Recommendations for standard committees, regulators, stakeholders groups, future R&D

D7.5

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Executive Summary

In the smart grids of the future, there will be a growing need for a more active participation of demand in power systems (Active Demand – AD) and an increasing concern of consumers about environmental and energy efficiency issues. In this context, the aim of project ADDRESS is to develop a comprehensive technical and commercial architecture to enable AD at small commercial and domestic consumers, and to exploit the benefits of AD, with supporting activities

This document, written at the end of the project, is intended to present recommendations on the aspects most critical for a broad acceptance of ADDRESS results. The main recommendations follow, for the different players involved in the ADDRESS architecture. The recommendations for future R&D, as they are often transversal to the single category of stakeholders, are separately presented here.

Aggregation function

- The AD potential in a specific setting should be modeled with scenarios defined by the geographical characteristics of the area (e.g. weather conditions, etc.), customer characteristics and load density, power sector environment, and technological context.
- The Aggregator should have balancing responsibilities associated to the activation of the AD services and their payback. For the latter, a new type of bid, namely payback bid, could be introduced to the market.
- The Aggregator should formulate and maintain a diversified portfolio of active customers to account for the ever changing requirements of AD buyers and uncertainties associated to customer flexibility and availability.
- Instead of introducing new markets, minor changes should be made to existing market mechanisms to enable AD services; particularly reducing minimum requirements (e.g. MW) for products to be traded in the markets.
- The data and interfaces used by AD enabling technology must be standardized as to allow customers' switching, and ensure a fair competition between the deregulated players..
- The AD interface (Energy Box - EBox) should be deregulated and all data and physical interfaces should be standardized to facilitate competition.
- AD data ownership should belong to the customers, whereas different parts of the aggregated data could be freely exchanged or sold to different players through separated data channels.
- Energy based AD business models could be implemented successfully in scenarios where the costs of AD enabling technologies and the burden for AD consumers become negligible.
- The economic attractiveness of capacity based AD business models can be case specific. Thus, it should be targeted to the most beneficial applications, such as for distribution networks operating near their limits and subject to significant load growth uncertainty.

Consumers

- For positive consumer engagement with AD, the usability of the technology, contracts and contextual issues are all important.
- User interfaces must be easy to understand, allowing users to input settings and to access the different functionalities that the EBox can provide.
- In this respect, accessing information about electricity consumption, possibly with environmental messages, is very important to consumers.

- Consumers need support with the installation of AD technology to minimize technical problems and to facilitate setting the parameters of the load control.
- The ability to over-ride the system when needed is central to acceptance.
- Contracts need to be understandable, transparent and clearly set out the potential financial benefits and implications of different actions;
- Consumer privacy and data must be protected. The privacy and ownership of the consumers' data must be ensured whatever the concerned party and the infrastructure used for their collection and exchanges.
- Financial savings are important to consumers, although other factors such as environmental protection are important in their decision to adopt AD technology. The full range of benefits must be clearly communicated to consumers to ensure as wide a take-up as possible.
- The contracts between Aggregators and consumers should keep a balance between transparency to protect consumers, and flexibility to allow for different business models

System Operators

- With AD, the behavior of consumers, who can be at the same time producers, can be different from expected and the providers of AD products could be concentrated in such a way to determine network violations. In this framework System Operators (SOs) have to ensure, anyway, a reliable operation of their networks without prejudice of the quality of energy supply.
- AD can be used by SOs to solve their own network operation problems as well. But because SOs are also in charge of balancing the system in real time, they must be totally confident in the tools they use: energy services / products delivered by AD must offer a sufficient level of reliability could be subject of additional contractual clauses to guarantee specific reliability expectations.
- Coordination is necessary among TSOs and DSOs taking into account their own responsibilities and different needs and constraints of regional and local networks.
- SOs control systems have to be upgraded introducing new functions to enable and exploit AD.
- The services provided by SOs to AD market, guaranteeing transparency and non discriminatory access to all involved actors, are: location information, technical validation, metering information (depending on the regulation).
- SOs, as well as Aggregators, also have to ensure the consumers' privacy dealing with their data/information.
- SO's regulation (way of remuneration) has to include the fixed costs associated to the services provided to enable AD and has to allow DSO/TSO to purchase AD products (country specific) in order to maximize the existing network usage factor integrating Renewable Energy Sources (RES) in a sustainable way.
- The SO should have a role in the verification and measurement of AD products.

