convergence, there will be different prices in different bidding areas.

When market coupling is used, the implicit auction is organized through cooperation between two or more power exchanges. The different power exchanges submit information about their market to a central coupling algorithm and the TSOs submit the available transmission capacities between the market areas. The central coupling algorithm then calculates the flows between and prices in all market areas. The flows between are al least used by the different power exchanges, but it is also possible for the local market to use the prices and bid results from the central calculation.

It does not need to be any difference in calculation algorithms or principals used for market coupling and market splitting (Nord pool, 2010). The difference lies in how the algorithm is operated and owned, and also which results from the central calculation that the local market in the end will use.

Nord Pool for example uses a market splitting mechanism to manage the interconnections between its own regions, but uses market coupling mechanisms with countries outside of its region, such as Germany for instance.

3.1.3.2 Explicit auctions for transmission capacities

In an explicit auction setting, the TSO starts by determining the net transfer capacity. Energy and transmission capacity is traded separately and the market participants decide how much capacity they request and how much they are willing to pay for it. All the bids are sorted and allocated with the highest bid first until the net transfer capacity is fully utilised. All the participants pay the transmission capacity price given by the “transmission market”. One important assumption is that the market is characterised by perfect competition. This method provides the market participants with the appropriate economic signals for the operation and the value of the transmission network. Common features of explicit auctions include:

- A uniform transmission capacity price design, where all market participants pay the same price or a pay-as-bid design where all the participants pay the price that they have bid.
- A joint coordinated mechanisms between the TSO’s that are involved in the auction.
- The possibility to trade capacity products with different duration (year, month or day).

In the Nordic countries, the interactions are traded entirely based on implicit auctions. In Central Western Europe (CWE) the basic mechanisms is one of explicit auctions with a minimum capacity, for example between countries, being reserved for implicit auction via a market coupling system. Both auction types can thus coexist.

3.2. AD services and market organisation

3.2.1. Introduction

This chapter contains proposals and considerations with respect to a market organisation for AD services. Starting points are the following:

- Deregulated market players, whether they are generators or consumers, should be treated without any difference with respect to their general obligations and rights when participating in different markets.
- Networks and their operation are considered to be aiming at supporting and allowing as much transactions as possible at the lowest possible social cost in order to increase social welfare (e.g. increasing share of renewable energy resources, reliability and security of supply etc.).

Points that will be treated in this chapter are:

- a brief discussion on the nature of markets
- different time windows for different markets
- proposed links between the AD services and potential market places
- a discussion on the (potential) locational aspects of AD
- some specific considerations on the curtailing and/or re-dispatching requested AD actions by the system operator.

3.2.2. Nature of markets

An extensive description of existing market places and their specifications was done in the chapter 3.1.1.

Based on those markets, one could identify four different types of (potential) markets for trading services for the power system:

1. Energy markets
2. Reserve markets
3. Capacity markets
4. Flexibility markets

The first three types of markets can be considered as rather "known" as those types could be easily identified in current market organisations for the power system. The last type of market could be considered as rather new, although also in current markets some kind of flexibility could be already integrated implicitly into one of the two first markets. A few words of explanation on each type of markets are given in the subsections below. It should be noted that current markets not necessarily strictly belong to only one type of the aforementioned possibilities (*depending on the interpretation/definition)*.

3.2.2.1 Energy markets

Energy markets refer to on the one hand power exchanges in which amounts of energy are traded anonymously for specific periods of time but on the other hand also to any market platform in which energy is exchanged, e.g. bilateral agreements in which energy exchanges are agreed and contracted: a certain agreed price is paid for the agreed amount of energy. Those types of markets and some specifications are described in chapter 3.1.1.

3.2.2.2 Reserve markets

Reserve markets refer to existing markets in which capacity is kept available for short term actions (roughly within maximum half an hour). An example is the market for tertiary reserves, as contracted by TSOs nowadays. Reserve markets are thus markets in which the agreement consists of promising to keep a certain capacity available during an agreed contractual time period. That capacity can be called upon to at any moment during that contractual time period and should be activated on request by the buyer and according to certain requirements agreed during the contract negotiation (e.g. activation time). The remuneration can consist of a capacity fee (for keeping available the capacity) and/or an activation fee.

3.2.2.3 Capacity markets

Capacity markets refer to markets existing in some countries. Their objective is to guarantee the medium to long-term adequacy of production and consumption. Producers receive capacity credits according to their maximum production and retailers must buy enough of those credits to obtain a capacity sufficient to supply their consumers in some determined situation such as a consumption peak or some percentage over it. There is no direct link with the energy markets as the buyer of capacity credits does not buy a right to activate the energy. The purpose of the capacity markets is only to guarantee that the production will be sufficient for the consumption, it doesn't involve any actual exchange of energy.

The integration of the flexibility in the capacity market would require additional activities. For instance, the AD potential of an aggregator could be certified. Then the aggregator could sell these capacity credits into the capacity market. This could be an additional resource for the aggregator. There is no real barrier to integrate AD into this market provided that the potential and the AD delivered is well estimated and verified.

3.2.2.4 Flexibility markets

Those types of markets can be considered as the potential “new” markets for AD to trade flexibility in general or AD services (consisting of AD products) in particular.

Flexibility markets could be a step allowing small flexibility and small aggregators to form products large enough to act on the energy or reserve markets. The basic idea is to have a market where owners of flexible power (aggregators, owners of small or maybe larger flexible DG…) could pool their resources to build together products that could be bought by other actors or sold on other markets. We propose an example of a flexibility market in 3.2.5.2.

3.2.3. Different time windows for different markets

Not only the nature of the markets and thus the related intended kind of products or services will determine the market design. The timeframe or time window is a second crucial factor.

Apart from the long-term markets on which futures and forwards can be traded, the most commonly used timeframes are day ahead, intraday and (near) real-time:

- Day ahead markets typically concern transactions of services/products for which the need is known in advance and for which the delivery can be scheduled (one day) in advance. Services for portfolio optimisation or to fulfil expected system needs in advance are the most suitable to be traded day ahead while there is still time for technical validation.
- Intraday markets have been introduced to give the opportunity to further fine tune positions of market players in a shorter time period before delivery (in some countries even 5 minutes). They are mainly used to deal with unexpected changes (incorrect wind or solar prediction, unexpected maintenance...).
- Real-time or near real-time is a relative notion: in the ADDRESS project, real time has been defined as 15-20 minutes ahead although for some services in existing markets, real time mostly means within 15-30 seconds up till maximum 15 minutes. This is particularly the case for some reserve markets (primary and secondary reserves for balancing the system). From this perspective, only the existing tertiary reserve market, which includes for instance switchable industrial loads, could be a potential target for AD services. It should be noted that this type of market is currently often intended for power system support, i.e. to stabilise or balance the power system. Therefore, high requirements are imposed on the delivery within these types of markets.

As the time for technical validation is virtually non-existing, it will be tough to use AD offered by a group of aggregated single consumers while still guaranteeing the exact delivery of the product.

3.2.4. ADDRESS services in the existing market places

In *Table 8*, a list of services which can be offered by an aggregator was extracted from the work done in work packages 1 and 2. Table 8 lists them as originally found in the ADDRESS Deliverable D1.1.

In a second stage, the lists was re-ordered by identifying the underlying cluster of services, timeframe and locality of the service as can be found in Table 9.

Table 8: Summary of AD services & products for different players and their classification based on time scale and products

REGULATED PLAYERS			
Principle service	**Buyer**	**Response time scale or type of service**	**Type of AD product**
Scheduled Re-Profiling Load Reduction	DSO/TSO	Slow	**SRP**
Scheduled Re-Profiling for Voltage Regulation and Power Flow Control			
Scheduled Re-Profiling Load Reduction	DSO/TSO	Fast	
Conditional Re-Profiling Load Reduction	DSO/TSO	Fast	**CRP**
Conditional Re-Profiling for Voltage Regulation and Power Flow			
Bi-directional Conditional Re-Profiling for Tertiary Reserve (TSO)	TSO	Slow	**CRP-2**
Bi-directional Conditional Re-Profiling for Tertiary Reserve (TSO)	TSO	Fast	
DEREGULATED PLAYERS			
Short-term load shaping in order to optimise purchases and sales	Retailer	Long	**SRP**
Load shaping in order to optimise its economic profits	Decentralised electricity producer		
Short-term optimisation through load shaping in order to optimise the operation of its generation portfolio. This may involve attempting to avoid forced generating unit shutdowns in valley periods or avoiding having to turn on expensive and dirty peaking units in high demand periods	Centralised producer		
Minimisation of energy procurement costs	BRP		
Short-term optimisation of purchases and sales by load shaping	Traders and brokers		
Management of energy imbalance in order to minimise deviations from declared consumption programme and reduce imbalance costs	Retailer	Balancing services	

Management of energy imbalance in order to reduce imbalance costs	Centralised producer		
Short-term management of energy imbalance in order to minimise deviations from declared production programme in the case of low uncertainty	Decentralised electricity producer		
Management of energy imbalance in the case of low uncertainty	BRP		
Tertiary reserve provision in order to meet contracted tertiary reserve programme	Decentralised electricity producer	Tertiary reserve services	
Short-term local load increase in order to compensate the effect of network evacuation limitations and to be able to produce more	Producers with regulated tariffs	Local management	
Short-term load increase in order to avoid being cut-off (for example in valley hours)	producers with regulated tariffs	Other	
Reserve capacity to manage short-term risks, e.g., to mitigate the effect of large wholesale prices in period of high demand	Retailer	Long	**CRP**
Short-term optimisation of purchases and sales through reserve capacity	Traders and brokers		
Reserve capacity to short-term management energy imbalance but the DP knows the direction of the imbalance probably because the time to the forecasted imbalance is shorter in the case of medium uncertainty	Decentralised electricity producer	Balancing services	
Management of energy imbalance in the case of medium uncertainty	BRP		
Tertiary reserve provision in order to meet obligation of tertiary reserve provision contracted with the TSO	Centralised producer	Tertiary reserve services	
Reserve capacity to manage provision of contracted tertiary reserve in the case of medium uncertainty	Decentralised electricity producer		
Local load increase reserve in order to compensate the effect of network evacuation limitations and to be able to produce more or to invest more in generation capacity	Producers with regulated tariffs	Local management	
Load increase reserve in order to avoid being partially cut off, or even to be authorized to invest more	Producers with regulated tariffs	Other	
Reserve capacity to short-term management energy imbalance in order to minimise deviations from declared production programme in the case of high uncertainty	Decentralised electricity producer	Balancing services	**CRP-2**
Reserve capacity to manage energy imbalance in order to minimise deviations from the production program previously declared and reduce the imbalance costs	Producers with regulated tariffs		
Management of energy imbalance in the case of high uncertainty	BRP		

Reserve capacity to manage provision of contracted tertiary reserve in the case of medium uncertainty	Decentralised electricity producer		

Table 9: List of services sorted by service type.

Service	Regulated	Buyer	Response time scale	Product	Local
Balancing	D	BRP	Hours to minutes	**CRP**	N
Balancing	D	Producer (decentralised)	Hours to minutes	**CRP**	N
Balancing	D	Producer (decentralised)	Hours to minutes	**CRP-2**	N
Balancing	~	Producer (reg. Tariff)	Hours to minutes	**CRP-2**	N
Balancing	D	BRP	Hours to minutes	**CRP-2**	N
Balancing	D	Retailer	Hours to minutes	**SRP**	N
Balancing	D	Producer (centralised)	Hours to minutes	**SRP**	N
Balancing	D	Producer (decentralised)	Hours to minutes	**SRP**	N
Balancing	D	BRP	Hours to minutes	**SRP**	N
Congestion management	R	DSO	Minutes	**CRP**	Y
Congestion management	R	TSO	Minutes	**CRP**	Y
Congestion management	~	Producer (reg. Tariff)	Hours to minutes	**CRP**	Y
Congestion management	R	DSO	Hours	**SRP**	Y
Congestion management	R	TSO	Hours	**SRP**	Y
Congestion management	R	DSO	Minutes	**SRP**	Y
Congestion management	R	TSO	Minutes	**SRP**	Y
Congestion management	~	Producer (reg. Tariff)	Hours to minutes	**SRP**	Y
Tertiary Reserve (TSO)	R	TSO	Hours	**CRP-2**	N
Tertiary Reserve (TSO)	R	TSO	Minutes	**CRP-2**	N
Tertiary reserve provision	D	Producer (centralised)	Hours to minutes	**CRP**	N
Tertiary reserve provision	D	Producer (decentralised)	Hours to minutes	**CRP**	N
Tertiary reserve provision	D	Producer (decentralised)	Hours to minutes	**CRP-2**	N
Tertiary reserve provision	D	Producer (decentralised)	Hours to minutes	**SRP**	N
Wholesale market optimisation	D	Retailer	Hours	**CRP**	N
Wholesale market optimisation	D	Trader	Hours	**CRP**	N
Wholesale market optimisation	D	Retailer	Day	**SRP**	N
Wholesale market optimisation	D	Producer (decentralised)	Day	**SRP**	N
Wholesale market optimisation	D	Producer (centralised)	Day	**SRP**	N
Wholesale market optimisation	D	Trader	Day	**SRP**	N
Wholesale market optimisation	D	Large consumer	Day	**SRP**	N
Voltage Regulation and Power Flow	R	DSO	Minutes	**CRP**	Y
Voltage Regulation and Power Flow	R	TSO	Minutes	**CRP**	Y

3.2.4.1 AD in wholesale markets

The aggregator can offer services to the deregulated actors so that they can optimise their operations on the day-ahead and intra-day markets. If the market functions well, the aggregator should be able to receive more benefits from acting on the markets directly. Selling the services to other actors should probably be considered only if the aggregator doesn't have access to the market. A service that could be traded on an existing market, but which is not would bring inefficiencies and inequalities in the system.

Cases where the aggregator doesn't have access to wholesale markets[14]:

- the aggregator is not able to provide the minimum tradable volume
- the costs to access the market are too high for the aggregator's business
- the aggregator hasn't placed a bid on the day-ahead market and is thus forbidden to place one on the intra-day market (need for a regulatory change?)

An aggregator trading on a wholesale market will be faced with a pay-back issue (see Figure 6 of the ADDRESS Deliverable D1.1). He can take it into account by forecasting the prices in advance or by using some other flexibility to negate an adverse pay-back effect cost.

There are block bid possibilities on the wholesale markets. A block bid is accepted only if the average price over a time span of several periods is over the bid price. Block bids nowadays must go in the same direction (production or consumption) during the whole bid period. **We could imagine block bids taking into accounts the pay-back effect.** To make it best suited for the aggregator purposes, such a "pay-back" bid would consist of a total price P and two sets of volumes, the first spanning over the primary action period of time and the second over the pay-back period.

For example, a "pay-back" bid could look like the following (we consider imaginary units for the sake of example):

- Price P = 100
- Time of start and end T = (3, 5)
- Volume V = (10, 9, -15)

In the market clearing algorithms, the block bids are taken into account after a first clearing is made for the simple hourly bids. The reason for it is simple. The block bids can not be included in the demand and offer curves to calculate the price for each time period since they also depend on the situation during other periods. The same would hold true for "pay-back" bids. There could be discussion to know if "pay-back" bids should be taken into account after, before or at the same time as block bids but such a discussion would probably require a long analysis through which we are not going in this document.

If we consider that we have a temporary clearing price from the aggregation of the hourly (and possibly block) bids, a pay-back bid can be estimated and accepted or rejected. Taking our previous example, the market prices for the periods 3, 4 and 5 are p=(12, 13, 8), the total revenue for the bid would be:

$$V \cdot p = 10*12 + 9*13 - 15*8 = 120$$

which is higher that the bid price P and the bid would therefore be accepted.

We should note that such bids, like block bids, should be accepted one by one because after a bid is accepted, a new market price is computed. The order in which they would be taken into account can be open to discussion. Also, note that it is possible for a "pay-back" bid, if accepted, to modify the market position so that it itself wouldn't be accepted anymore with the new prices. In that case, as for block bids, the best option is probably to reject the bid. It would however be for the aggregator possible to have his "pay-back" bids only partially accepted in that case.

[14] None of these situations will appear if the aggregator is already active on the market (such as if he is a retailer for example).

The introduction of new bid types in the existing markets would be possible, but would require careful planning and modification of the clearing algorithms.

3.2.4.2 AD for balancing services and tertiary reserves

As for the wholesale markets, balancing services and tertiary reserves from the aggregator should be more beneficial if they are traded in the existing market organised by the TSO. They however have requirements harder to fulfil than wholesale markets (in Finland, minimum bids of 10MW for balancing services). It could therefore happen more regularly that the aggregator doesn't have access to the existing market and would need to sell his products directly to the other actors.

Cases where the aggregator doesn't have access to balancing markets:

- the aggregator is not able to provide the minimum tradable volume
- the costs to access the market are too high for the aggregator's business
- the TSO or the regulation judges that AD is not reliable enough to offer balancing products

The two first points can be dealt with by adjusting the market mechanisms and rules, or the aggregator can, as mentioned, sell the services to other actors in need of balancing services or tertiary reserves. The third point however is up to the aggregator. The aggregator should be able to show that his AD products are reliable and can be used for balancing and tertiary reserve purposes. We touch here not only at the aggregator forecasting tools and the reliability of his consumer base, but also at the used measuring system; how the service is measured and to which baseline it is compared (see chapter 4.1.4). This measuring and assessment obstacle is also relevant if the aggregator sells the services to other players without going through the official market as that actor will have to show his new position to the TSO.

The balancing services and tertiary reserves would have to be contracted or activated between the gate closure of the intra-day market and the delivery, thus if there is no centralized market for the exchange, the product is most likely to be a CRP(-2). Contracting an SRP OTC would probably take too much time.

For these services, as well as for the ones detailed just below, **the aggregator should be extremely careful about the pay-back effect.** It can basically be handled in two ways. Either the service buyer buys the full product including the pay-back and deals with it himself or the aggregator keeps the responsibility for it. In the first case, the description of the aggregator's offers would be similar to the description of the "pay-back" bid detailed above. In the second, the aggregator would have to cancel the pay-back effect by activating other resources or by purchasing power on a later market. An aggregator with enough capacity could for example sell 10MW of balancing power from time 1 to 2, activate other resources from time 2 to 3 and buy the needed power on the intra-day market from time 3 to 4.

3.2.4.3 AD for voltage regulation, power flow and congestion control

These services are the services with a localisation component. They are mainly offered to the network operators. There is currently no organized market to trade these services at the DSO level. At the TSO level congestions are taken into account implicitly or explicitly in the wholesale markets mechanisms and are resolved by coupling or splitting the markets. When there is no such mechanism, the TSO must activate resources as detailed in the section 4.2.1.

At the distribution level the DSO is responsible for the good utilization of the network. Instead of improving the network components, he could choose to reduce the costs by contracting local AD or other resources or by setting up a market similar, on a smaller scale, to what is done at the TSO level for balancing or tertiary reserves.

The simplest way for a DSO to contract these services would be to sign a bilateral contract with a service provider (the aggregator or a local producer for example). However, the regulator may see it as going against the transparency and market based approach directed by the EU. The second step would be for the DSO to issue regular calls for tenders, to take in the different offers and to select those with a lesser cost. Finally, the DSO could organize a local market (see 3.2.5.1).

A local market would present the advantage of allowing other actors, such as a producer subject to feed-in tariffs, to purchase AD products for example to increase his production at times of network congestions when he would normally have to curtail his output.

We should note that the choice for a DSO between a call for tender or holding his own market should be made based on the possible liquidities on the market and especially the market option should be considered if there are other actors willing to buy the AD service. From the simplified list of services (Table 9), we see that the only other actor that would be willing to buy local AD services, besides the network operators, would be the producers with regulated tariffs.

In a meshed network with interconnections between different DSOs, it would be possible for a DSO to become buyer on his neighbouring DSO.

We see thus that a local market approach would be considered in the case of interconnected networks with a lot of local resources connected to them and thus possible liquidities on the market.

If a DSO contracts AD to solve local constraints within a short time frame, it will have an impact at the local level, not only regarding power flows at the TSO level, but also on the global system balance. We provide a deeper analysis and a suggestion for a solution in the chapter 4.1.

The remarks made in the chapter just above about the pay-back effect remain valid here.

3.2.5. Possible new markets

In this section, we consider markets for SRP products. Only the last point will deal specifically with the possibilities to exchange CRP products based on market mechanisms.

3.2.5.1 Local market

As mentioned earlier, local organised markets could be set up to answer to local needs (voltage, power flow and congestion control). It could be set up by the DSO or another regulated agent (TSO or a new actor) to exchange services locally. The design of the market could be very similar to the existing wholesale markets. The local market could actually be obtained by applying a market splitting mechanism (see 3.1.3.1) from the TSO level market in case of a local congestion or problem. That approach is considered for example in the MoreMicrogrids project where the microgrid, which can be viewed here as a local market, receives supply and demand information from the wholesale market, checks for network problems and, if any are found, takes adjustment bids on the local level to resolve the situation.

It should be kept in mind that the more local a market becomes the less liquidities will be available on them. For this reason the size of a local market should be influenced by both the need for such a market and the available liquidities on it. A local market could be extremely local and cover a small part of a DSO network or it could be larger and be put up by the TSO to manage a specific network situation.

We try here to identify the actors who could be willing to buy or sell products on a market set for one or several load areas (or market area):

- DSO managing the market area. He could buy or sell power in order to solve local constraints;
- DSO managing a neighbouring area. He could buy or sell power in order to solve his own problems. Note that this DSO can be the same as the one above or that there could also be a local market for the neighbouring area. In this last case, market coupling mechanisms could be used, with limitations on the transfer capabilities, to make them interact;
- Local controllable DG (e.g. fuel fired generators) owner. He could sell or buy on this local market to improve the income he gets from his generation unit. In the case of very small producers, such a local market may be easier to enter than the typical wholesale market (lower minimum power limits for example);
- Local uncontrollable DG (e.g. wind or solar power) owner. He could buy or sell power in order not to have to shut down or limit his operation for local constraints reasons. It would be especially true for producers subjected to regulated tariffs. If a market is set up for the congested load area all the resources available at a price lower than the producer's regulated tariff are activate before the producer needs to turn down his unit;

  Comment: We should note that in the case of such market, the DSO might have to pay the regulated tariff to the producer for the loss of business due to the congestion, depending on the country-specific situation. In Germany for instance, DSOs and TSOs indeed have to compensate owners of feed-in-tariff based DG units for any loss of sales caused by network constraints. This is a point of regulation which will not be discussed in this document.
- Aggregators. He could buy or sell power to provide services, locally or not.

3.2.5.2 Flexibility market

The existing markets, especially those for balancing and tertiary reserves services, can present limitations that are difficult for an aggregator to follow. Moreover, keeping the markets separated can lead to inefficiencies.

That market would be targeted for aggregators and possibly small scale generation on the supply side and different actors or markets on the demand side. It could also be run by an aggregator willing to extend his portfolio.

The characteristics of a flexibility market would be dictated by the use there is for it. If the purpose is to build services for the intra-day market, there should be updates and gate closures at least as frequent as for the said intra-day market. If it is to have services available for balancing or tertiary reserves purposes, the flexibility market products would have to comply with the restrictions concerning measurement and reliability.

We present here (see *Figure 6*) an example of an SRP flexibility market. It could be a continuous market in which the bids are taken for a period extending from 15 minutes to 36 hours before delivery. Each bid would have a "drop-off" time when it is removed from the market. With this option, bids wouldn't be allocated as they arrive, but there would be a market clearing occurring any time a "drop-off" time is reached. It would allow a lot of gaming which could be prevented by various means, such as not making the bids public or giving a minimum period of time during which the bid must be open. It could also be dropped altogether and we could have a classical continuous market or one with fixed gate closures.

On top of the clearings based on the "drop-off" times, the flexibility market could send its aggregated products propositions to the other markets. For example, the demand and supply curves from the flexibility market can be submitted to the regular day-ahead market in the form of supply and demand bids.

For the services that require a faster response, the system could switch at a fixed period before delivery (for example 30 minutes) to a regular continuous market. For instance, let us imagine that a TSO wishes to activate tertiary reserves. He still has to have the reserve available under a CRP contract with other actors (as of now, the TSO must have a fixed amount of capacity available at all times. It is due to security of supply reasons and is unlikely to be changed in a near future). He could still however make a quick request on the flexibility market to see if some resources there would be available at a lower price than the activation price of the cheapest available tertiary reserve capacity.

This market example would still need a lot of tuning and detailing before even considering if it would be feasible. We insist on the fact that a flexibility market could be innovative and propose systems that are not found in regular markets, as long as the interactions with the other markets are clear and unambiguous.

Figure 6 – Example of situation for a flexibility market

We describe in *Figure 6* an example of a situation that could happen on a flexibility market. The purpose of this is to attempt to make clearer the clearing process and the drop-off times. In green are the times when the bids are put on the market and in gray the time when they are present on the market. We consider here a situation with several offer and demand bids, but only a single time for the delivery of service and a single volume being exchanged.

T_1: The maximum activation time between the offer 2 and the delivery time has been reached and the owner of the resource offering it needs to know if it will have to deliver or not. There is another offer and one demand on the market at this time. If $P_1 > P_2$ the offer 1 beats the offer 2 at fulfilling the demand 1 and the offer 2 is not activated. The activation of the offer 1 can wait until a later clearing time. If $P_2 > P_1 > P_3$ the offer 2 beats the offer 1 and is activated

T_2: The demand 1 needs to know if its need can be fulfilled by the market. If we replace the demand 1 by another market place, it is the time to send bids to that market place. The prices of the bids are compared. The offer 1 will be booked for fulfilling the need from the demand 1 or 2, depending on which one proposes the highest price. If the offer 2 was cheaper that the offer 1 at T_1 it could be associated to one of the two demands and the offer 2 to the other. The way prices should be calculated at this level is open to discussion but we would propose that the clearing price would be the cheapest of the fulfilled demand prices.

T_3 and T_4: The situation is re-evaluated. In this example no new bids have been put in the market and no recalculation is needed.

3.2.5.3 CRP markets

The exchange of CRP nowadays is made on bilateral contracts or on calls for tenders. We investigate here if we could consider having a pool market for CRPs. The complexity with CRP products is that there usually are two prices, one for having the capacity available and another to activate it.

One possibility of which we here only scratch the surface would be a CRP market spanning over a long, but defined, period of time split into smaller units and to integrate the two prices into one, which can then be compared to other offers. We will treat it with an example. We could have a market for booking capacity during a month. There could be two categories of day types, namely week days and weekend/holidays. Each participant willing to offer a service would send bids of the form:

- Day-type category: week days, weekend/holidays or both
- Time for availability: between hours H_1 and H_2
- Volume: V
- Option price: π_o
- Exercise price: π_e
- Maximum number of calls for a specific day-type category: c_{max}
- The potential service buyer on the other hand would send only one total price π_b that he is willing to pay.

Each activation possibility could become its own bid with a single price (we use the index 1 for the service provider and 2 for the buyer):

$$\pi_1 = \pi_e + \pi_o / c_{1,max} \text{ and } \pi_2 = \pi_b / c_{2,max}$$

With these data, typical offer and demand curves can be built and evaluated for the different day types. Although it shouldn't be a problem to combine several offer bids to fill in a demand one, it could be more complicated to split an offer bids into smaller parts. The reason for this is that if called by different actors at different times, the offers could end up being called partially more times than their c_{max}. There should probably be a field in the offer bids signalling if it can be split or not. If a lot of them can not be split, it may cause problems for matching the offers and demands. In such a case, the market could impose restrictions on the possible volumes that can be put as bids.

3.2.6. Local market evolution

We have in these last two chapters described the current market situation as well as how AD would fit in them and we have proposed some new market possibilities to trade AD products. We propose here our view of how AD could be traded in the future. The limiting factors for the appearance of new markets and the development as described below are the available liquidities on the possible markets (and other exchange types), the business situation of the DSO and the need that he has of frequent local services.

In a first time there would be very little AD and other local flexible resources. The aggregator would act on the existing day-ahead and intra-day markets and would propose his CRP products to other actors (especially the DSO) on a bilateral contract basis. If the aggregator manages to gather enough flexibility, he could start participating to the balancing or the tertiary reserve markets.

In a second stage there will be more available distributed resources and, to remain fair, the DSO will have to open calls for tenders for his network needs. The aggregators active locally will have to send their offers then, considering also the benefits they could get from keeping their resources available for the other markets they are involved in.

In the last stage, the system is fully integrated and there will be a local market obtained from splitting the market at a very small scale. All the actors interested in purchasing local flexibility could act on that market. Note that if very few AD consumers participate, the impacts on the forecasts and balances will be weak. If in the long run, the local market is mature with in particular a lot of AD consumers, it could maybe be necessary to set up a kind of local balancing market in order to take into account deviations between forecasts and real loads. We can suppose that aggregators will follow a collective learning-by-doing process which will permit them to participate actively in this local market.

The three stages could of course exist at the same time in different network areas. In theory also the third stage would bring the same results as the second one. The advantages it offers are on an increased ease for regarding balancing and re-dispatching issues (as described in their respective chapters).

They could also coexist at different local levels. A recurring network problem at the TSO level may push him towards implementing second and third stages while the DSO at the low voltage level has bilateral contract with some of the resources.

4. Balancing, technical validation and settlement and billing issues

In this section, we review three issues that have been identified as needing solutions in the ADDRESS project and we propose some solutions based on the current electricity system functioning and, when possible, on market principles. Those problems are the assessment of the baseline the ADDRESS products are deviations from, balancing responsibilities and the technical validation by the distribution system operators. Finally, we have a word about some billing concepts to the AD consumers.

4.1. Balancing

The aggregator, in the same way as any other actor involved on the power markets, is responsible for his balance, either directly or via a BRP. Some issues have been pointed out in the project about balancing responsibilities when the aggregator and the retailer are different actors. In this chapter, we observe how it is handled currently and we give some possibilities of how it could be dealt with if an aggregator is active.

4.1.1. Belgium

A detailed description of the balancing mechanism in Belgium can be found on http://www.elia.be/repository/ProductsSheets/E1%20E%20BALANCE.pdf

The TSO ensures balance between production and consumption within its control area. BRPs are helping the TSO by nominating daily the production and consumption for their own perimeter, being the total of injection and off-take points for which this entity has been assigned as BRP (see Figure 7). The BRP is responsible for balancing its perimeter on quarter-hourly basis:

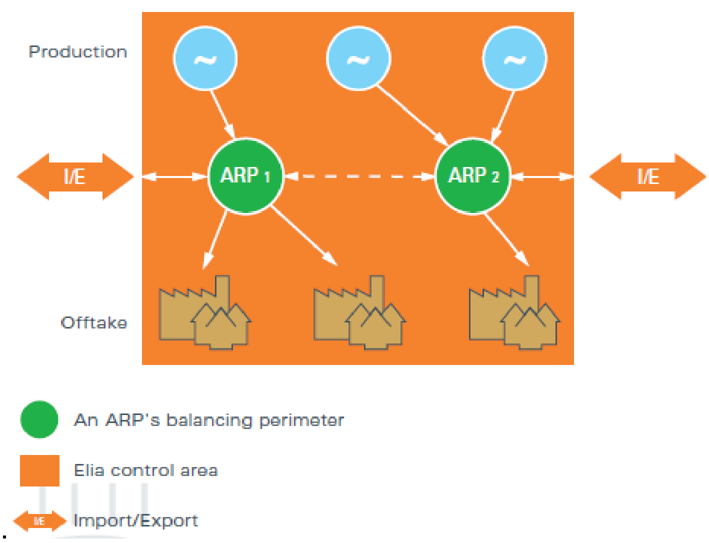

Figure 7 - TSO and BRP balancing mechanism (source Elia)[15]

[15] ARP (Access Responsibly Party) is the name given to the BRP in Belgium.

Injections can be provided by:

- Production units of its own perimeter on the transmission grid
- Production units of its own perimeter on distribution level
- International imports
- Energy exchanges with other BRPs on a day-ahead or intraday basis

Off-takes can be provided by:

- Off-takes at access points in its own perimeter on the transmission grid
- Off-takes at access points in its own perimeter on distribution level
- International exports
- Energy exchanges with other BRPs on day ahead or intraday basis
- Off-take related losses

As deviations in real time always occur compared to the predicted production and off-take, the TSO is responsible to maintain the balance in real time and can do this by the use of secondary reserves, tertiary production reserves, tertiary off-take reserve and the possibilities offered by the CIPU contract (see later in 4.2.1.1). Finally, also agreements with TSOs of neighbouring countries are made. It should also be noted that the balancing mechanism is combined with automatic frequency control by a number of power plants, which is applied 24 hours a day.

The costs for balancing differ from one country to another but they are transferred to the BRP who caused the imbalance. Those costs are based on the market price at that moment, adjusted by a certain factor in order to discourage imbalances.

4.1.2. Sweden and Nordic Countries

SvK's (TSO) system responsibility entails planning and coordinating the national balance between the production and consumption of electricity, as well as overseas exchanges. The frequency of the system, which is a measure of its balance, must normally be within a specific range around 50.0 Hz (±0.1 Hz).

In order to be able to do this, SvK has established a special function, the balance service, which must:

- Maintain the country's electricity balance in a decentralized way via balance regulation,
- Distribute the costs of maintaining the balance between the players on the market via balance settlement.

SvK and about thirty players, including the biggest electricity producers, have signed a Balance Obligation Agreement (BOA). Players signing a BOA are called balance providers. They have undertaken to plan, on an hourly basis, for the production and purchasing of power to correspond to the expected consumption and sale vis-à-vis what they supply to their customers. Discrepancies in the balance are settled financially with SvK afterwards.

When required, SvK can order regulation resources to be used when the frequency deviates from normal. Balance providers by way of bids to SvK have put these resources at the disposal. It is anticipated that AD products also would be part of this bidding procedure in the future.

All the cross-border transmission capacities in the Nord Pool area are allocated through day-ahead implicit auctions. The capacity not allocated through the day-ahead market is made available for the intraday and the balancing markets. In November 2009, market coupling was introduced between the Nordic and German Spot market (Nordpool, 2010). Market coupling is now performed on the two interconnectors between Germany and Denmark and on the interconnector between Sweden and Germany. Market coupling is performed on the Estlink interconnector between Estonia and Finland. The Nordic market will also be coupled to the Polish power exchange through market coupling on the SwePol link, the interconnector between Sweden and Poland (ERGEG, 2008). For the interconnector between Norway and Netherlands explicit auctions are used to allocate the transmission capacity.

As mentioned above, congestion within a bid area is managed through countertrading. The generation output is reduced in an area with surplus and increased in an area with deficit with help from different up and down regulating bids on the balancing market.

The balancing service is the mean that the TSO uses for receiving information about resources in order to regulate the balance at different geographical locations. The balance service is regulated through a Balance Obligation Agreement that is signed between the TSO and large market actors (c. 30 in Sweden). The players have undertaken to plan, on an hourly basis, for the production and purchasing of power to correspond to the forecasted consumption and sale in relation to what they supply to their customers. Any discrepancies in the balance are settled by the TSO.

The balance service is divided into three levels of responsibility:

1. National level – the TSO's responsibility on a minute-by-minute basis
2. Balance providers – company balance on an hourly basis
3. Electricity suppliers – in agreement with the balance provider who manage the balance on the suppliers behalf

In order to plan their physical balances right balance providers can trade in electricity up until just before the delivery hour. Trading can take place on Nord Pool Spot, which closes at 12.00 the day before delivery. Alternatively, trading in electricity can take place on the adjustment market Elbas from 15.00 on the day before up until one hour prior to delivery, or bilaterally with another player, see Figure 8.

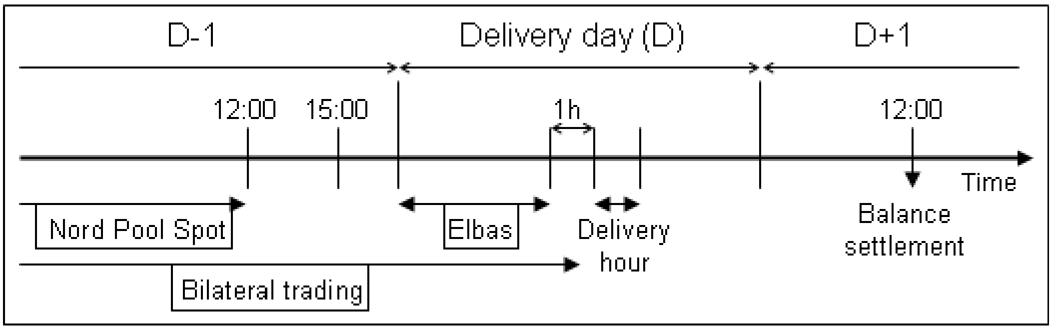

Figure 8 - Timetable for trading and balance

Balance service can be seen as the mechanism to balance the grid when the delivery hour begins. Prior to managing the physical balance, the so-called balance regulation is used. The TSO accepts bids (power in MW and price in SEK/MWh) from balance providers who are willing to increase or decrease their level of production or consumption (within 10 minutes). The bids for balance regulation are arranged in order of price and form a step-wise supply curve for each hour of operation (Figure 9) and when regulations are needed the most favourable bid is hence activated. At the end of each hour, the regulation (market or spot) price is determined by the lowest upward regulating and the lowest regulation price, whichever is the desired regulation need, and this price applies for all actors involved in regulating power either downward or upward.

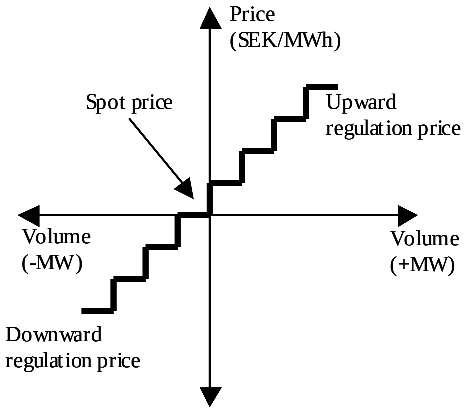

Figure 9 - Balance regulation bids

Note that the balance regulation is combined with automatic frequency-controlled regulations of certain power generation plants. This regulation power is bought by the TSO via weekly and 24-hour contracts, from balance providers that have these possibilities.

All balance providers pay or get paid for their balance power, i.e. for their unplanned deviation from the balance, in accordance with the different alternatives for the so-called settlement curve (Figure 10). Case a) shows that an upward regulation has been ordered and the price applies to all players with a negative imbalance while the other settle at spot market prices. Case b) shows that when no regulation has been ordered all actors settle at the spot market price. In case c), where both up and downward regulation has been ordered, the upward and downward price is applied in the settlement according to which regulation represents the greater energy volume. If the volumes are equal, the spot market price is used. Finally, in case d) a downward regulation is ordered and the downward price applies for all players with a positive imbalance while the other settle at market prices.

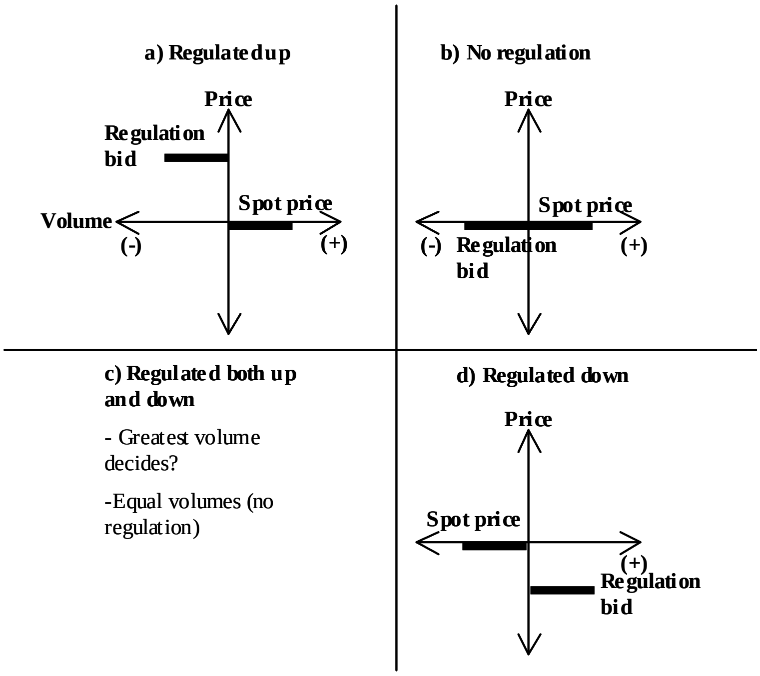

Figure 10 - Settlement curves for regulating power

4.1.3. Aggregators and balancing responsibility

As explained in the previous chapter, nowadays generators and energy suppliers have some strict information exchange obligations to the TSO. Those obligations are fulfilled by BRPs for every access point on the transmission network. In general, it can be stated that every injection, off-take or change of predicted energy flow pattern[16] in a BRP portfolio should be communicated to the system operator. This allows the system operator to have a complete overview of the predicted and expected power flows in the power system and to predict potential network problems such as congestion.