Deregulated players

- Wholesale markets are rather well prepared to incorporate AD products without large changes. But AD products should be standardized to facilitate trading in these markets.
- The creation of local markets for AD is probably too complex at the time being.
- The relationships and interactions between Aggregator, retailer and BRP are crucial and their respective responsibilities must be clearly defined. A proper way to manage the impacts of AD on the retailer has to be found".
- A fair method for the measurement and verification of delivery of AD products has to be defined.

The SO might have a role in this respect.

- The ownership of AD data and infrastructure needs to be allocated appropriately, and data privacy ensured absolutely.
- Regulators may need to intervene to allocate correctly costs and benefits among agents.
- Regulation must also prevent an unfair competition with the regulated default tariff, if it exists.

Communications

- Smart Grid AD communication architecture needs to connect a large number of very different players each having very different communication needs, interfaces, communication channels and specific problems and requirements.
- Large parts of the required communication infrastructure have to be accepted as being “given” and cannot be changed. Any communication solution for AD has to be realized given this constraint.
- ADDRESS advocates the consequent usage of available, open and proven standards for any active demand related communication.
- No restriction to specific communication channels in order to avoid ruling exclusion of certain AD participants. Heterogeneous communication infrastructure needs to be acknowledged.
- Successful communication requires a comprehensive underlying modeling. The Unified Modeling Language (UML)-based Common Information Model (CIM) has been proven to be very suitable for this purpose.
- The main recommendation for a realization of AD communication infrastructure is the use of a Service-Oriented Architecture (SOA) and the exchange of standardized eXtensible Markup Language (XML) messages by the means of services.
- A strong requirement for the success of AD is the simple, robust and efficient implementation of standardized and well-proven communication in end-customers’ homes.

Manufacturers

- Rules and market structures are needed to favour a large diffusion of smart devices able to concur in a successful diffusion of AD policies offered by Aggregators. It is important to create the conditions for active customer involvement, attractive commercial offer, interoperable and flexible technical infrastructure.
- The availability of interoperable standards is a crucial element to make possible the successful commercialization of smart devices.
- These interoperable application profiles are mainly related to support the communication between the smart devices and the EBox.
- The interoperable standards for the integration of the smart devices should be open, flexible, secure and global, covering the information to the customer, the control signals and the user needs.
- Global solution able to manage the regional differences in a flexible way to avoid to multiple the effort with dedicated versions for the smart devices.

Future R&D

- Even if local markets seem too complex to implement nowadays, such new potential trading mechanisms of AD services should be investigated for the future.
- R&D could result in the reduction of the costs of AD services enabling infrastructure and in the availability of smart appliances.

- Accurate algorithms for the evaluation of customer flexibility would facilitate the efficient and economical implementation of AD products.
- Research and usability experiments during development would ensure that interfaces are easy to understand and to use.
- Continued trialling of AD technology in the field to gain a better understanding of consumers' acceptance of AD services.
- Priority of validations by DSO should be investigated deeply, and the commitment for validated conditional AD products as well.
- An alternative to curtailment of AD program by DSO without remuneration based on a market approach method could be investigated.
- A fair method for the measurement and verification of delivery of AD products has to be found. In this respect the appropriate definition of the baseline for the assessment of demand modification may be a key element.
- The way to properly manage the impacts of AD on the retailer has to be found. The energy modification, including the shifting, performed by the Aggregator has to be well estimated in order to have a fair share of energy costs between the retailer and Aggregator.
- The most advantageous communications implementation and how to proceed to achieve the best solution shall be determined.
- A deeper understanding of how to exploit the whole flexibility of devices is deemed necessary.
- Integration of AD functionalities with other added value services made available by the communications infrastructure should be sought.