As explained previously, this “closed” system allows the instantaneous deviations due to inaccurate predictions to be rather small and the required corrective actions by the system operator to be manageable from a technical and economic point of view. The costs of instantaneously balancing the system or exactly matching supply and demand will in the end be charged to the BRPs and thus producer and/or consumer. The BRPs should have acquired enough generation to provide electricity for their consumption side in advance, while the costs of corrective actions by the system operator will be passed through to the BRPs who were in an imbalance position at the moment of those corrective actions.

Assuming that, in a world with a substantial amount of intermittent and less predictable energy resources, AD will be unavoidable and should be activated by aggregators, this would mean that aggregators might have (in the long run) a considerable impact on the power system by influencing the behaviour and production/consumption of individual producers/consumers that nowadays belong to the portfolio of one BRP, notably when they intervene particularly during peak periods or other critical periods potentially imposing additional costs on the BRP.

As for one particular consumer/AD consumer, BRPs have nowadays an idea of the expected

[16] Not only production and consumption but also non-physical exchange between two BRPs or a transaction on the power exchange that should be reported by buyer, seller and the power exchange operator.

production/consumption profile,[17] those predictions, that are indispensable for the system operator, will be changed by the aggregator. In order to keep the system closed from the system operator point of view, the aggregator should have the balancing responsibility for his AD actions, as it is the case for any other actor buying or selling electricity in the electricity market. **That would mean that an aggregator should be a BRP himself or should pass this responsibility to another party by having a contractual agreement on the costs of this responsibility as it sometimes happens nowadays for generation units**.

For one particular AD consumer[18] on distribution level, this would lead in theory to a situation in which the original BRP of the energy supplier would predict the production/consumption profile of that particular AD consumer without any AD activities on that network access point (monitored by a smart meter and having the potential to be activated by the E-Box) while, from the moment that the consumer signs a contract with a certain aggregator, **the aggregator's BRP will be responsible for the change in profile due to price/volume signals sent out by the aggregator**. From this perspective, the aggregator's BRP should also be responsible for potential payback effects, changing the predicted consumption/production profile.

Although the approach as described in the paragraphs above seems to be logical and simple, a number of potential issues can be identified originating compared to the current situation on transmission level:

1. Price/volume signals by the aggregator versus energy pricing of supplier[19]
2. Identification of baseline by the energy supplier versus AD pattern activated by the aggregator
3. Imbalance costs to be shared by two different BRPs?
4. Impact of AD can be very local (load area level): needs for and set up of local markets
5. The (changing) role of the distribution network operator
6. Ability to predict and monitor accurately a single consumer's consumption and AD response

The first three issues can be clustered into "settlement and billing issues": they are relevant for ongoing work in other work packages and will be treated in the next section.

Points 4 and 5 are related to the "locality" of AD actions and will potentially lead to new and more extended responsibilities of the distribution "network" or "grid" operators, who might have to become more distribution "system" operators, implying a more extended role comparable to the current role of transmission system operators but then on a local (distribution/load area) level. This potential extended role will strongly depend on the level of responsibility that will be put on the local level for dealing with AD: this can vary from "simply" avoiding local constraints by approval or rejection of certain AD requests during a technical validation process, to a very active role in managing and dispatching AD services on local level but in close cooperation with other system operators.

4.1.4. Baseline profiles with different actors

In the case where the aggregator and the retailer are different actors they will have to share the

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[17] A more correct wording would be: injection or off-take profile or pattern.

[18] From now on the terms AD consumer and consumer will be used equally to indicate a consumer/AD consumer on the distribution level.

[19] More information on this topic can also be found in 2.1.6.2 on contracts: we consider that, except in particular cases, the AD consumer should not be obliged to mention to his aggregator any change of his power pricing offered by his retailer.

reponsibility for imbalances. In addition, a baseline must be defined in order to measure the delivery of the aggregator service.

The baseline issue from the consumer's point of view has been removed by the design of the information exchanges with them, as described in ADDRESS activities dealing with the specification of the aggregator, E-Box and DER. The most crucial information concerns the price/volume signals sent by the aggregator in order to change the behaviour of the consumer. It was decided to use only one signal: combined price/volume signal which will give an incentive (in euros) with a condition on the instantaneous consumption (in kW), but without a reference on absolute values (so no reference based on forecasted consumption). An example of this price/volume signal can be found in *Table 1*.

Although for the sake of simplicity from a technical point of view the choice for avoiding a reference baseline for the incentives might be a practical and "easy" one, this will have consequences for the market organisation and settlement and billing. Nowadays, market players have to estimate their positions based on predictions of the behaviour of their portfolio (production and consumption): producers have to predict their production side (nominated by BRPs, see earlier), suppliers/retailers have to predict their consumption side (to buy the right amount of energy for the right moment while consumption is also nominated by BRPs, see earlier) etc. To keep the power system balanced, deviations from the predicted positions (communicated by the BRPs to the system operator) lead to imbalance costs, charged upon the market player in an imbalance position. Changes in this position, due to no matter what cause, e.g. price/volume signals of an aggregator, will thus affect this business, at least when it happens on a relevant scale[20].

A logical consequence of this, is the fact that in current markets and current settlement and billing systems (energy bills, imbalance markets, etc), there is always a reference baseline, namely the predicted/estimated production/consumption.

Activities carried out by an aggregator by sending price/volume signals to an AD consumer will eventually change the behaviour and thus the production/consumption profile of that particular AD consumer (see Figure 11). Afterwards it is impossible to determine whether the deviation was due to:

1) Bad estimations of the original retailer
2) Bad estimations of the response of the AD consumer by the aggregator
3) Combination of both

This point, as well as the following related discussion, becomes irrelevant if the aggregator is also the AD consumers' retailer.

[20] One should note that investments in PV by an end consumer also affects the retail business although it is not explicitly taken into account nowadays.

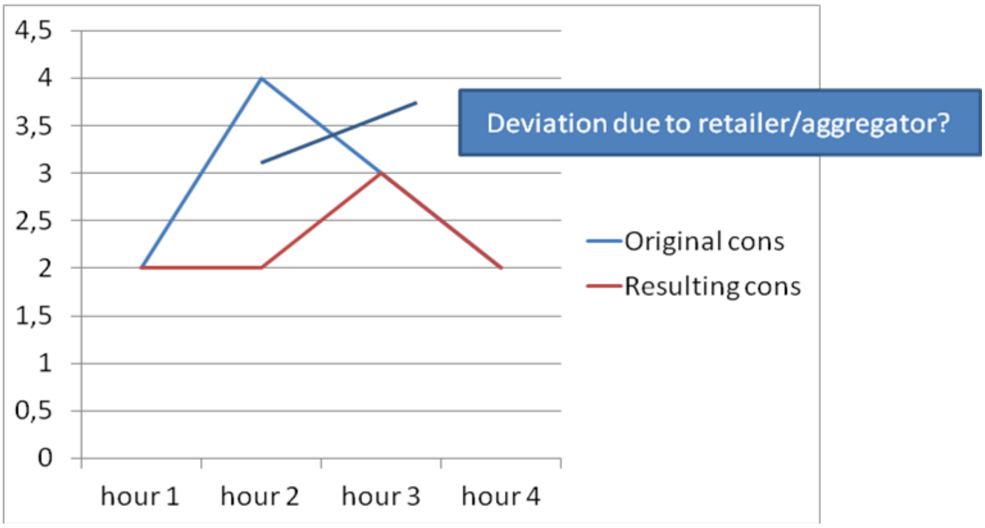

Figure 11 - Example reference baseline issue

Nevertheless, by summing up these deviations, someone will have to pay for the net deviation in the power system.

In practise, the consumption profiles of consumers are aggregated and are not considered individually for each AD consumer. That allows in the current markets to assign general baselines to consumers. In the ADDRESS context the baselines should be refined appropriately. The current baseline curves can remain valid for services at the transmission level, but a lot more details is needed when going to smaller levels, especially when coming to the consumers attached to a single pair of aggregator/retailer in a single load area. The following discussion assumes individual baselines and load curves, but we should keep in mind that in reality, we are considering curves aggregated at the appropriate level for the specific service that is provided.

A number of potential solutions can be proposed:

1) Deviations will be settled as it happens nowadays: by the BRP of the retailer. A lot of uncertainties nowadays already impact the business of the BRP/retailer (e.g. weather conditions, DSOs taking some actions for maintenance of the network, events asking consumers to change their behaviour on a given moment, etc) (see *Table 10*). Next to that, one can assume that AD will not (immediately) be adopted massively, which means that the consequences will not be very harmful. Comparable to the introduction of residential PV (which is nowadays also not actively taken into account by many retailers), one could state that the changes of consumption patterns will change smoothly and gradually over time so that the BRP/retailer will be able to deal with it and to learn to estimate the risks of these new AD services on its portfolio. On the other hand, in case the BRP of the retailer already anticipates the AD effects in its portfolio by providing more or less energy for certain timeslots, then this will lead to the additional complexity that an AD change will not anymore be a profile change and can thus not be sold in the market as an AD product. The choice of assigning the deviations completely to the retailer/BRP **could be a short term solution to get started with AD services** as long as the AD impact on the global profiles is rather limited. A disadvantage could be that the aggregator starts gaming when he is not responsible for deviations from declared positions. In case the aggregator is the same entity as the retailer, that single entity will be responsible for the total deviation and the mentioned potential issues will disappear.

Table 10: Pros and cons of leaving imbalance risks with the retailer

Pros	*Cons*
Easy to implement	
Clear rule	
Risks rather low as long as volume of AD is rather limited	Uncertain risks for retailer when volume of AD services grows substantially
	Fairness of solution could be subject of discussions
	Gaming opportunities for the aggregator

2) The responsibility for deviations will be put solely on the aggregator. This potential solution could be subject for discussion as this would mean that a retailer making bad predictions would be not penalised at all, as all risks and costs for deviations would be charged on the aggregator (see *Table 11*). Assuming that this aggregator is different from the retailer, this would even leave some space for intended gaming strategies by the retailer.

Table 11: Pros and cons of shift the imbalance risks to the aggregator

Pros	*Cons*
Clear rule	
	How to determine baseline or reference?
	Fairness of solution could be subject of discussions
Positive impact on existing business of retailer	High(er) risk for aggregator
	Gaming opportunities for retailer
	Obligation for aggregator to predict load changes

3) The deviations responsibilities will be shared by the retailer and the aggregator: this would lead to a situation where both the retailer and aggregator have to cooperate in order to minimize additional costs due to imbalances. Deviations from that result can be charged upon both retailer and aggregator according to specific rules that are agreed or imposed in advance (see *Table 12*). The baseline in that case is the sum of the predicted profile by the retailer plus the predicted profile by the aggregator.

Table 12: Pros and cons of sharing imbalance risks between retailer and aggregator

Pros	***Cons***
If agreement on the rules, this is probably the most fair way of dealing with deviations	Clear algorithms or rules have to be set up to split the deviations between retailer and aggregator
	Hard to determine baseline and to assign part of deviation to the appropriate market player: technical feasibility?
Both should estimate/predict the best they can => drive for the best outcome by both players	What in the case of conflicting businesses between retailer and aggregator (in case one of them does not do his job properly with increasing costs as a consequence)?

Finally, it should also be kept in mind that the baseline without AD will evolve over time, due to changing behaviour of the end consumers. This would mean that, in a world where AD is generally accepted and applied (e.g. at any household), there will be practically almost no objective way anymore to identify the reference baseline, unless the E-Box would be capable of recalculating again and again “what if” scenarios in function of the signals arriving at the E-Box and assuming that there is a general agreement or imposition on the way this baseline should be calculated. This issue arises especially when the number of consumers included in the needed baseline becomes very small as it could be the case for very local services if a consumer can have a different retailer and aggregator.

In conclusion the baseline and the balancing responsibilities become quite complex when the aggregator and the retailer are different actors. It can be circumvented by the two actors agreeing on a method to calculate the baseline profile. It would however be difficult for either of them to be ensured that it not being taken advantage of. This is one reason behind the ADDRESS decision that the aggregator and the retailer should be a single entity.

4.2. Technical validation by the grid operators

An issue that has arisen in the ADDRESS project in that of the technical validation or, in other words to decide what happens if network constraints render impossible the flexibility exchanges based on the market results. The solution already proposed and developed in ADDRESS (not price related curtailment) refers to approaches adopted by TSOs in some liberalized markets.

We propose here another additional market oriented solution which follows the concepts from the transmission level: we start by describing how it is handled nowadays at the transmission level in two countries and we propose a market based potential solution for handling the problem at the DSO level.

4.2.1. Description of current validation for generation by TSOs

The following sub-sections describe the current validation process for generation by TSOs in Belgium and in the Nordic countries. The Belgian example is worked out and described in detail while a general description is provided for the Nordic countries.

4.2.1.1 Belgium

This section is focused on a practical example, being 100 MWh/h produced by generator X in area A but curtailed to 90 MWh/h by TSO so that a generator Y in area B has to generate an additional 10 MWh/h. The general process flow for technical validation of the proposed production is as follows:

- He nominated th program of *Figure 13* to the TSO[21];
- Based on the nominations, the TSO notices that in this network area A, a congestion will occur if the program will be executed as nominated;
- Therefore the TSO curtails producer X, so this one will only produce 90 MWh/h (Figure 13);
- As producer X sold 10 MWh/h in the market, this makes no market difference, however producer X has to spend less fuel as he is curtailed. The money he saves will be paid to the TSO (Figure 14);
- The TSO asks producer Y to produce 10 MWh/h more than foreseen. He will reward producer Y for this action by paying the extra fuel cost (and uses therefore the income of the fuel cost reduction for producer X);

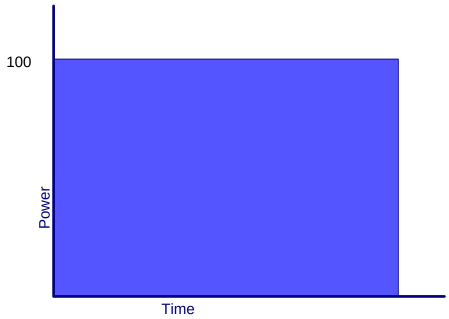

Figure 12 - Intended program producer X area A before approval

[21] Before approval by the TSO, this is called a "program". After approval, it is called a "nomination".

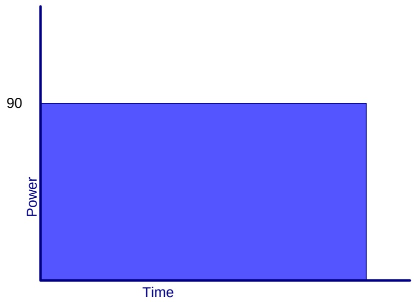

Figure 13 - Curtailed nomination for producer X in area A

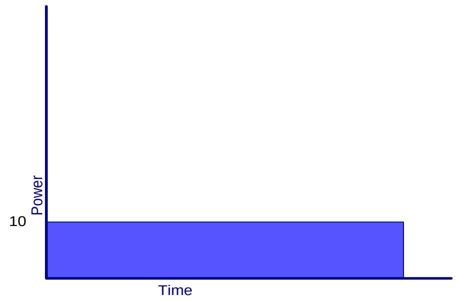

Figure 14 - Requested production for producer Y in area B

The following paragraphs give a more detailed description of two the different steps with respect to the information exchange during the validation process.

Every producer sends his scheduled production to the TSO on day D-1 before a certain deadline for execution the day after. This scheduled program is in Belgium not managed and sent by the producer himself but by the Balance Responsible Party (in Belgium sometimes called "Access Responsible Party"). In this example, producer X has sold 100 MWh/h for the next day for a time period of 24 hours (Figure 12)

This producer has also a congestion and compensation agreement with the TSO. This means that they agreed what fuel costs are realistic to when they are curtailed (congestion bid = money saved because they have to produce less than sold in the market) or when they have to produce more on request of the TSO (compensation bid = money they should receive to compensate for additional fuel costs due to the fact that they have to produce more than sold in the market). Those agreed fuel costs are based on the technical characteristics of the power plant and are compulsory for generators connected on the transmission network (CIPU contract framework = contract for the coordination of the injection of production units[22]).

When the TSO receives the scheduled programs, he will execute an analysis on D-1 to see if congestions might occur. In case they foresee a congestion e.g. in area A, they will curtail producer X (in this example 10 MWh/h out of 100 MWh/h, Figure 13) in the congested area A (and receive the saved fuel costs), re-dispatch the generation to another producer Y in another area B (and pay the fuel costs for upward regulation), see Figure 14. In case those "upward regulation costs" for producer Y are higher than the saved fuel costs from producer X (which should be normally the case as otherwise also producer Y could be considered as being "in the market"), the difference is paid by the TSO. This additional cost is covered by the transmission tariffs. The re-dispatching process occurs following the technical constraints of the network and the cheapest solution based on the CIPU-contract. If possible, the TSO tries to stay within the same BRP portfolio. Applying this re-dispatching mechanism also means that there might be less flexibility on the day D for the producer who was regulated upwards. This means that this re-dispatching process on D-1 is not very popular among the producers.

Note that this process happens on D-1 basis and that the balancing mechanism on day D (near real time) happens through the existing balancing mechanism, being primary, secondary and tertiary reserves and the incremental and decremental bids for day D as they have been sent by the producers the day before. The fines for imbalances are market based adjusted with a certain percentage.

At the end of D-1, the TSO also sends a kind of map on which the transmission network is divided in

[22] More information on http://www.elia.be/repository/ProductsSheets/S5_E_CIPU_08_07.pdf.

several zones and on which a colour indicates how congested the zone will be on day D (red or green). This colour indicates the amount of flexibility for adjustments during the intraday nominations in a certain area. Some market players would like to have a more specified colour code such as on a power plant level (nodal colour codes) although this is not yet agreed and it is not clear if it will be. The reason for this is that a higher level of detail would allow more flexibility for adjusting positions: a certain power plant could be curtailed due to some very local reasons (e.g. interconnection capacity constraints) which may not always be the case for another power plant in the same area.

4.2.1.2 Sweden and the Nordic countries

On the open Nordic market, two methods are used to manage transmission bottlenecks: market splitting and counter-trade. Both principles are used simultaneously on the joint market, primarily at national borders. Market splitting is used between countries, between north, middle and south Norway, and between eastern and western Denmark (Nordreg, 2007). In Sweden, it has been decided not to rectify anticipated bottlenecks on the grid during the planning phase, instead dealing with them during the operational phase using counter-trading. In addition, market splitting will be introduced within Sweden by November 2011. In Sweden, a large share of the generation capacity is located in the northern part while the largest part of the consumption is located to the south. Hence, congestion occurs when the transmission network capacity is not sufficient to transfer all the power required in the southern part. There is also congestion between the Nordic countries which can be observed when there are differentiated prices in Nord Pool bid areas and on the interconnectors to the continent, for example the Baltic cable and the SwePol link (Swedish Energy Market Inspectorate, 2010).

Nord Pool carries out market splitting. The auction principle on the spot market enables the management of potential bottlenecks on the network during the operational planning phase (i.e. the day prior to delivery). For this, the market is divided up into different price areas. The different prices in the areas provide market players with signals for planning their production or consumption.

If, for instance, transmission needs to be reduced between two areas within Sweden, an increased level of electricity production can be ordered in the area with a shortage of production at the same time as a decreased level of production in the area with a surplus. This is known as countertrade and is carried out with the assistance of the balance service during the delivery hour (i.e. real time). The cost of counter-trade is charged to SvK.