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1. Introduction

1.1. Scope of the document

This document presents recommendations on the aspects most critical for a broad acceptance of ADDRESS results.

1.2. Structure of the document

The recommendations are proposed as seen from the different parties involved in the ADDRESS architecture: Aggregators, Consumers, System Operators, Other deregulated parties, Communications, Manufacturers. For each category of stakeholders, the recommendations are organized into four main groups: rules and market structures, standards, engagement of stakeholders, future R&D.

1.3. Notations, abbreviations and acronyms

EC	European Commission
EU	European Union
PC	Project Coordinator
TM	Technical Manager
QM	Quality Manager
QA	Quality Assurance
QAS	Quality Assurance System
QMO	Quality Management Office
QAP	Quality Assurance Plan
TB	Technical Board
MB	Management Board
GA	General assembly
WP	Workpackage
WPL	Workpackage leader
DOW	Description of Work
QO	Quality Objective
KPI	Key performance indicator

Table 1. Abbreviations

1.4. Acknowledgements

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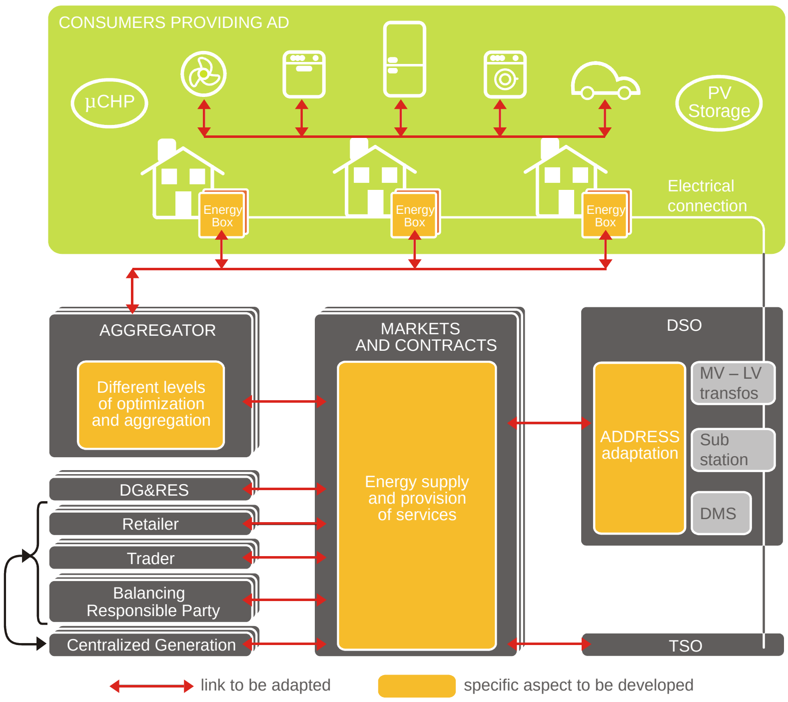
2. Overview of the ADDRESS architecture

The goal of ADDRESS project is to enable the active participation of domestic and small commercial consumers to electricity system markets and the provision of services to the different electricity system players.

In the smart grids of the future, there will be a growing need for a more active participation of demand in electricity systems (AD) and an increasing concern of consumers about environmental and energy efficiency issues.

In this context, ADDRESS aims is to develop a comprehensive technical and commercial architecture (Figure 1) to enable AD at small commercial and domestic consumers, and to exploit the benefits of AD. Once implemented, this architecture is expected to contribute to the achievement of flexible, reliable, accessible and economically efficient grids by enabling and exploiting the flexibility of consumers. AD based solutions are also proposed to remove commercial and regulatory barriers for the full integration of distributed and renewable generation, thus supporting sustainable energy consumption.



Consumers providing AD - Domestic and small commercial consumers with single-phase or three-phase connection to LV networks and with 100 kW maximum power consumption and/or generation.

Energy Box - For the optimization and control of appliances and DER and the interface with the Aggregator.