4.2.2. Technical validation for AD by DSOs

With new flexible resources connected to its network, the DSO will probably operate its network closer from its limits. We should therefore consider the possibility that actions from the aggregator will push the network over its capabilities. For this reason, the aggregator should request a validation from the DSO when activating an AD product. Close from the delivery period, when AD actions are declared individually, the DSO can validate them as they arrive, on a “first-come, first-served” basis.

4.2.2.1 Curtailment, the present ADDRESS solution

When the AD actions arrive together however, a need arises to select on which grounds some will be validated and others not. A possibility is for the DSO to partially curtail all the AD products by the same percentage [23]. This solution treats all the AD operators equally without the need for the DSO to receive

[23] In the ADDRESS project, the curtailment does not mean that the DSO is allowed to tell consumers how to consume. It is clear that regulation can not allow the DSO to do so: all consumers - including AD consumers - must be free to consume what and whenever they want as long as their technical installations is compliant with the grid code.

information on the price of the services. The DSO here does not compensate the aggregator for the curtailment. The technical aspects of this solution are elaborated in the ADDRESS deliverable D3.1[24]. The regulator must just decide whether AD should be subject to the same regulations as DER or not.

We can however imagine other possibilities for handling the congestions at the distribution level. It would be possible, as described for transmission in chapters 3.1.3.1 and 3.2.5.1, to split the market to the level on the congestion. It is the approach taken on the day-ahead and intra-day level for example between Finland and Norway. This possibility would however require all the involved actors to nominate their production and consumption at the appropriate level. For this reason, we do not consider this option as advisable except possibly in far future with fully integrated communications between all the actors.

We consider, in the ADDRESS project that when a curtailment is required, the DSO can not allow a transaction, or a part of it, to take place without having to offer any compensation. This leads to an increased risk for the aggregator business. It raises the issue of the aggregator being treated in the same way as the other unregulated actors. We would touch here to a regulatory issue and different approaches could be taken.

The easiest, as considered in the ADDRESS project, is to consider it fair for the owners of flexible resources to have to be at the disposition of the network operators for solving network constraints.

4.2.2.2 Re-dispatching, a possible alternative in the future?

We propose here another possibility which could possibly be better suited to different future regulatory environments. We consider here that the DSO should give a monetary compensation. In this case, the compensation should be determined as to both avoid misuse by the aggregator while in the meantime give incentives to the system operators to do network reinforcements when necessary. AD services could offer opportunities to postpone network reinforcements but care should be taken that the power of allowing or rejecting AD services by the system operator does not turn into a blocking factor for further (sustainable) growth of social welfare. The solution we propose would require a quite strong involvement from the DSO into the market mechanisms. We should therefore note that it would probably be quite unpractical unless the DSO has an easy access to some flexibility market or has a CRP contract with another aggregator.

Let's assume a load area in which a lot of decentralised production such as PV is available. For environmental considerations it should be good that as much PV-generated electricity as possible can be put in the market (there is a strong possibility of the regulator or legislator to push in that direction). Assume now that there is a general demand for consumption decrease for the macro load area which the load area is a part of. Therefore, an aggregator who is exploiting AD activities in this load area could be willing to offer AD services in terms of consumption decrease. When “asking permission” in terms of a local technical validation by the distribution operator, the latter will not be willing to accept this request as it could potentially harm the local distribution network as at that same moment lot of PV-electricity is injected into the grid. It could be that the best thing for society is indeed that the AD service request will be simply curtailed. However, as there is apparently a need in the market for

The ADDRESS project assumes that the aggregator is as a separate body that carries out AD solely for its own purposes (and not a middleman between active consumers and the grid). Under this assumption, previous ADDRESS works have decided that the DSO could validate (i.e. allow or disallow) the AD programme of the aggregator before the aggregator sents his price / volume signals to his AD consumers (who can then decide on his own if he changes his consumption pattern accordingly). In the future, we can just imagine that if consumers reach an agreement with DSOs (indirectly through the aggregator) by which they may be curtailed at certain times (similarly to the interruptibility clauses currently in place with large consumers), then of course this may happen.

[24] ADDRESS Deliverable D3.1 - Prototypes and Algorithms for network management, providing the signals sent by the DSOs to the aggregators and the markets, enabling and exploiting active demand – on progress

consumption decrease at a certain price, it would be a pity if this decrease should be offered by another aggregator (or by other mechanisms) at a higher price. When this higher price is still lower than the price of the network reinforcement for the DSO, this situation would be fine. But from the moment on that this is not the case, the DSO should receive some incentives to do network reinforcements in order not to harm social welfare. If he does not receive that incentive, there is a risk of being stuck in a situation where no additional AD services are allowed because of network constraints.

With our assumption that the DSO could have to compensate the aggregator in case of curtailment, what should be the price for that compensation? If it is too low, there is the risk of the DSO using curtailment methods instead of investing in its network or of contracting services from flexible resources. If it is too high, the aggregator may willingly cause constraints on the network in order to be paid for, in the end, doing nothing.

A solution might be found in putting the responsibility for re-dispatching at the DSO side. If we assume in our example that any AD request for which a market counterpart has been found should be allowed, then the DSO becomes responsible for finding solutions when local network constraints are met. The basic principles can be summarized as follows (*Figure 15*).

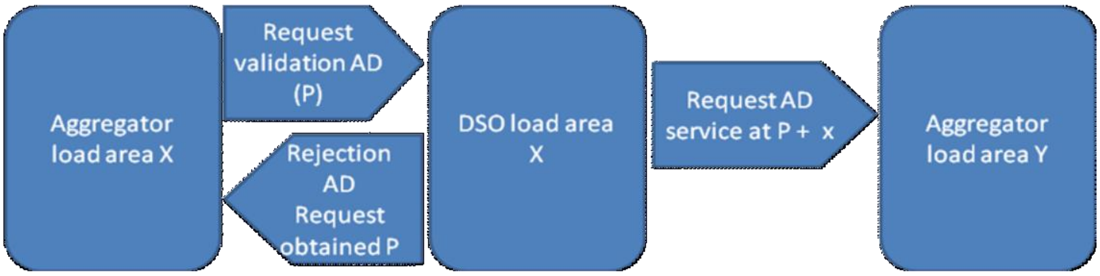

Figure 15: Curtailment and re-dispatching process aggregator-DSO

- Aggregator X sold AD product at total price P in the market to buyer A and asks for technical validation
- DSO notices that there will be congestion or other violation of network constraints and rejects the AD request
- Aggregator X will transfer the agreed price P that it will receive for the sold quantity of AD to the DSO
- Buyer A does not have to know that there are local technical constraints (assumption that the buyer is not someone interested in the locational aspects of the AD service)
- DSO will dispatch the sold AD from load area X to another load area Y,
    - preferably to the same aggregator if possible at the same price P
    - if previous option is impossible: to another aggregator Y (this doesn't have to be another aggregator, any other flexible resource could do) at price P + x. The selection of the aggregator Y among the possible alternatives should also be market based.
- Aggregator X will not be affected as he did not win nor lose money because of the re-dispatched AD service
- In a well-functioning market, aggregator Y will be more expensive than aggregator X, otherwise the merit order of the commercial market in which the AD product was traded would not have been logical: If the aggregator Y were cheaper (price P – x), he would have

contracted the requested AD service initially.

- DSO will lose some money (P – (P + x)): in case those costs will be substantially and continuing on the long term (because there is a persistent need for AD in the weak load area X), the DSO will consider network reinforcements (which is the purposes when certain parts of the grid are too weak for requested transactions).
- Aggregator Y is the only benefiting market player as he will win some money because of the fact that the DSO has to re-dispatch the AD service. This should not be a persistent situation as explained in the previous bullet.

It should be noted that the abovementioned proposition is only feasible when there is enough time for technical validation after market clearing (comparable to the day-ahead congestion management as described previously in this document). A certain time margin can be made obligatory for such re-dispatching procedure according to the technical feasibility and current existing markets with their gate closures. In a first stage it can be assumed that this type of re-dispatching process will be possible on day-ahead basis.

For intraday AD services or near real time actions, it can be assumed that the existing balancing mechanism should deal with potential technical constraints although it should be noted that balancing on the distribution level is no common practice at this moment. Once DSOs notice on day-ahead basis that the network is close to its limits, this can be notified to the aggregators and other market players located in that load area so that potential last minute intraday actions will be limited or impossible.

In the situation presented here, a DSO curtailing a service would become responsible for the caused imbalance at the transmission level. The volume refused by the DSO to the aggregator X should be removed from the aggregator's balancing account and moved to the DSO's one. If he fails to find a player Y to offer the service, he would have to pay the balancing price for that period. This may even sometimes be preferable to buying from another market actor.

It would also be possible to leave the DSO out of the balancing mechanisms. The aggregator X would remain responsible for the balance until the DSO finds a resource from the actor Y. If the DSO doesn't find one, the aggregator X could then bill the difference between P and the balancing cost for the curtailed volume to the DSO. We get back in this case to the possibilities of misuse by the aggregator.

4.3. Main issues dealing with monitoring of service provision, measurement and control

4.3.1. Aggregation of baselines, deviations and imbalances

As mentioned in the previous chapter the service delivery and the comparison to a baseline will not be made individually for each consumer. Nowadays, allocation and reconciliation of imbalances on distribution level happens on an aggregated level, based on the measured data gathered by metering companies and analysed and validated (sometimes much) later[25] than the moment of delivery.

In what follows, it should be kept in mind that deviations on the predicted profiles (imbalances) nowadays and in the future can be settled on aggregated level (assuming that a correct and exact measurement takes place or an agreed method can be applied to determine these deviations). Next to that, it is also possible that local deviations lead to local constraints and thus additional costs for the system, charged upon the actors causing the local problems. As long as there are no local constraints,

[25] The exact moment of finalization and validation of the outcome of this process might be country specific.

only total deviations should lead to penalties.

In 4.1.3 and 4.2 we propose methods to integrate AD as correctly as possible into the current power system (validation) processes. Two major issues arise when assessing these methods: a correct definition and measurement of the baseline and the technical feasibility of dealing with bulks of data for validation, settlement and billing on the lowest household level.

One potential simplification for these issues could be to gather all information and only assess it on an aggregated level. For guaranteeing the reliability and stability of the power system, technical validation happens nowadays on the connection points to the transmission level. Based on the previous ADDRESS works, one could state that the lowest relevant level for technical validation might be the load area. AD consumers will always be assigned to one particular load area operated by a DSO. A cluster of load areas will belong to one particular macro-load area operated by a TSO. AD consumers are free to choose their retailer and aggregator (as both are deregulated market players). The example in *Figure 16* is simplified: the four load areas correspond to a DSO (1-4) and altogether belong to the macro load area of one TSO. In load area 1 only one retailer is doing business together with one aggregator on the same connection point (note that in reality, there will be much more households in a load area). In load area 3, there are two different retailers combined with two different aggregators depending on the connection point.

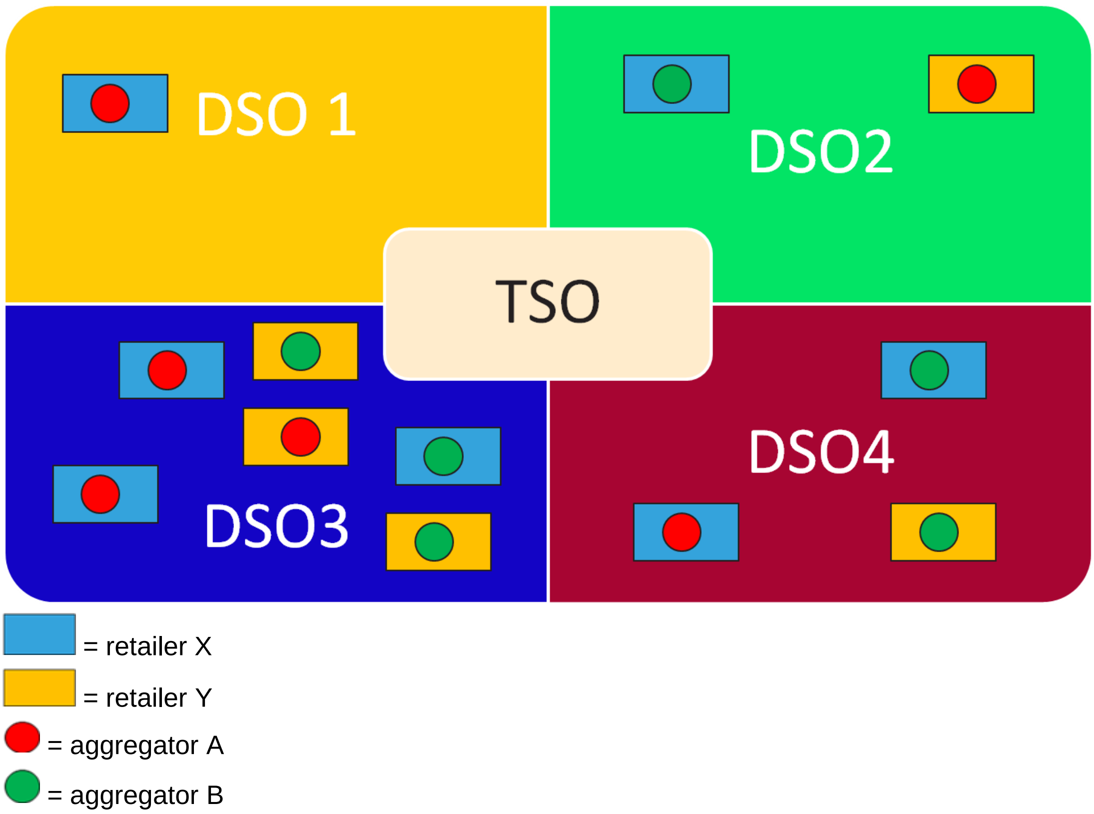

Figure 16 - Overview TSO-DSO-retailer-aggregator per load area

Based on statistics, retailers nowadays manage and predict their portfolio quite well thanks to the law of the large numbers. One could assume that aggregators will learn to estimate the effects of price/volume signals on a portfolio of AD consumers offering flexibility through the E-Box although this may counteract the intended effect of AD.

Assume now that the predictions as made by the retailer (reference baseline) and aggregator (predicted changes) are assessed on the level of a load area, see Figure 17. Note that the X-axis represents a fictional period of time and the y-axis represents a fictional volume of energy, units therefore have been abandoned. For load area 3, the total operational result will be measured on the connection point to the transmission network (see Figure 18). Note that in real life there is no distinction between the individual contributions to the load for retailer X, Y and aggregator A and B, only the total load for this load area will be measured.

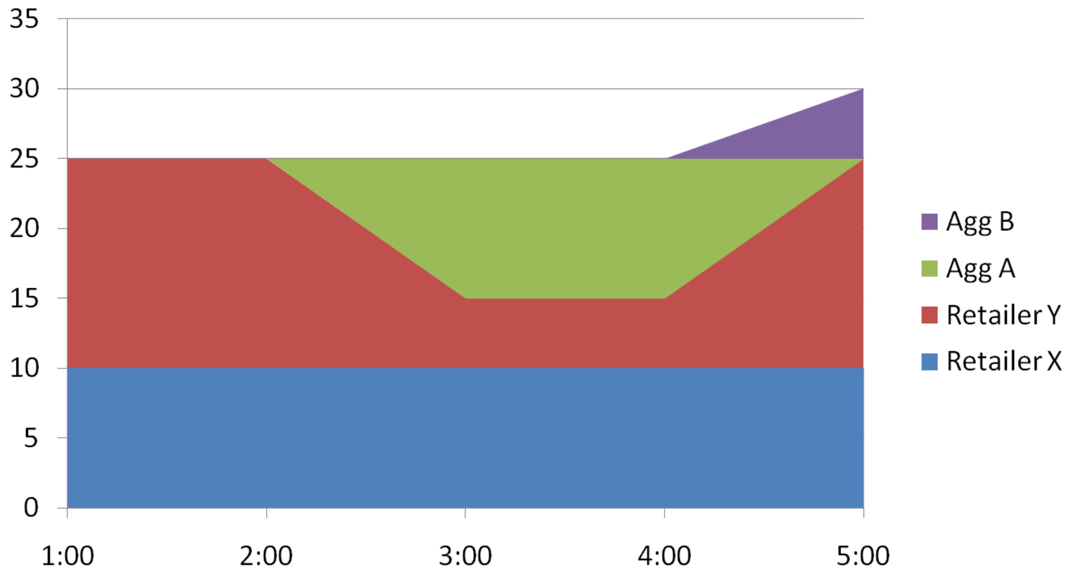

Figure 17 - Predicted profile for load area

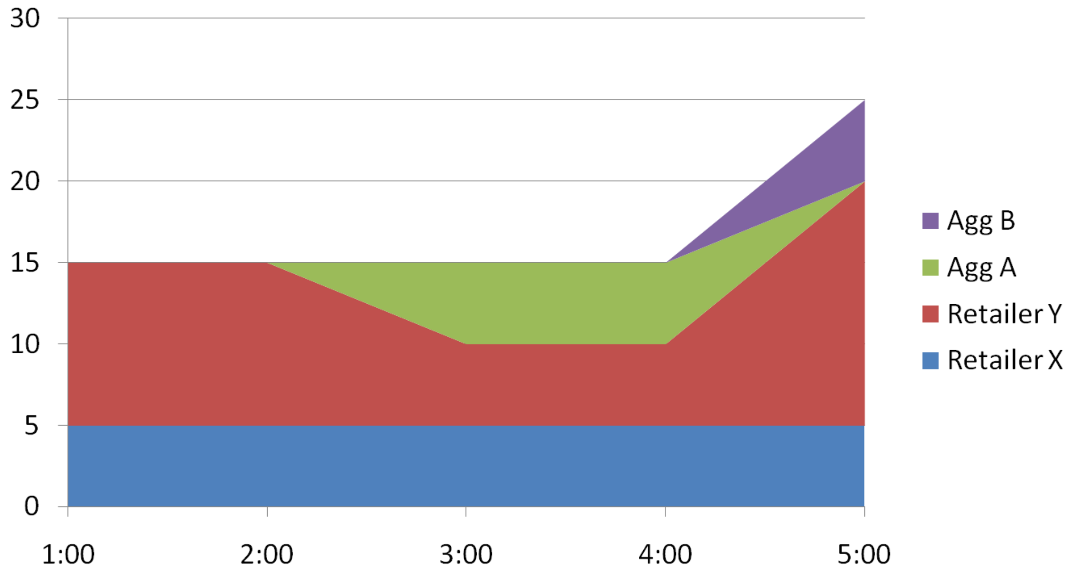

Figure 18- Measured profile for a load area

The monitored profile will be compared to the predicted profiles, as estimated by the market players that are active within that particular load area. This comparison will result in a certain imbalance for the considered timeslots. The imbalance is the difference between the realized profile and the predicted aggregated profile by retailer X, Y and aggregators A and B, see Figure 19.