Aggregator - Mediator between consumers and markets, collects requests and signals from the markets, gathers flexibilities of consumers to built active demand services and make offers to the markets.

Markets and contracts – Energy supply, relief of overload and network congestions, balancing services, ancillary services, load shaping services.

DSO - Plays a key role since the consumers considered are directly connected to the distribution grid and DSO is responsible for the secure and efficient operation of the grid.

Figure 1. ADDRESS conceptual architecture.

The architecture, depicted in Figure 1, is based on the following four main concepts:

a. the interaction among participants is based on the exchange of price and volume signals sent in real time or longer ahead, where “real-time” means a time scale of 20 to 30 minutes ahead. Direct load control by DSOs is not considered;

b. a “demand” (as opposed to “generation”) approach is used with particular attention on the expectations, needs, cultural and behavioural aspects of domestic and small commercial consumers;

c. distributed intelligence and local optimization are necessary to enable the provision of services dependent on network topology and for real time optimization of consumption;

d. scenarios elaborated on the basis of the potential success for AD development. This success is measured with respect to AD global impact on the electricity system.

The following figure depicts the relationship between all the deliverables developed during the project:

e.

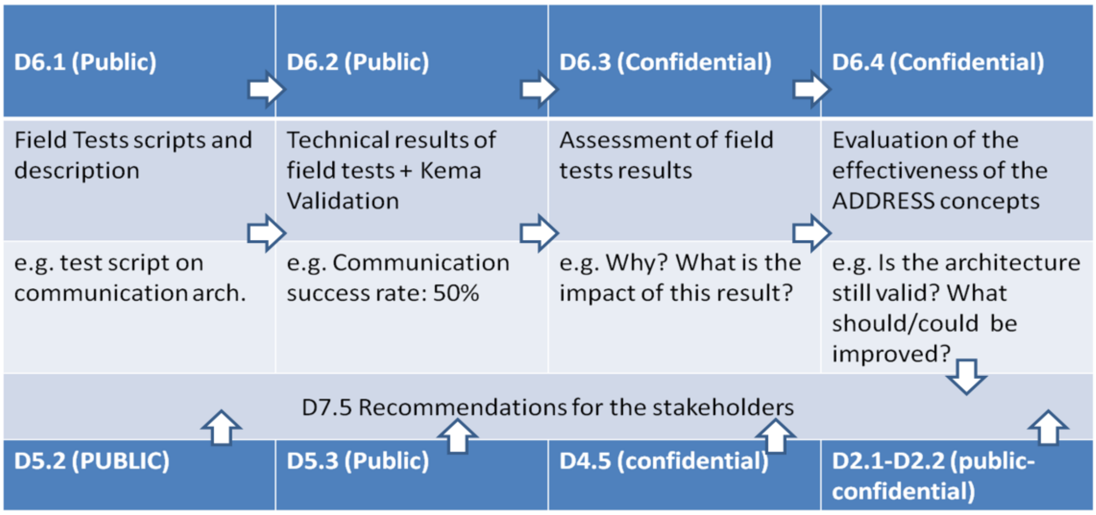


Figure 2. Relationship between Field Tests Deliverables

2.1. The ADDRESS actors and their relationships

2.1.1. Players

In the ADDRESS architecture, all the players of the electricity system are considered, with a major emphasis on the Aggregator, the Consumers and the DSO.

The Aggregator is a central concept: he is the key mediator between the consumers on one side and the markets and the other electricity system participants on the other side. The Aggregators gather the flexibilities and the contributions provided by the former to build AD-based products relevant and interesting for the latter. “Flexibilities” and contributions of consumers are provided in the form of modifications of their consumption: an Aggregator sells a deviation from the forecasted level of demand, and not a specific level of demand.

At the consumer level, the EBox is the interface between the consumer and an Aggregator. It carries out the optimisation and the control of the loads and local distributed energy resources at the consumer’s premises. It represents the consumer from an Aggregator’s perspective.