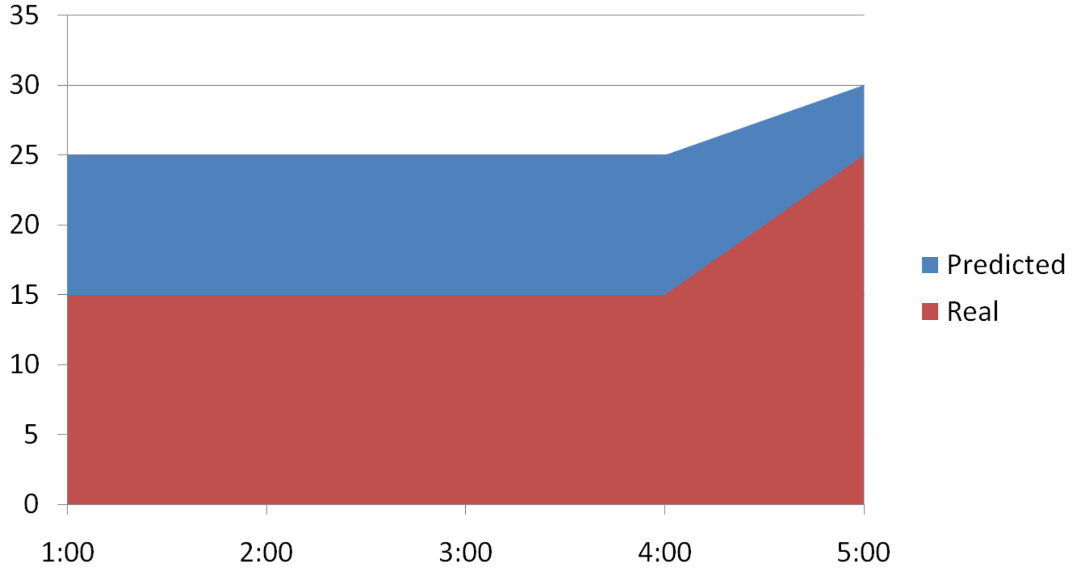

Figure 19 - Comparison predicted profile and measured profile for a load area, resulting in imbalance assessment

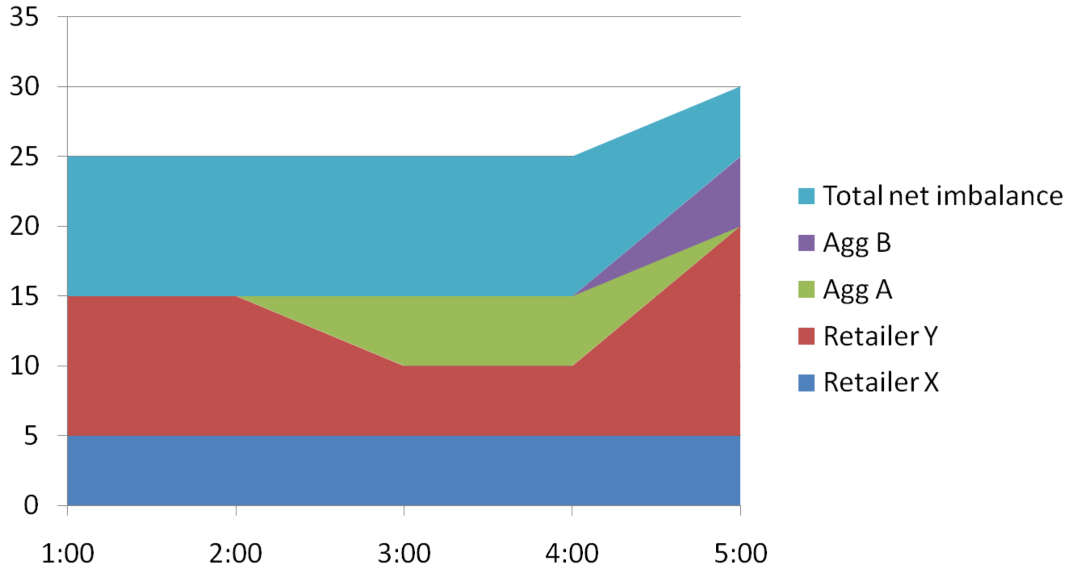

Figure 20 - Real operational positions of the market players within a load area resulting in imbalances

The cost of dealing with the imbalances for every timeslot will have to be charged upon the market players who are active within that particular load area. However, the exact real division of the imbalance contribution caused by each individual market player (namely retailer X and Y, aggregator A and B), as depicted in Figure 20 and to be compared with the individual predictions of those market players (Figure 17) will not be known, due to the lack of an objective reference baseline and the fact that more than one market player affects the behaviour and thus the profile of the end consumers.

It is not trivial to solve this issue without ending up having extremely high expectations towards technical monitoring and measurement equipment on the lowest level (household) and without still keeping some doubts about the fairness of the imbalance allocation process.

Although this was already identified earlier in the ADDRESS project (IR1.34c) as being a potential barrier, it should not be a blocking one. The challenge is to find a way of assigning the costs of imbalances on the aggregated level in such way that it becomes an acceptable and manageable risk for the market players who are exploiting activities within that particular part of the network (load area).

In the case that the aggregator would be the same market player as the retailer, the resulting situation is comparable to the situation of today (Figure 21), except that the retailer is also deploying aggregating activities and should not only take those effects into account for its own business but also optimise them for its own portfolio and/or to offer services to other market players.

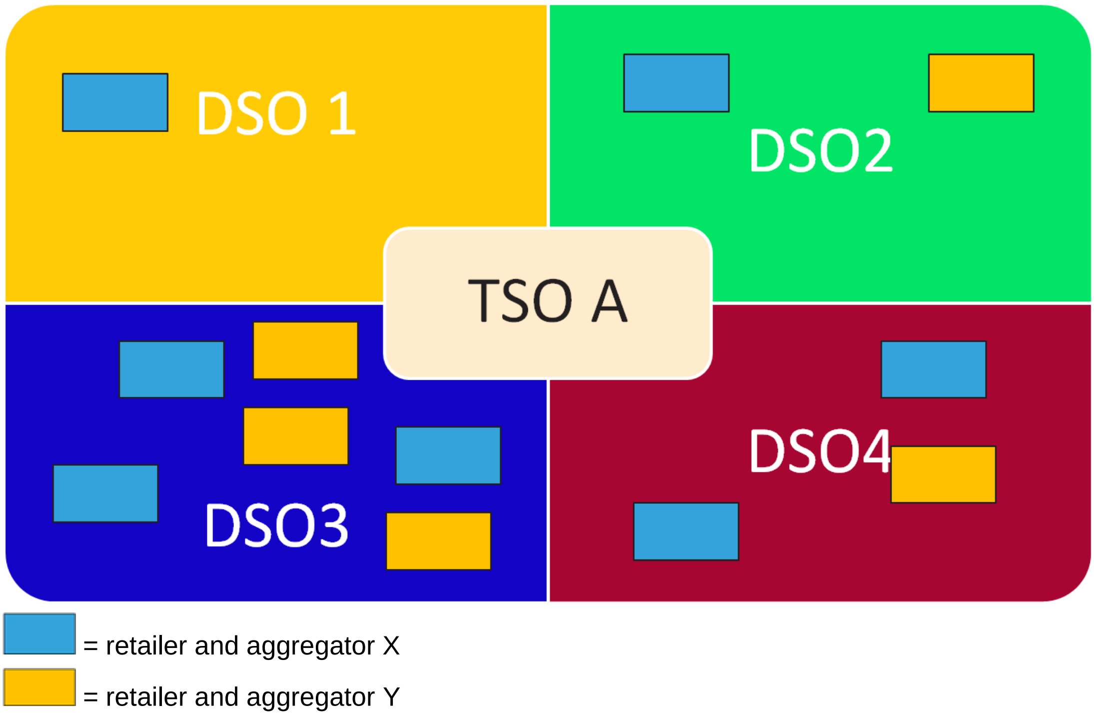

Figure 21- Overview TSO-DSO-retailer/aggregator per load area

In the more complicated case that retailer and aggregator might be different actors, the means to divide the measured imbalance costs on aggregated level among the market players within the particular load area are:

- The predicted profiles by the individual market players
- The sum of the measured profiles on the access points (smart meters), being the result of the activities of the retailer and the aggregator on that particular point

Nowadays, the imbalance costs on that level are subject to an allocation and reconciliation process, which in some countries without smart meters, can be time consuming. Once smart meters are widely installed, and by means of the information in the "access register" owned by the DSO and containing relevant information for each access point (i.e. the current retailer supplying energy on that access point), it should be possible to easily aggregate the measured profiles until the level of a load area and split up per retailer.

It could be then an option to assign the imbalance costs to the respective retailers and not to charge the aggregators (see the discussion earlier in this chapter).

Another option would be to define a commonly agreed division factor to assign part of the imbalance costs to the aggregators who are active in those load areas. Some basic rules could be then applied:

- Imbalance costs can only be charged for the timeslots in which the aggregator was indeed impacting the consumer behaviour by sending price/volume signals and predicting this change in its nominations towards the system operator. In the example of this chapter (Figure 17): aggregator B can be only charged for a part of the imbalance costs between moment 4 and 5, while aggregator A predicted activities between moment 2 and 5.
- The share of the imbalance costs assigned to each market player could be different whether it concerns a retailer or an aggregator, see Figure 22.

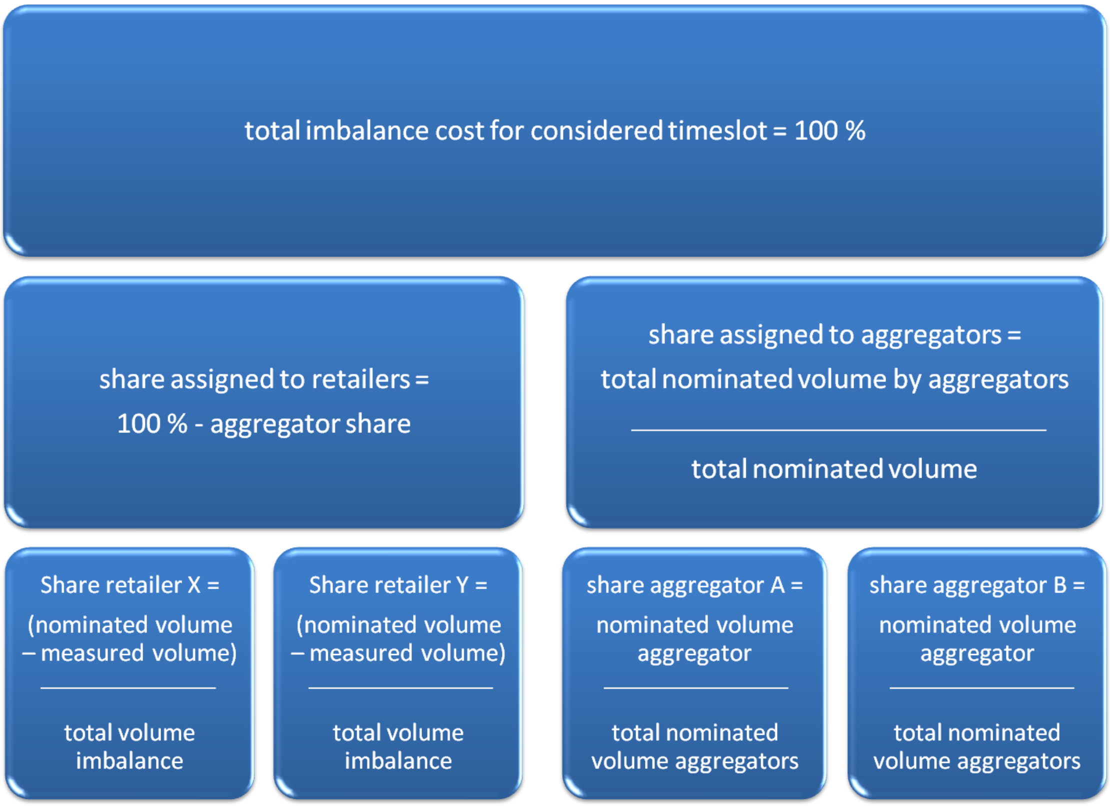

Figure 22 - Example cost sharing imbalance costs per load area

In this method, it is assumed that the baseline to determine the actual imbalance costs on load area level is the same as nowadays: the measured profile on aggregated level. The share of costs assigned to the aggregator will be based on their aggregated predicted profiles compared to the global load in that load area (the sum of all nominations) assuming that it is impossible to measure the actual performance of aggregators. The remaining imbalance costs are assumed to be caused by the retailer but will then be divided according to the measured aggregated profile per retailer portfolio in that particular load area (as it is done nowadays). Summarising, this method results in parts of the imbalance costs being transferred to the aggregators according to their pretended impact on that load area.

Although the proposed method for cost assignment is not exact, measured on the lowest level and thus subject to potential discussion, it would be a practical method to assign system costs in a reasonable way by spreading the risk among multiple partners. The idea behind this cost sharing model, is that each market player is responsible for its own activities and should be driven towards maximised efficiency and minimised costs by optimising its activities, estimating the effects of its activities on the system and informing the system operator as good and complete as possible.

Again it should be noted that the most likely player to perform the best in such activities will be the existing retailers. In case there are a number of aggregators pretending to offer huge flexibility by nominating big deviations compared to the existing nominations while not making it true in practice, they will be penalised and out-competed in the long run.

Nevertheless, to make the actors confident with the AD, a solution could be to find a way to assess as well as possible the deviations induced by the aggregator.

4.3.2. Elements on the measurement of AD deviations in the wholesale markets or in the local areas

Measurement is a key point to make the TSO confident with AD activity: without measurement, there is a major risk of lack of credibility and, as a result, AD product could be forbidden in power markets.

In previous sections, it is said that it is very difficult to measure the AD realised, so alternative methods are developed. For instance, a solution for balancing responsibility is proposed.

Admittedly we do not know at this point how to measure the real AD profile, but an agreed methodology to estimate/calculate as accurate as possible the AD deviation at the aggregated level, has to be investigated.

Measurement is also crucial at the distribution level and whatever the option retained (curtailment, re-dispatching…): how should the DSO verify if the nominated AD has been activated in his load area? If the non-allowed AD product has not been activated? One of the key questions is how to assess if the load reduction was initiated by the aggregator or by the AD consumer himself / herself. Measurement is also a serious issue of concern for the aggregator for instance regarding how to fairly compensate his AD consumer.

The objective of this document is not to describe these potential technical solutions for measurement. We can just say that the licence for playing on the wholesale market should be adapted in order to define the method of measurement implemented.

If the methodology for measurement requires data from the E-Box, regulation could set up a process for certifying the E-Box data. For sure, the E-Box is not a meter and so its data are not reference data. Maybe a process of certification including a certification for measurement with possible controls/audits could be imagined.

Measurement and control aspects remain a key issue to be investigated in ADDRESS.

Let us add that such sophisticated solutions are not necessary in the case of an integrated aggregator - retailer. In this case, reactions of the AD consumer to the aggregator's signals are automatically integrated in the retailer consumption's perimeter. So the measure of the consumption is sufficient to verify the unbalances of the retailer.

5. Regulation

This chapter presents the results regarding the identification of regulatory issues which may have an influence on the development of AD; the separation of these issues into those which can be solved by adapting existing regulation and others which need a more sophisticated regulatory design; and for the latter ones, the proposal of regulatory solutions.

5.1. Regulatory tools as facilitators for ADDRESS options

Regulation plays a key role in electricity markets across the world, and also in Europe. Although there has been a push for more liberalized electricity markets, following several European Commission directives, the power sector remains a highly regulated one.

This includes of course electricity transmission and distribution, which are still considered natural monopolies and are therefore fully regulated, although under private management in some cases. But also generation and retailing, which are in principle deregulated in many countries in Europe, are subject to many regulations: those guaranteeing fair markets, those promoting different energy technologies, or those protecting consumers, more particularly those more vulnerable (in many countries through default tariffs).

Therefore, the introduction of AD into the power sector has to take into account regulation, as one of the most important drivers (or hindrances) for the development of its products.

We may think of four possible ways in which AD can interact with regulation:

- AD may need specific regulation for its development: for example, and given its regulated nature, DSOs or TSOs may require specific rules for using or buying AD products.
- The development of AD may find regulatory barriers: for example, if the costs and benefits due to AD activities are not duly allocated because of previously existing regulatory regimes (again, in particular for regulated agents) then participants in the power sector may not realise the benefits they expect from AD.
- Some AD activities may have an impact on current regulations: for example, the installation of smart meters and energy boxes by aggregators or retailers may deter switching, and therefore require additions to the existing rules on this issue.
- Finally, there may be other instances where AD can be integrated almost seamlessly into the current regulation and therefore will not find obstacles, threats, or particular requirements. A good example is price control, unfair competition, etc., which are already addressed by existing regulation in most countries, and would only therefore require to add this new relationship (consumer-aggregator) in the areas covered by the existing regulation.

The objective of this section is to present all the possible interactions that may arise, classify them, and provide solutions for those issues which are deemed relevant or which require a specific solution.

The way to proceed is represented in *Figure 23*. First, we have identified those issues which required a regulatory approach (that is, those not covered adequately by market and contractual tools); then, we have analysed if the current regulations are able to integrate this new AD requirements. If not, then we have studied possible regulatory solutions.

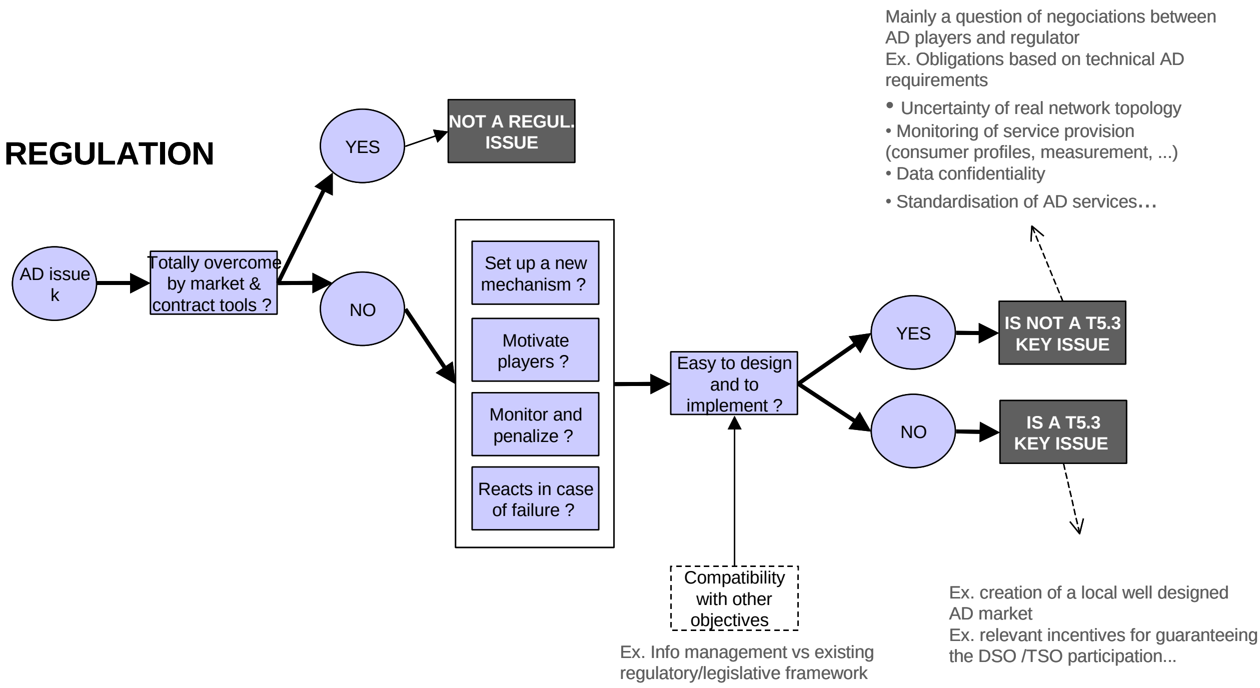

Figure 23 - Methodological scheme used for indentified regulatory issues

5.1.1. Step 1 – Review of the regulatory issues for AD

This first step has consisted in the survey among WP leaders of the regulatory issues which they envisage as significant for the elements considered in their Work Packages.

Among AD issues already identified in other WPs, some of them just need a very light regulatory answer in order to be solved. In these cases, AD players must just verify during negotiations that the regulator takes into account technical AD requirements as defined in ADDRESS technical WPs. Other issues may prove more difficult to solve.

In the following paragraphs we describe the issues pointed out by WP leaders. These issues have been regrouped for consistency, and therefore do not necessarily follow the order in which they have been collected.

- Data and infrastructure ownership

  Who owns the data and the infrastructure (smart meters, energy boxes, smart appliances). Probably this ownership has to be distributed among consumers, DSOs, aggregators or retailers. The final decision will have an impact on the following item, cost recovery. Given that DSOs are regulated, cost recovery must be ensured. But aggregators or retailers are not regulated, and therefore the recovery of the costs in which they incur should be subject to market considerations.

- Cost recovery of fixed costs: validation, measurement, settlement, information on load areas

  The provision of AD products entails significant fixed costs, such as settlement and validation of agreements, measurement, and information services. Some of them may be easily integrated into existing schemes (e.g., settlement services at power exchanges); other must be done by DSOs and TSOs (e.g. information on load areas or AD validation); other allow for more flexible decisions (measurement may be done by DSOs, by aggregators-retailers, or by third parties). Again, depending on who provides the service, cost recovery must be regulated or can be left to market forces. Therefore, the regulator must decide: first, who does it; and second, how to recover costs (including who pays for the service).

- Incentives (permanent or temporary), allocation of costs and benefits

  If AD services are beneficial for society (mainly because they reduce the cost of providing electricity, or its environmental impact, or the risk of non supply), then this is because the benefits they provide are larger than their costs. The difference between benefits and costs is the profit, the incentive for agents to provide these services. Therefore, one might conclude that there is no need to regulate this incentive, because that can only lead to inefficient decisions. However, life is not that simple.

  First, as with many other initiatives, start-ups are costly and may require additional incentives to overcome cultural, behavioural, or lock-in barriers. Therefore, the regulator may be interested in providing these temporary incentives to jump-start the participation of AD in the power sector.

  Second, although AD in global terms may result in a positive profit, this does not mean that the profit for all agents may be positive: some of them may lose (e.g., electricity generators may lose revenues because of the reduction of demand induced by AD programs), some may win more than their fair share, due generally to the existence of regulated and liberalised agents, but also to other reasons. And, if one agent loses, he may not be interested in participating and therefore may break the chain, not allowing for AD to take place. Again, regulators may have to correct the allocation of costs and benefits, so that there are no cross subsidies or unexpected outcomes, and that AD can take place through the participation of all agents involved.

- Market rules

  Potential barriers that should be avoided could also be the lack of market access of potential providers and users of AD products, e.g. due to minimum power requirements for the participation in balancing energy markets, or in day-ahead markets. This issue is analyzed in the section on markets.

- Regulation of distributed generation

  The way distributed generation is regulated (and promoted) may also have an impact on AD. For example, when flat feed-in tariffs are used for DG, these do not provide any incentive to manage their imbalances, and may therefore reduce the interest for them in using AD.

- Relationship between players: particularly regulated ones

  DSOs and TSOs are expected to play a large role in AD: they will demand AD services (if they have the right incentives, see below), and therefore will have to participate in AD markets. However, given that they are regulated agents, they cannot participate freely in these markets, but rather they must follow rules and protocols that prevent the misallocation of public funds. Therefore, specific procedures must be devised, for example, for tendering the provision of AD services, or for deciding the amount of AD that must be contracted. Furthermore, rules may be needed to avoid negative implications of a potential conflict of interest that may arise when network operators are users of AD and, at the same time, have responsibility of validating if AD used by other parties is feasible from the network's perspective.

  All other agents can be left to deal with one another freely in the market. However, there may be one exception: consumers, which due to information asymmetries may require some level of protection (see below).

- Issues regarding consumer switching

As mentioned before, AD services and infrastructures may complicate the existing situation in retail markets. First, a new agent is introduced, the aggregator, which may even require a separate bill for AD; second, new technological barriers may arise, such as the use of proprietary smart meters, energy boxes, and such. This may make more complicated for a consumer to switch among retailers and aggregators. Therefore, specific provisions will have to be made to avoid that the introduction of AD deters the efficient functioning of the retail market.

- Consumer protection regarding data privacy

  One of the major concerns of smart grid developments is the increased possibility to access consumer data and to use it for the wrong purposes. Part of this problem already exists: DSOs and retailers already own data from consumers, and regulation exists to care for their privacy[26]. However, the huge upscaling of the data may require new approaches.

- Consumer protection against excessive costs

  Another idea related to consumer protection is the use of AD for vulnerable consumers: the mandatory installation of energy boxes may result in an increased protection of this customers from large energy expenditures. Indeed, these consumers may be benefited from an optimized management of their energy consumption through AD.

- Require TSO/DSO to manage their systems efficiently (including allowing for the recovery in fair terms of AD investments and operational expenditure as compared to grid investments)

  This concern may be summarized as: efficient regulation of TSOs and DSOs. If an efficient regulation is in place, then TSOs and DSOs will always have the right incentives to use AD services when it is beneficial for the system. Unfortunately, this is not the case in many member states, which feature remuneration schemes that make it more profitable for the SO to invest in grid additions (or, in general capital expenses) instead of recurring to AD services (which are usually operational expenses). The solution here is not to offer additional incentives, but to modify the existing regulation so as to provide the incentives itself. In this context, it should also be ensured that existing principles for regulation of TSOs and DSOs do not lead to disincentives in the context of AD application. For example, if AD would reduce peak load and peak load is used as a benchmarking parameter to assess a DSO's efficiency, the DSO might be reluctant to make use of AD. Such disincentives need to be avoided.

We should note that, although in many cases we talk about TSOs and DSOs equivalently, it is true that the existing knowledge and familiarity with sophisticated tools for operating the grid may be very different among them (even with large differences among DSOs). Therefore, sometimes DSOs may require a specific treatment.

5.1.2. Step 2 – Classification of issues

From the list above, a first analysis has been carried out to sort which issues may be addressed by adapting existing regulation (termed here "simple" issues), and which ones need more sophisticated solutions ("complex" issues).

We consider that the following items may be integrated into the existing regulation without serious problems:

[26] As mentionned in "Smart Grids: from innovation to deployment" - April 12th 2011: "Directive 95/46/EC of 24 October 1995 of the European Parliament and of the Council on the protection of personal data constitutes the core legislation governing the processing of personal data. The Directive is technology-neutral and the data processing principles apply to the processing of personal data in any sector, so also cover some Smart Grids aspects".

- Consumer protection and privacy: regulation already exists for consumer protection in many areas, including the electricity sector. However, data flows for AD, as for smart metering and smart grid in general, introduce a new risk level for privacy in the power sector (linked to the new real-time nature and volume of the information collected). The question is whether this regulation must be performed just within the power sector, or should be integrated into a larger framework (which for example includes data collection through the internet, etc.), given the many parallel cases which may arise.
- Recovery of fixed costs: although it seems that this may be a complex problem, the truth is that the real problem is not to recover fixed costs[27] (this is already done in most power systems for many costs), but rather to determine which are these costs, and who should pay for them. This is addressed in the "complex" issues section: infrastructure ownership, and allocation of costs and benefits.
- Temporary incentives: being temporary, their determination and integration with other incentives (and their compatibility with them) do not seem to pose major problems.

In the contrary, the following issues may require more thoughtful consideration:

- Data and infrastructure ownership
- Allocation of costs and benefits
- Consumer incentives and switching
- Coordination between regulated players
- Efficient regulation of TSOs/DSOs

An additional issue is market rules. This has been identified as one of the possible barriers for AD. However, given that Chapters 3 and 4 deal specifically with markets, this issue is not be addressed in Chapter 5.

5.1.3. Step 3 – Regulatory solutions for complex issues

Finally, for those issues which require more thoughtful solutions, we propose regulatory alternatives, also based on the preliminary analysis carried out in Deliverables D1.1 and D1.2 (see references).

However, some of these issues are outside the scope of this project. For example, the efficient regulation of TSOs and DSOs has a much wider scope, and in fact is currently being addressed both by the European Commission and by many member states. Therefore, it does not seem sensible to hold a partial discussion here. The same goes for the infrastructure ownership: many member states are already deploying smart meters, and therefore the decision has already been made on the property of this equipment. A review of the major elements in this discussion may be found in Batlle and Rodilla (2009).

Anyway, although no regulatory solutions will be provided for these issues, we will still inform on the problems that may arise for AD because of the existing or expected regulation.

Before starting, one important idea: regulation is not an end in itself. Regulation will always be acceptable to remove pre-existing, non-efficient barriers (be them market failures or other type of institutional barriers). However, regulation as a driver for the development of AD is not always desirable: the costs and benefits of AD and of the regulation required have to be carefully measured to prove that regulation is indeed beneficial for society.

[27] Unless there are problems to recover these costs because of the desire to keep electricity tariffs low.

Unfortunately, there is not much literature on the regulation of AD. Although some proposals have been put forward on the regulation required (e.g. Centolella and Ott, 2009), they have generally been limited to those systems where small retail is not liberalized, contrary to what we deal with in this project.

5.1.3.1 Data and infrastructure ownership

As mentioned before, we may divide between data and infrastructure ownership.

Concerning the **data ownership**, it seems clear that the consumption and appliance data belong to the customer, who must always transfer them to the relevant party: the DSO, the retailer and the aggregator, under the usual data transfer conditions. The technical data (energy and power consumed, technical parameters) must be known by the DSO, and in the case of energy and power consumed, also by the retailer and aggregator; but the commercial data (energy prices, total bill, etc) can only be known by the aggregator or retailer.

The ADDRESS project assumes in general that the retailer and aggregator perform different functions, but may be the same agent. Therefore, in the following, we will cover both alternatives.

Here arises an important issue, the separation of aggregators and retailers, which can pose an additional complication concerning **data access**: some data must be transferred to both, and some to only one of them. This will require separate data channels, but also communication between them: sometimes aggregators will need to send information to retailers and vice versa. The aggregator may also need the load profile or the prices paid by the customer, which are known by the retailer. Of course, this might be avoided if all communications were managed by the customer. However, it seems a bit unrealistic to think that the customer will be able to manage this large amount of information. The regulator could then define which data are necessary to be shared and exchanged in free access between the aggregator and the retailer (other data being available via commercial services). Or it could impose that the two entities sign an agreement. This regulatory decision could be dependant on the national context.

Regarding the **ownership of infrastructure**, some discussions have been held in many countries, usually related to smart meters. Batlle and Rodilla (2009) cover nicely most of this issue, offering also additional references.

In principle, in most electricity systems the distributor is responsible for metering activities. International experience is inconclusive in this regard and indeed, a number of alternatives have been implemented, most somewhere between the two extreme approaches. The first is to liberalize completely (or better still, to explicitly state that the regulator's position consists in leaving the decision on the advisability of change to actors' initiative) and the second to regulate completely (leaving no decision-making capacity to any agent, instituting an equipment renovation timetable and clearly defining the technical specifications to be met).

Inasmuch as the renovation of metering equipment is expected to constitute one of the key factors for the development of retail business, maintaining metering as a regulated activity, responsibility for which is therefore attributed to distributors, is the most appropriate alternative to launch the development of the AD tools, since it is the only way to guarantee that the necessary meters (able to provide up to fifteen minutes measures) will be available for every consumer interested in managing demand actively

The basic conclusion is that smart meters can be separated in two elements for regulatory purposes:

- The metering element
- And the interface with the customer (e.g. for sending time-varying price signals)

The metering element is clearly a regulated one, and is generally considered to be a responsibility of the DSO (although its management can be subcontracted, as currently is in some countries, or done by a separate metering company, not linked or subcontracted, as in the new German legislation).

The interface with the customer (which may be loosely defined as the E-Box) is however a non-regulated part, and therefore its ownership does not need to be defined. It may be owned by the customer, or by the aggregator, or by the retailer, depending on the different business models that may be implemented.

Of course, this does not mean that this is an easy task: the Chapter 2 on contracts looks at this issue, since aggregators must be able to recover the cost if they are the ones owning the equipment, but at the same time they must not impose too strict requirements on customers which may prevent switching.

In this regard, rules must be defined on the conditions that can be demanded by aggregators to install such equipment in consumers' homes. Primarily, the regulator should supervise and authorize each aggregator's AD equipment, guaranteeing minimum installation fees and limiting the commitment to a reasonable duration that does not condition possible medium-term changes[28].

The major regulatory issue is to ensure that the two elements are compatible: that is, that the E-Box and the meter are able to communicate under a standard protocol, so that there will be no problems for switching supplier (see the discussion below.

The regulator might also require that both the meter and the E-Box use the same communication channel (e.g., the power line). However, that is less clear: wireless communications with the E-Box may be much cheaper than using current power lines (used by the meter).

5.1.3.2 Allocation of costs and benefits

AD brings different benefits and costs to different agents in the system. Even if aggregated benefits exceed aggregate costs, the uneven distribution of the benefits and costs may result in some agents not having enough incentives to participate in AD programs, so the regulation must ensure that benefits and costs are correctly allocated. We now go on to review the costs and benefits borne by the different agents:

- Consumers: consumers will benefit from lower energy costs (due to a more efficient operation of the generation, transport and distribution system) and from a better quality of service. In turn, they must pay (depending on the business model) the E-Box, and in some cases, penalties for not delivering AD. We assume that comfort levels are not changed. The critical issue here is the extent to which the savings achieved in the system (lower generation costs, lower transmission and distribution losses, etc.) are passed through to the consumer. If regulated tariffs do not allow for an efficient pass-through, then the consumer may not be interested in participating in AD programs. However, if the aggregator pays the consumer directly for their services, then there is no need to regulate (except for consumer protection issues, such as not being charged excessive prices). Indeed, if gains are not enough for the consumer, he will decide not to participate. The regulator should only care about whether the consumer is adequately informed.
- TSO/DSO: Network system operators will benefit from a better operation of their system, and lower costs in doing so. In addition, they may reduce or delay their investment needs to achieve the same level of service. The costs incurred will be those paid to the aggregators to buy AD products. Again, for a correct allocation of costs and benefits, grid operators must be able to realize effectively the benefits. If the remuneration of the grid operator is based on capital

[28] Of course, privacy and cyber-security issues need also to be taken into account.

expenses, but not on operational expenses, then grid operators will not be able to observe any benefits from AD (see the section on efficient regulation of TSOs/DSOs), and therefore they will not be interested in engaging in the system. As for the consideration of the costs, it will depend on the regulation of the grid.

Another possibility is for regulators to impose on grid operators the obligation to incorporate AD options in their operation and planning. In this case, these costs should also be recovered. However, due to the liberalised nature of retail and aggregation a procedure must exist to ensure the competitive supply of these options from the aggregators to grid operators. However, this does not solve the problem that the costs may be unknown by grid operators at the time of planning.

Finally, another alternative would be the development of AD services directly by the DSO/TSO. This would imply changing the current unbundling rules that prevent DSOs and TSOs to perform generation or retailing activities.

A different issue is the allocation of the costs imposed by AD validation: in this case, existing regulation should be enlarged to cover this cost category.

Finally, we should also take into account that, for some DSOs, additional costs may arise to comply with the new technical requirements.

- Aggregator: The aggregator is in a fully liberalized environment, so here the allocation of costs and benefits will require less regulation. Basically, aggregators will appropriate part of the benefits obtained by consumers through AD, in exchange for a better risk management (this will depend on the business model). The regulator should only guarantee that aggregators have a fair access to consumers.
- Retailers: Retailers will be affected by the introduction of AD, particularly if not integrated with the aggregator. Indeed, when aggregators are separated from retailers, care should be taken about fair access and also about the costs imposed by one on the other.
- Generators (or any other non-regulated buyer of AD products): The change in the load curve, or the change in the operation schedule of power plants, may change due to the introduction of AD services: for example, less peakers will be required by the system, or more renewable energy may be produced. This will in turn change the profits of all existing power plants, in some cases increasing them, in others reducing them. This may lead to unexpected losses by some power plants, which will not be able to recover their investment costs. Some transitional regulation might be required to account for this situation, if the penetration of AD is large enough to justify it, and also if we assume that the rules have changed for the investors.

5.1.3.3 Consumer incentives and switching

One of the problems usually cited is that small customers are too risk-averse to like to be exposed to real market prices, and in fact most of the evidence shows that in liberalized retail markets consumers tend to prefer hedged contracts, or flat tariffs (e.g. Littlechild, 2003).

This again might change through technology and regulation:

- the development of energy boxes, which automatically optimize consumption subject to certain constraints, may help consumers hedge their exposure to price volatility, and in fact some studies (Faruqui and Sergici, 2009) show that small customers do respond to price signals.
- a regulation that prevents unfair competition by default regulated tariffs. We discuss this issue further below.

The existing regulations in the EU provide for the disappearance of regulated tariffs; at this writing, their replacement by the tariff of last resort is in the process of being defined. Unfortunately, in many electricity systems this liberalization process is unlikely to affect small-scale consumers in the short or even the medium term.

This inevitably poses the need to reflect on the best way for AD services to co-exist with a potential, regulated tariff of last resort which, judging from present tariff design, will consist in a default tariff. If the default tariff is a flat, cheap one (as usually preferred by customers), then it will represent a very strong disincentive for participation in AD[29]. On the other hand, if the default tariff is real-time-pricing based, then it will leave no space for improvement. Therefore, the default tariff should probably be designed as a flat tariff, but high enough, so that there is space for retailers or aggregators to develop different business models.

Another issue is consumer switching: although, on the one hand, AD may provide new opportunities for retailers and aggregators to attract new customers (and therefore enhance switching rates), the need to pay for the AD equipment may represent a significant barrier of entry. If, for example, certain energy boxes are only compatible with certain smart meters, DSO-related retailers and aggregators might have an unfair advantage. The same would happen if energy boxes are used by retailers and aggregators as proprietary equipment, unable to work with other suppliers.

The regulatory response to this problem lies in the standardization of the communication of energy boxes to smart meters, to prevent previous suppliers (usually the incumbents) from abusing from their market position, and also to facilitate switching. This can also be achieved by setting a maximum duration for the retail contract.

Additionally, in order to stimulate consumer switching, it may be temporarily required to prevent incumbent-related aggregators/retailers to contract with customers served by their mother-company DSO. Although the regulation is in place (unbundling; Chinese walls[30]…) to prevent problems in this extent, and it is highly efficient in some countries, it is also true that consumers are usually averse to changes and this may direct them to bad economic decisions in these cases. This might however be a strong barrier in some situations to the quick development of a liquid AD market. And of course, this is a global regulatory problem for the electricity market, not just an issue of AD.

5.1.3.4 Coordination between players

The role of the grid operators, i.e. the TSO and the DSOs, and how their relationships with the rest of the system agents should be arranged and regulated (to allow the maximization of the AD beneficial impact for the overall electricity system efficiency) are undoubtedly among the most intricate issues to be discussed.

Network system operators' main responsibility is to manage the system trying to maximize the system security in the more efficient way. As stated, AD is expected to be a major contributor to this optimization, providing grid operators with a novel resource that allows a more efficient management of the system not only in the short term (reducing the costs of reserves, the congestion management mechanisms as well as emergency protocols), but also in the long term (allowing to at least postpone grid reinforcements). Grid operators are at the same time validators of AD planning and potential

[29] This problem does not occur if we consider the remuneration for AD as something to be paid separately (i.e. additionally) to the default tariff.

[30] "Chinese walls" means measures (e.g. legal unbundling, unbundling of information systems etc) put in place to prevent information exchange between two departments of an integrated company operating regulated and deregulated activities: it is a light requirement to ensure that, e.g., distribution and generation activities are run independently within a utility. These measures are monitored by the regulator.

buyers of AD products.

The main complication lies essentially in the following facts:

- As well as in the case of many other regulatory discussions (e.g. the need for implementing additional security of supply mechanisms), the optimal design has to take into consideration at the same time technical criteria (led to maximize system security) and economic criteria (aimed to increase markets efficiency). Unfortunately, more than often these two objectives are conflicting. This fact implies the need to opt for a compromise solution, which could adequately balance both objectives.
- TSOs and DSOs are linked through the grid, so often TSO's managing decisions have an impact on DSOs duties and the other way around. The first consequence of this is the critical need for strong coordination and clear definition of hierarchical procedures. And moreover, from both point of views, the best alternative to manage a system operation event is not necessarily coincident: the value of a particular AD action in the TSO utility function can be different from the one that represents in the DSO's.
- Electricity network and system operation are by nature monopolistic activities, so all the procedures developed by the grid operators should be under the strict supervision of the regulator, and at the same time, they should not get involved in the market game (i. e. any purchase of flexibility should be made under special circumstances assuring total transparency).

But, as previously mentioned, AD emerges as a key alternative to increase the efficiency of the grid operator's duties, so the key analysis required is whether there are already mechanisms in place to allow making the most of AD, which adjustments should be made if required in the existing ones and which new ones should be implemented and how should they be designed.

Until now, all these ancillary services mechanisms have been implemented at high voltage level, so the actions taken by TSOs have barely had any impact on DSOs operation (except in emergency cases in which major load shedding had to be implemented). The development of AD, together with the increasing penetration of distributed generation in their networks turns to be a major challenge for DSO, since they will have much more alternatives to efficiently operate and plan their grids. But AD is not just a source of flexibility at local, low voltage level: as above stated, it is expected that it can also suppose a key contribution for the overall system operation. Therefore, in the upcoming scenario it will be crucial to design efficient procedures to assure the grid operators coordination.

The importance of respecting each others' "jurisdictions"

One of the main novelties behind the implementation of AD will be that for the first time there will be a factual opportunity to send discriminated operation signals to low voltage consumers, and as stated, this will completely change the way DSOs will have to manage their grids. These consumers will be able to modify their previously scheduled (or estimated) consumption and moreover, they will be able to do it at short notice, responding in principle to their retailers' commands.

These AD actions could eventually change the load flows in the distribution grids, what might affect to the stability of the networks if DSOs are not properly informed, with sufficient prior notice.

Therefore, in order to guarantee system security, it will be of major relevance to design operation procedures to coordinate the TSO with the different DSOs, in which the hierarchy of powers is clearly defined (who does what, who must validate, etc.). While the first one is responsible of the overall system security, and particularly at the transmission level, DSOs have the responsibility of assuring the supply to the consumers connected to their networks. This of course may change in the future, if DSOs receive more responsibility regarding the security of the system.

Avoiding duplicities

First, even under the assumption that the distribution network topology has no impact on the actual results of the actions taken at the low voltage level (see below for a discussion on this issue), the coordination between the TSO and DSO will prevent any single customer (or aggregator) from selling the same product (capacity to modulate or even interrupt demand) to different actors. This can also be achieved through the validation phase for AD. The TSO may consider necessary to count on load flexibility in certain nodes of the transmission network, and therefore it would be interested in acquiring this service from the consumers connected to each of them. At the same time, the DSO managing the distribution network connected to one if these nodes may have similar interests in being able to resort to reducing at short notice the demand in its network under certain circumstances. It is pretty straightforward to notice that in many occasions both network operators will have the necessity to resort to the flexibility services at the same time[31].

Although it is true that this problem could in principle be solved by establishing efficient protocols of coordination and cooperation between both network operators, real life shows that this is more than often very difficult to implement, leading to a fuzzy regulation without the necessary hierarchical structure to guarantee the optimization of the resources. However, the final decision on this issue will depend on the significance of AD: if the real incidence of AD on the system is very small, maybe detailed protocols will not be required.

Valuating the impact of the distribution network topology

As previously introduced, at the same time, given their understanding of their own grids, distributors are the only actors able to measure the effectiveness for the system operator of reducing portfolio demand at a given node on its grids.

Technical management must abide by a hierarchical sequence in which each distributor requests flexibility from aggregators, verifies the effectiveness of each on the basis of the topology and specific characteristics of its grids and then establishes the volume of the reduction that can be placed on offer when so required by the System Operator.

Allowing the maximization of the efficiency of the AD services at local levels

While the TSO can be willing to contract AD flexibility to no matter which consumers connected to a transmission network node, i.e. assuming every MW reduced has equal value for its purposes, the DSO, since it is aware of the distribution network state in each particular situation, can have a different valuation of the different contribution of the consumers connected to the distribution network linked to the transmission network node in question.

This can be solved by a correct market design which allows each agent to reveal their valuation of AD. That is, DSOs and TSOs may participate jointly in AD markets, or they can be previously coordinated to attribute the right value for AD for the whole system.

Need for the TSO to define zones for allowing aggregators selling AD balancing services

Balancing mechanisms are in principle an ideal mechanism for aggregators to extract value from AD flexibility. Aggregators will have the ability to resort to the flexibility previously agreed with their

[31] For instance, this is the typical situation in the Spanish power system. Summer time (particularly August) is a hard period for the networks in the Mediterranean coast, due to the big population growth. This periodical juncture implies that both network operators might have AD services in these particular areas as an alternative to incur in the cost of reinforcing the networks.

customers (large and small, industrial and domestic) to modify the energy programs declared before gate closure.

However, to allow aggregators bidding their AD products to contribute to solve the nodal or zonal imbalances that might appear at the transmission network level, the TSO should predefine these nodes/zones. Therefore, aggregators should be able to distinguish among their AD consumers, assigning each one of them to their corresponding zone/node. Then, they should differentiate in their energy programs declared before gate closure the expected load in each of the zones, so it would be possible for them to subsequently submit nodal or zonal bids.

Need for defining areas in the distribution networks

Again, as we have discussed for the case of the TSO, DSOs will have to define differentiated areas within their networks, so aggregators can assign their corresponding clients and afterwards offer AD flexibility when and where requested. The configuration of these areas will have to be properly justified by technical reasons and if possible large enough to gather sufficient critical mass to allow competition. This information should be provided under non-discriminatory rules.

This should be requested by the energy regulatory agency in each country, who must also define the requirements regarding the level of detail and publication of the data.

5.1.3.5 Efficient regulation of TSOs/DSOs

As mentioned before, this is a very broad issue that goes beyond AD. However, here we will reflect upon AD-specific issues.

There are three elements to be regulated: the validation of AD planning (which is dealt with by other tasks in the ADDRESS project), the technical operation and the remuneration of the cost. On the one hand, the grid operator purchase of AD services should be subject to a specific operating procedure. On the other, the methodology for remunerating CAPEX and OPEX should enable the grid operator to earn additional profit by making efficient use of AD tools to minimize the cost of new grid investments. Standards should also be established as necessary to include AD measures in service quality measures, so that consented outages do not impact service quality indices. The validation of AD also entails costs which recovery needs to be regulated (but again, we leave that to other tasks of the project).

Regulation of grid operator's AD actions: operating procedures

European legislation prohibits distribution companies from conducting supply-related business and requires them to unbundle both the operations and the accounts of their regulated (distribution) and unregulated (retail) businesses. This restriction should not by any means be viewed as a limitation to distributors' participation in the AD activities under the terms established in the business architecture described above, but it does probably pose the need to redefine their role in regulation.

In much the same manner that the existing regulations govern the system operator's management of the flexibility service, distributors' participation calls for rules formulating specific operating procedures to regulate the ways in which they conduct and channel their AD activities.

Essentially, these procedures should ensure that:

- The AD resources purchased by distributors are acquired transparently and impartially, i.e., in public auctions supervised by the regulator. The bidders would be the system aggregators.
- The product purchased by distributors in such auctions is clearly defined and at the avail of the system operator at all times.

- The conditions under which the distributor may implement AD actions are clearly specified, along with the timing involved and the information flows to be established with the aggregators (and consumers) providing the service.
- Regulator supervision suffices to guarantee that distributors purchase AD products from aggregators under conditions in which all are treated equally (e.g., guaranteeing that the group's own aggregator/retailer is not favoured).

AD service purchase mechanisms

As noted, regulation should guarantee the distributor's absolute impartiality when resorting to DSR services. The mechanism proposed to contribute to transparency is for the distributor to call for bids from the retailers-aggregators operating on its grids and having customers who offer services such as load modulation, interruptibility and even hierarchical restoration of power.

The primary aim is to prevent the distributor from purchasing these services from its own retailer-aggregator at prices higher than offered by competitors. This should be already covered by existing regulation which does not allow privileged relationships between the DSO and the incumbent retailer-aggregator. However, even if the regulation is not effective, this, counter-intuitively, is not necessarily a problem, as long as the distributor is unable to transfer this cost to grid tariffs (see the discussion on the financial incentives included in the remuneration mechanisms for distributors). If the remuneration for regulated activities is properly defined, the group as a whole has nothing to gain when its distributor pays its retailer-aggregator a higher than market price, because the retailer-aggregator's earnings translate into the distributor's loss. If this regulatory prerequisite should not be fulfilled, i.e. if the regulatory regime allows the distributor to directly pass through all its cost to the network tariffs, then it may be necessary to introduce some particular regulations in order to avoid that the distributor is incentivised to buy AD products at excessive prices.

The main problem is however not short-term, but long-term balance. If the AD service is ultimately implemented as designed, it would be very difficult, not to say impossible, to compete on the retail market without offering such tools. Consequently, the distributor may attempt to purchase them from its group retailer-aggregator only (regardless of price) to thereby build an unsurmountable entry barrier for the competition.

The primary aim of the auctions is to channel distributor purchases at a given time (so all potential competitors can plan their participation) and at the same time to ensure that both the product and the prices finally paid are transparent, public and challengeable.

Consequently, detailed regulation beyond existing governance rules must be provided for the following:

- Products: the characteristics of the products purchased by distributors must be sufficiently standardized to guarantee that auctions are suitably competitive. Of course this should be balanced against the need to allow for different business models for aggregators.
- Timing: both the minimum amount of time for announcing the auction (grace period) and the duration of the agreements must be closely supervised by the regulator.
- Access to data, which must be available for all AD sellers at the level required.

Finally, one last problem will in all likelihood have to be addressed. In light of the enormous inertia of retail markets and consumers' aversion to changing suppliers (as already mentioned before), the majority retailer-aggregator on each distribution grid is likely to belong to the same business group as the distributor. Therefore, rules should be considered to prevent potential unfair practices (such as bidding under the market price, knowing that the loss would ultimately be offset by the distributor's gain). One alternative might be to link the auctions called by different distributors, requiring retailers-aggregators, which will (and if that is not the case, should) normally supply customers outside their own grids, to submit one and the same price in all auctions. This measure reduces the aggregator's incentive to discriminate between its own and other distributors.

Again, as mentioned before, a detailed regulation may only be necessary when the degree of penetration of AD is significant enough.

Regulation of distributors' revenues

In order to make the (efficient) use of AD services attractive to distributors, the distributors should be given appropriate financial incentives via the regime for regulation of their revenues. Such incentives should have the effect that savings in total expenditure (investment plus operating expenditure) that distributors can realise by buying AD services lead to an improvement of the distributors' financial profit. In a traditional "cost plus" regulatory regime, incentives like this do not exist, because it allows (and obliges) the distributors to pass any cost savings through to the network tariffs more or less immediately. Nowadays, however, regulatory regimes in most European countries evolve increasingly towards incentive-based regulation, which better allows to incite distributors to make efficient use of operative solutions like AD.

In detail, the way in which incentives can be introduced depends strongly on the characteristics of the regulatory regimes, which are highly country-specific.

If – like in Spain for example – the determination of allowable revenues for distributors is based on the application of a standard grid model, appropriate incentives can simply be generated by not taking AD into account when setting up the standard grid model. (We understand the application of standard grid models here as an approach to determine the revenues for a distributor on the basis of a computer model that calculates an optimal network for the given supply structure and monetarises this network by using standardised unit cost, without making reference to the actual cost of the distributor.)

Such an approach grants distributors full credit for the optimal grids that they must have in place to meet quality requirements. Remuneration will be independent of demand side management services (i.e., the standard grid will not take account of the potential of such new AD services). Therefore, the distributor will be able to increase its earnings if it manages to lower costs to below the value established by the model (by reducing the need for new grid reinforcement, for instance) thanks to these new services.

This incentive should be regulated in the same way as traditional incentive regulation (RPI-X), in which an efficiency factor, X, is set (and re-adjusted after a number (typically 3-8) of years has lapsed) to incorporate improvements in efficiency in subsequent updates. Analogously, a period of years (sufficiently long for the incentive to be effective and sufficiently short to be able to convey the benefits of this improved efficiency to consumers) should be established, after which the new configuration should be incorporated into the standard grid model.

A different typical approach to regulate revenues of distributors does not build upon standard grid models, but on determining the efficiency of distributors by comparing them with each other, based on benchmarking techniques. An approach like this can also inherently generate appropriate incentives for making use of AD services, as long as it is based on the distributors' total expenditure, like for example in Germany. In this case, distributors who find solutions to reduce total cost can improve their efficiency score and, in consequence, their X factors, which leads to an increase of their profits.

In incentive-based regulatory regimes that treat capital and operating expenditure separately from each other, it can be more difficult to generate appropriate incentives towards the use of AD services. Such a regime can even produce disincentives. If, for example, capital cost are directly passed through to the tariffs, while operating cost are subject to efficiency factors, distributors are incited to seek for (excessively) capital-intensive solutions, and not to make use of solutions that substitute capital by operating expenditure (like AD services). In case of such regulatory regimes, it may be necessary to introduce specific regulation principles for the cost of AD services in order to make their use financially attractive for distributors, for example by passing these cost through to tariffs without efficiency discounts, and by giving the distributors a financial reward for the savings in capital cost that they realise by using the AD services.

5.1.3.6 Market rules

We mentioned before that this issue is covered by Chapters 3 and 4 on markets. However, it may be useful to give some indications about it here.

In most power systems TSOs already have ancillary services mechanisms in place that in principle will let them taking advantage of AD possibilities (although some design refinement could be required to allow retailers participate offering AD in an efficient way). But the procedures that will rule the DSOs AD purchases it is a fully open issue, so an analysis first on the best manner to design them, and second, the protocols needed to coordinate both grid operators, TSO and DSOs is of a major relevance for the future of the AD tools.

Balancing markets, AD and DSOs

In principle, there is no particular need to modify the current design of balancing markets to allow DSOs intervening in any way. There are various reasons that justify this assertion. First, because balancing markets call for bids at the overall system level, so it is expected that the retailers bids placed in these markets will be spread all around the system, and therefore the probability of affecting a particular zone of a low voltage network will be low.

But maybe the main reason is that the way balancing markets are organized allows DSOs having the information they require with sufficient prior notice. At gate closure, some time before real time, DSOs will be able to have a sufficient idea of the potential load shifts that could take place in their networks, so they will be able to operate the network taking it into consideration.

Finally, it will be possible that due to constraints in the distribution network, the actual contribution for balancing the system of certain AD bids in the balancing market does not correspond to the amount offered by retailers. If this is the case, we consider these bids should receive the same treatment that currently is applied to generation plants' bids: if the final response of a retailer whose bid counted on AD is lower than the amount offered due to distribution network constraints, there should be no way to claim liabilities to the DSO.

The essential coordination of grid operators' balancing services acquisitions

While there are no forceful reasons to significantly modify the current design of the balancing markets to allow the participation of AD, on the contrary there are numerous ones that justify that the purchases of AD solutions for balancing services of TSO should be in any case if not channelled through DSOs at least coordinated with them by implementing common auctions (again, as mentioned before, only if the penetration of AD is significant enough).

The two main reasons we just mentioned to justify that no change in the current design of balancing markets will be required (particularly in the way the market is currently being cleared and prices are calculated) are not valid when dealing with the purchase of balancing services: first, as aforementioned, these services are usually thought to provide the TSO with the ability to resort to short-term flexibility, notified at short notice, and additionally, contrary to the case of balancing markets, it is much more common that the DSO needs when resorting to these services are much more local, oriented to solve eventual grid stresses in certain node of the network. This means that first there will be not much time for the DSO to react when the orders are announced and that the demand response called by the TSO will be much more concentrated in certain areas of the distribution network.

This might have a doubly harmful impact: the distribution network security could be severely hampered and also, in case the DSO could act to prevent potential damages for its networks of sudden shifts, the actual response of the demand could not be the one expected and required by the TSO, something that would be particularly unacceptable in an emergency situation (which is however not within the scope of the ADDRESS project), as it is commonly the case when TSOs resort to this services.

Settlement procedure for AD in TSO's ancillary services

The settlement procedure applied to aggregators' accepted bids in the TSO's ancillary services markets will not have to be different from the only currently implemented, i.e. the difference between the energy schedule at gate closure and the final energy consumption in real time.

However, unlike generating plants' bids, since the mechanism needed to modify the program is much more fuzzy, less straightforward, there is a certain risk for the aggregator to partially deviate from the amount agreed with the TSO (in the balancing market or in any of the remaining balancing mechanism). Aggregators therefore will have to bear this risk, and the TSO will have to implement a special mechanism to penalize these divergences. Alternatively, the uncertainty about the actual response can be reflected in the prices paid for AD products.

Therefore, there is no need for the TSO for new tools to exploit the added value that AD can offer. What it is indeed needed, besides the issues just reviewed, is an analysis of the potential adjustments required to remove potential barriers for AD and also of the way to make them compatible with the mechanisms designed to allow DSOs also resorting to AD for their needs. Thus, the aim is to allow AD competing on equal terms with the agents that currently provide TSOs with them (mainly generation plants and large consumers), and also, to guarantee maximum coordination and efficiency, avoiding redundancies.

6. Conclusions

Since the electricity markets and regulation in all EU member states are not exactly the same, the conditions may be different for aggregator business concepts and for implementing AD based services, at least under present circumstances. Consequently, there may be markets where certain alterations to the following conclusions and recommendations of this document may become necessary taking into account these markets specific requirements. However, in this document it is not possible to cover all market conditions, business concepts or service variations.

Recommendations for contractual issues

<u>The contract between the aggregator and the AD consumer</u>

The relationships between the aggregator and the AD consumer are decisive for AD acceptance. That is why the contract defining the relationships between an aggregator and an AD consumer must propose the best balance between transparency and clarity to guarantee the protection of the AD consumer, and sufficient flexibility to permit the development of various business models by aggregators.

Hence several groups of contractual aspects can be clustered according to the following main topics and the following classification is proposed:

- Necessary clauses for respecting general legal obligations. They are common whatever the type of product / service exchanged;
- ADDRESS necessary clauses proposed in order to respect ADDRESS assumptions or options retained early in the project (payment for monitored energy – decreased or increased - and not for the right to control directly the premises; comfort settings...);
- Recommended but not mandatory clauses for guaranteeing a good AD relationship (conditions of delivery, use, maintenance and repair of the E-Box when the aggregator provides it...);
- Optional clauses, not considered as necessary, but can permit an increase in flexibility for each aggregator to adapt his contracts to his own AD business model (payment for the E–Box; penalty for limiting excessive overriding in case of a remuneration partly based on monitored capacity...);
- Clauses depending of the aggregator's status: it is pointed out that several clauses could be simplified or totally eliminated in case of an aggregator-retailer (declaration in case of change of retailer, declaration of new power pricing by the retailer). This distinction appears also relevant for the billing issue. In the case of an integrated aggregator-retailer, the integrated bill is recommended, notably when the retailer also proposes dynamic power pricing; in the case of a pure aggregator, separated bills for the AD remuneration and for the power supply appears unavoidable in a lot of countries.
- Early-stage elements: it is mentioned that the contents of some clauses or elements of the contract can be specific to each aggregator in the early years but could become common to all aggregators as soon as the AD activity is mature (reminders of AD objectives, description of payment, billing...). Such a normalisation in a second period, could be an efficient way to make aggregators' offers more transparent and comparable, and thus permit a more efficient way to inform AD consumers.

<u>The contract between an aggregator and an AD products buyer on the wholesale electricity market</u>

Even if organised markets become more complex and flexible, the trading of products has to respect some rules: different products exist but some standardisation is necessary. For example, CRP markets do not exist and would be very difficult to implement (cf. chapter 3.2.5.3).

The bilateral contract is a way to trade more specific products: products with more specific technical clauses such as a precise location requirement, limits on energy [energy min & energy max] to represent load shifting, Conditional Re-profiling Products (CRP), CRP at a very short notice, CRP with a range of possible values between [Pmin, Pmax] (Pmin may be a negative value where demand increases), etc.

In organised markets, the seller is committed. The product purchased by a player is automatically considered as delivered. The buyer assumes no risk of non-delivery by the seller. Just as other power system players, an aggregator who sells energy in the market is responsible for the provision of this energy. More accurately, depending on the imbalance settlement rules of the country, the aggregator or its Balancing Responsible Party (BRP) is responsible for the provision of the balance on its perimeter (transactions / AD productions). Concerning the risk of non-delivery, the contract can sometimes allow the sharing of responsibility of delivery between the aggregator and the buyer via the addition of a special cancellation clause : this optional clause may detail the way by which the aggregator declares the non-availability of the demand resource to the buyer and the penalties linked to this.

On the other hand, the way to verify and measure the delivery of energy is not part of the contract between the aggregator and the AD buyer but has to be defined by the System Operator (SO) in the “Balancing mechanism and imbalances settlement” rules. For SOs’ acceptance, the SO may require some proof of reliability from the aggregators such as a description of the programme, the type of device, the methods of measurement, etc. Even if the product is not bought directly by the SO, the SO may want the demand resource to be certified. For example, without measurement, there is a major risk of lack of credibility and, as a result, AD product could be excluded from power markets. Therefore, the method of measurement chosen is an important aspect of these rules.

Note that where the aggregator and the retailer are the same player, the action of the aggregator on a consumer is automatically integrated into the retailer’s consumption perimeter. Therefore, the measurement of consumption is sufficient to verify the imbalances of the retailer.

<u>Functional requirements of a regulated player buying AD</u>

An important point for regulated players is their non-discriminatory obligation: SO must study offers from power plants, decentralised power plants, large demand resources and AD.

Another important point is the reliability of energy delivery. A SO can apply penalties to an aggregator (just as it does to energy producers) if there is a deviation between the energy product delivered and the energy product sold. But a reliable product may be difficult to achieve by the aggregator when the specified area of delivery is very small, in particular when the DSO is the buyer.

Nevertheless, if a grid emergency should occur, just before load shedding, and if there is no other standard solution, the SO could require the aggregator to activate available AD as a “best effort” attempt to resolve the problem. In this case, no penalty is applied and the aggregator can be remunerated for the energy provided as defined in the technical rules.

For CRP product, as in the contract between the aggregator and a deregulated player, some clauses of availability, penalties and pre-activation may be defined in the contract. The clause of pre-activation may oblige the buyer to pre-activate the delivery at a specify date. If he does not, the reserve is released; therefore the aggregator can sell his AD to other players, thus reducing his opportunity loss.

Recommendations for market issues

Recommendations for the market include all types of commercial transactions that take place in order to exchange the ADDRESS services. These include bilateral contracts, calls for tenders and, of course, organised markets.

The document describes the different types of transactions as well as the current situation. It appears that existing market mechanisms are already flexible and complex. In organised wholesale markets we find hourly, block, linked and time flexible bids. For the services that can not be exchanged on such markets, we have calls for tenders and bilateral contracts available. In the current market, only minor changes and adaptations need to be made to the arrangements in order for an aggregator to provide services. The major market obstacle is the minimum size of the products which can be too large for the aggregators to provide, but would be a very minor change in the market organisation. Such changes do not present much technical challenge. They would result however in increased communication and data storage requirements.

We have also envisioned different types of new markets such as local markets, flexibility markets and CRP markets and we have proposed mechanisms along which these could operate.

Local markets

Local markets would help solve problems due to location, typically network problems. On a very large scale local markets are already implemented by the means of market splitting or market coupling mechanisms between countries or regions. When considering local markets at the distribution level, where currently very limited amount of local flexible resources exist, the best way for the DSO to obtain services is to sign bilateral contracts with the providers of such services. If the liquidity increases calls for tenders become necessary if we wish local actions to be based on market principles. The splitting of national (or international) markets down to distribution levels is probably very complex when compared with the benefits that it could bring. In addition the DSO would be the single service buyer, making that such a local market would end up yielding the same results as a call for tenders.

Flexibility markets

Flexibility markets would be markets designed especially for pooling flexibility capacities. The owners of several resources could set up such a market in order to make offers on other markets. A flexibility market would be needed only if the individual actors cannot participate directly to the other markets. An example of this would be where small aggregators pool their capacities in order to provide balancing services to the TSO.

A flexibility market could be a very simple bilateral contract between aggregators or a complex organised platform. Flexibility markets would however increase the complexity of the system. They should be considered only if the increase in complexity is balanced by the increase in possible revenues.

We would recommend adapting existing markets in order to allow the aggregators to participate rather than integrating this new layer of complexity.

CRP markets

We describe a possible new form of market designed to exchange CRP contracts. This design requires the exchange of standardised volumes, which may be an issue. Moreover the needs for CRP services are often related to network constraints and present a location aspect. It would therefore be very difficult to obtain matches between demands and offers at all levels.

We do not recommend the implementation of a new CRP market. With an increased level of liquidities however a CRP market would allow a better use of the capabilities of flexible resources and such a market could bring in benefits in a far future.

Recommendations for technical validation

We have considered the issue of technical validation and the mechanisms that a DSO should go through if a strain appears on the network where flexible actors are active. We have based our thinking on the current mechanisms to handle network constraints at the transmission level.

For the technical validation of aggregators AD programme, whether the products are sold to regulated or unregulated players, grid operators need to define areas in the distribution and transmission networks (load areas).

Solving a network constraint has a cost. Should this cost be borne by the DSO or by the actor responsible for the excessive strain? In the long term the DSO can rely on its existing consumption and production predictions, associated with other available resources it would have access to in order to decide if it should reinforce its network or contract more CRP capacity through bilateral contracts, calls for tenders or organise a local market. Using AD and CRP contracts could mean that a DSO would work closer to its operational limits and that the actions of a local actor could make it cross that limit.

In this case we have identified several options. The one taken in ADDRESS so far is to allow the DSO to curtail the local resources without knowing economic information behind it or without knowledge on the economic aspects of the flexibility deployment, which possibly results in putting the cost of solving the constraint on the resource operators.

Inspired by some current practices at the transmission level, a market based alternative method has been investigated in which the DSO would be responsible for re-dispatching the curtailed service into another network area. This market based approach could be designed in such a way that the resource provider would not gain from constraining the network on purpose, but at the same time the cost of this re-dispatching network service would be borne by the DSO. This could be an incentive for the DSO to invest in network reinforcement to prevent network constraints being violated on permanent basis (even if other mechanisms to incentive it to invest in network reinforcement can be envisaged). This proposed new solution might be complex in the current situation to implement for the DSO as they are nowadays not prepared for finding resources on other networks. We would therefore not recommend it unless mechanisms are put in place to provide the DSO with an easy access to other flexible resources as it happens in some countries on TSO level.

Remarks on balancing and measurement

When the aggregator and the retailer are two different players and when the aggregator sells AD products on the market, balancing responsibilities have to be defined for protecting their respective activities. A solution is proposed in the document but even if we do not know at this point how to measure the real AD profile, an agreed methodology to estimate/calculate as accurately as possible the AD deviation at the aggregated level has to be investigated. Measurement is crucial for acceptance of AD and shall be investigated. Let us add that such sophisticated solutions are not necessary for an integrated aggregator - retailer.

Recommendations for regulation

A successful deployment of AD requires careful consideration of regulatory issues: both to address possible obstacles placed by existing rules, and to look for ways in which regulation may be used to promote it. This section has reviewed the major connections between AD business models and regulation, and in particular, has specified the topics that need specific regulatory work.

The objective of this section has been to think of all the possible interactions that may arise, classify them, and provide solutions for those issues which are deemed relevant or which require a specific solution. The issues identified as possibly requiring a regulatory approach are:

- Data and infrastructure ownership;
- Cost recovery of fixed costs: validation, measurement, settlement, information on load areas;
- Incentives (permanent or temporary), allocation of costs and benefits;
- Market rules;
- Regulation of distributed generation;
- Relationship between players: particularly regulated ones;
- Issues regarding consumer switching;
- Consumer protection regarding data privacy;
- Consumer protection against excessive costs; and
- Require TSO/DSO to manage their systems efficiently (including allowing for the recovery in fair terms of AD investments and operational expenditure as compared with grid investments)

Some issues, although very relevant, can (and should) be incorporated into existing rules: this is the case of price controls, consumer protection, or fair competition in the non-regulated elements of the AD business models (basically, those dealing with retailers and/or aggregators). The recovery of the costs incurred by regulated players (DSOs and TSOs) to develop AD programs can also be incorporated into the existing regulation for distribution and transmission activities.

Other topics do need to be addressed specifically, and here we provide the major conclusions about what we would recommend.

Regarding data and infrastructure ownership: whatever the entity responsible for mastering data, the data belongs to the consumer, who must transfer its use to the relevant party: the DSO, the aggregator and/or the retailer. When the aggregator and the retailer are different entities, some data must be transferred to both, and some to only one of them, then separate data channels may be required. As for the infrastructure, we propose that metering should be considered a regulated activity, likely in most cases to be attributed to DSOs, while the interface with the consumer will be a non-regulated part, and therefore its ownership does not need to be defined. However, rules must be defined in two aspects: the contractual terms under which the interface is provided by the retailer/aggregator (to protect consumers, and also to facilitate switching), and also the standardization of the interface (again, to facilitate switching). Finally, aggregators will need to send information to retailers and vice versa in order to guarantee fair competition: the regulator shall then 1/ define which data are necessary to be exchanged free of charge between them or 2/ propose they sign an agreement.

A second important element is the correct allocation of the costs and benefits of AD programs: this will require an appropriate regulation of electricity distribution, and sometimes transitional regulations for the generation sector (which may encounter unexpected losses due to the introduction of AD programs).

When AD programs are introduced as variable price schemes, regulation must guarantee a fair competition between non-regulated retailing prices. But regulation must also prevent an unfair competition with the regulated default tariff (when there is one). Therefore, the regulated default tariff should probably be designed as a flat tariff, but high enough, so that there is space for retailers or aggregators to develop different business models. When remuneration for AD is paid separately, this will not be an issue.

The coordination between network system operators (TSOs and DSOs) is another issue that must be considered by regulators. AD actions requested by one of them must be validated by the other, to prevent problems in the grid. This validation will also avoid duplicities (when one retailer/aggregator tries to sell the same product – including conditional offers - to both agents). Grid operators will also need to define areas in the distribution and transmission networks (load areas), so that aggregators will have better information on where to sell their services. The purchase of AD products by grid operators must be subject to a specific procedure, which guarantees its transparency and impartiality (e.g., public auctions).

Finally, the regulation of DSOs' revenues is also an important element for facilitating the penetration of AD: if DSOs are not able to materialize the benefits from purchasing AD, they will not be interested in doing so. The way they may materialize these benefits will depend strongly on the characteristics of the regulatory regime, which is highly country-specific. In case remuneration is based on standard grid models, AD services must not be taken into account when setting up the standard grid model. If revenues are regulated through benchmarking processes, then the incentive for using AD is already incorporated. In incentive-based regulatory regimes that treat capital and operating expenditure separately from each other, it can be more difficult to generate appropriate incentives towards the use of AD services. Such a regime can even produce disincentives. If, for example, capital cost are directly passed through to the tariffs, while operating cost are subject to efficiency factors. Therefore, specific regulation may be required.

Of course, the changes and additions to current regulations will depend largely on the degree of penetration of AD. In the early stages, while AD remains a non-relevant part of the system, coordination between grid operators may not need to be enforced strictly, and AD product purchase mechanisms do not need to be regulated in detail. The same applies to the regulation of distribution activities and the compensation to generators. All the remaining issues (data and infrastructure ownership, validation, and incentives for DSOs) are required from the start. Indeed, jump-starting AD programs may also demand the use of temporary incentives for consumers, DSOs and retailers/aggregators to remove non-economic barriers common in the early stages of every new business model.

The role of regulation is thus critical for the deployment of AD in the European power systems, moreover considering the differences in the existing regulatory regimes, which will require a country-specific adaptation of the basic principles described here. However, care should be taken not to develop a heavy-handed approach, which might be contrary to the market liberalization principles of the European energy sector. An additional recommendation is to take into account the social costs and benefits of AD when making regulatory decisions. The important point is that regulators become aware of potential regulatory barriers against AD in their frameworks, and then seek for solutions that are compatible with their general regulatory approach.

Next steps within ADDRESS

The electricity markets and regulation in all EU member states are not exactly the same: there may be national markets where certain alterations to the AD principles described and recommended in this document may become necessary taking into account these markets specific requirements.

The design of contractual, market and regulatory instruments proposed by this document will have to be also combined with and adapted in accordance to the outputs of the other ADDRESS tasks dealing with a better understanding of players' benefits and costs, motivations and AD acceptance. They will contribute to the social welfare metrics of AD.

Specifications for the development of a market simulator will be able to be partly based on the present outputs. Such a simulator is required by the French field tests.

7. References

ADDRESS reports and documents

ADDRESS Deliverable Report D1.1 - Technical and Commercial Conceptual Architectures, Core document – WP1 / T1.5 – May 2010

ADDRESS Deliverable Report D1.2 - Application of the ADDRESS conceptual architecture in four specific scenarios – May 2010

ADDRESS Deliverable D3.1 - Prototypes and Algorithms for network management, providing the signals sent by the DSOs to the aggregators and the markets, enabling and exploiting active demand – on progress

ADDRESS Internal Report 1.34b – Potential barriers against the development of AD and concepts for their solution – WP1

ADDRESS Internal Report - Aggregator's strategy for developing and optimizing its portfolios of contracts – WP2 / T2.2

ADDRESS Internal Report IR1.3c - Decision-making processes of the deregulated market participants and methodology for the design of real-time price and volume signals – WP1 / T1.3 – May 2010

ADDRESS Internal Report IR2.1 "Specification of the Aggregator, E-Box and DER", WP2 / T2.1 – May 2010

ADDRESS Internal Report IR5.2 - Survey and Analysis of Mechanisms behind Consumer Engagement with AD Principles and Technologies – March 2011

Other references

"A New and Separated Market for Demand Response in Restructured Power Systems" - D. T. Nguyen / IEEE, Negnevitsky / IEEE & M. de Groot / IEEE - 2011 IEEE PES POWER SYSTEMS CONFERENCE AND EXPOSITION

"The integration of price responsible demand into PJM wholesale power market and system operations" – P. Centolena & A. Ott – 9th of March 2009

"Electricity demand response tools: status quo and outstanding issues" – C. Batlle and P. Rodilla, in European Review of Energy Markets, volume 3, issue 2 - June 2009.

FENIX Regulatory Framework - WP 3.2.5, FENIX Project – D. ELIS, A. HUTTON, S. SOOR & T. WARHAM – November 2008

FENIX Contractual Framework (D 3.2.6) - D. ELIS, S. SOOR & T. WARHAM – November 2008

FENIX Financial and socio-economic impacts of embracing the FENIX concept - A. van der Welle, Ch. Kolokathis, J.Jansen & alii – September 2009

"Household Response to Dynamic Pricing of Electricity – A Survey of the Experimental Evidence" - A. Faruqui and al. - The Brattle Group 2009

"Household response to dynamic pricing of electricity – a survey of the experimental evidence" – A. Faruqui and S.Sanem – 10th of January,2009.

"The economics of energy service contracts" – S. Sorrell – in Energy Policy 35 (2007) 507-521 – 2007

Tariff Amendment to Implement Proxy Demand Resource Product – CAISO – 16th of February 2010

"Providing Incentives for Efficient Demand Response" – W. W. Hogan for EPSA & FERC - Docket No.

EL09-68-000 – 29th of October 2009

“When it comes to demand response, is FERC its own worst enemy ?” – J. Bushnell, B. F. Hobbs & F. A. Wolak – The Electricity Journal, Elsevier, Vol. 22, Issue 8 – 2009

A national assessment of demand response potential – The Brattle Group, Freeman Sullivan & Co, Global Energy Partners & LLC for FERC – June 2009

2010 Assessment of Demand Response and Advanced Metering - FERC, February 2011

“The intelligent cooperation between consumption and generation at the heart of the Smart Grid “ – Smart Energy Demand Coalition Position Paper – March 2011

“The Swedish Electricity Market and the Role of Svenska Kraftnät - Svenska Kraftnät, Vällingby, Sweden - January 2007

“Smart Grids: from innovation to deployment” – European Commission, April 12th 2011

8. Revision history

Version	Date	Authors	Notes
0.1			Internal working documents coordinated by EDF, VTT, VITO and U.P.Comillas during preparation of version 0.2
0.2	01/03/11	V. Alagna, L. Cauret, M. Entem, C. Evens, W. Fritz, M. Hashmi, P. Linares, M. Lombardi, S. Melin, F. Pettersson, D. Six, M. Trotignon & Ch. Yuen	First draft of the full deliverable document as a result of the merge of the mechanisms proposed in Subtasks 5.3.1 Markets, 5.3.3 Contracts and 5.3.4 regulation including comments of the Subtask partners
0.3	25/03/11	idem	Updated draft of the full deliverable document including general conclusions
0.4	01/04/11	idem	Updated draft of the full deliverable document including executive summary
0.5	18/04/11	idem	Full deliverable document sent to the D5.1 reviewers
0.6	09/05/11	idem	Updated D5.1 integrating reviewers' comments and sent to reviewers, Technical Board and QMO
0.7	25/05/11	idem	Updated D5.1 integrating the comments and suggestions made by the Technical Board and sent to reviewers, TB, TM, QM, QMO and PC
0.9	31/05/11	idem	Updated D5.1 integrating the comments and suggestions and sent to QM for the final approval
1.0	31/05/2011	QM/QMO/AMO/PC	Final approval

9. Appendix. Qualification of demand resource by the SO for capacity credits: the example of PJM

In order to illustrate the qualification of demand resources by the SO for capacity credits, this section describes the example of the Reliability Pricing Model (RPM) market in PJM [32].

With regard to capacity markets designed for security adequacy, the system operator may require documentation proving the reliability of the capacity credits sold by an aggregator. This is the case under the rules of the RPM market in PJM.

Providers of planned demand resources who wish to offer such resources in RPM Auctions must provide documentation no later than 15 days prior to the RPM Auction, demonstrating to PJM's satisfaction that the planned demand resources will be available for the start of the delivery year.

Providers of planned demand resources are subject to the RPM credit requirement33.

See below for extracts from PJM documentation. Planned demand resources documentation is required by PJM in order to allocate capacity credits to these demand resources:

1. *Project description/summary*

- Company name, project name, submission date, company address and contact information

- Project goals

- Demand resource application – method of load reduction during defined performance hours34 (i.e. guaranteed load drop, firm service level, or direct load control programme35)

- Location(s) of DR resource (transmission zone or sub-zone)

- Anticipated nominated value of DR resource

2. *Schedule: timeline for installing/procuring DR resources*

- Timeline for equipment installation

- Measurement and verification activities

- Schedule of milestones in obtaining customers via a marketing strategy

3. *If offering a direct load control programme, the documentation should include:*

- A load research study[36] or deemed savings estimates to determine impacts per participant

> *- If the direct load control programme employs a radio signal, the DR resource provider may elect either to submit a load research study to support base per-participant impacts of the project or utilise the base per-participant impacts contained in the "Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in the PJM*

[32] PJM Interconnection manages the high-voltage electric grid and the wholesale electricity market that serves 13 states and the District of Columbia

[33] For more information on the RPM credit requirement please see Section 4.8 of PJM Manual 18 and attachment

[34] A demand resource must be interruptible for up to six consecutive hours' duration between 12:00 PM to 8:00 PM eastern prevailing time for the months of May through September and 2:00 PM to 10:00 PM eastern prevailing time for the months of October through April, on weekdays other than PJM holidays.

[35] See PJM Capacity Market Manual, Manual 18 Section 4.3.9, which describes Guaranteed Load Drop, Firm Service Level, and Direct Load Control programs and the determination of the Nominated Value of such programs. See PJM Load Forecasting and Analysis Manual, Manual 19 Attachment A that describes how load reduction is estimated for such programs.

[36] Direct Load Control Research Study Guidelines are provided in PJM Load Forecasting and Analysis Manual, Manual 19, Attachment B.

*Region" report*37.

- If the direct load control programme utilises different technology, the DR resource provider must submit a load research study.

- Equipment to be used for load control

- Equipment standards

- Measurement and verification approach

- Baseline and post-installation assumptions that affect demand reduction (e.g., hour(s) of the day, WTHI Standard, cycling strategy, adjustment for switch failures)

- Pilot project results, if any

4. If offering a guaranteed load drop or firm service level programme, the documentation should include:

- A general plan to obtain customers

- Information to support the market potential and the type of customer (i.e., residential, commercial, or industrial) the programme will be focusing on

- Assumptions underlying estimates of the nominated DR value (customer penetration, EDC loss factors used, etc.) by zone

- Any adjustments for existing DR or considerations made for the potential for other curtailment service providers targeting the same customers

- If known, identification of end-use customer site targeted to provide load reduction

- Justification of a peak load contribution value for an end-use customer that is higher than the current peak load contribution value

- Some details of types of measures targeted and approximate number of devices or customers and per-measure/per-customer impact that would provide the nominated DR value.

- <u>Test activation to prove the reliability of the demand resources</u>

In order to avoid aggregator failures and thereby cause a risk of imbalance to the system, the System Operator may implement controls. Indeed, in some years, some AD resources may remain inactivated; in order to verify their reliability, the System Operator may activate them purely to test the response. Such a test was carried out by PJM in 2009: the demand resources provided a good response.

It should be noted that PJM provides only one type of example. At present in the US, AD for small customers is not well developed and demand resources mainly involve industry and large-scale commerce.

[37] "Deemed Savings Estimates for Legacy Air Conditioning and Water Heating Direct Load Control Programs in PJM Region", Final Report, RLW Analytics, March 2007 is available at http://www.pjm.com/~/media/documents/reports/20070406-deemed-savings-report-ac-heat.ashx.