The DSOs also play an important role because AD (as developed in the project) concerns consumers connected to distribution networks. With the development of AD, DSOs will have to continue to ensure the secure and efficient operation of the grid; they will do so mainly through interactions with the other power system participants and, in particular, with Aggregators via markets. They will also maintain direct interactions with TSOs for this purpose.

With the three above main actors come along other players:

- regulated participants: TSOs;
- deregulated participants or participants in competition. For these latter, 9 players have been considered and they may be divided into three main categories:
  - Producers: central producers, decentralised electricity producers, producers with regulated tariff and obligations (reserve, volume, curtailment, etc.)
  - Intermediaries: retailers, production Aggregators, electricity traders, electricity brokers, Balancing Responsible Parties (BRPs).
  - Consumers: large consumers.

2.1.2. Services and products

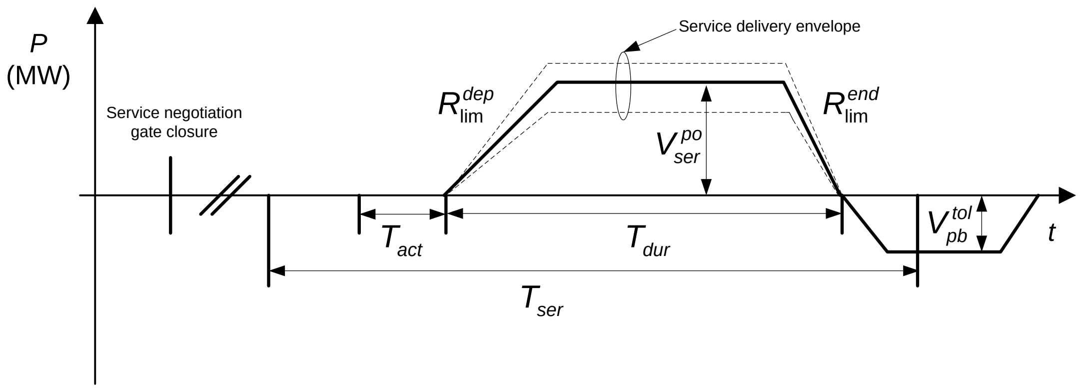
The analysis of the needs and expectations of all the players with respect to AD has led to the identification of a large number of different AD services, the fulfilment of players' needs by means of AD products (for more details see D1.1):

- 24 different AD services for the deregulated players,
- 7 different AD services provided to DSOs and TSOs.

Three basic standardized AD products (what is sold by the Aggregator to the players) have been defined, which permit to formulate the identified services; they are summarized in Table 2, and their basic parameters are illustrated in Figure 3.

AD product	Conditionality	Typical example
Scheduled re-profiling (SRP)	Unconditional (obligation)	The Aggregator has the obligation to provide a specified demand modification (reduction or increase) at a given time to the product buyer.
Conditional re-profiling (CRP)	Conditional (real option)	The Aggregator must have the capacity to provide a specified demand modification (reduction or increase) during a given period. The delivery is called upon by the buyer of the AD product (similar to a reserve service).
Bi-directional conditional re-profiling (CRP-2)	Conditional (real option)	The Aggregator must have the capacity to provide *a* specified demand modification during a given period in a bi-directional range [-y, x] MW, including both demand increase and decrease. The delivery is called upon by the buyer of the AD product (similar to a reserve service).

Table 2. AD products and their main characteristics



T_{act}	The time between activation by the buyer and the effective delivery (CRP & CRP-2)
T_{dur}	Deployment duration
T_{ser}	Time interval over which the conditional product may be called upon (CRP & CRP-2)
R_{lim}^{dep}, R_{lim}^{end}	Deployment and ending ramping limitation range
V_{ser}^{po}	Product volume or volume range
V_{pb}^{tol}	Tolerance on the energy payback the delivery of the product may generate

Figure 3. AD product delivery process and basic parameters.

In addition, information about the location of the AD consumers contributing to the provision of the AD product is necessary, both for the provision of topology dependent services and the verification of technical feasibility of the AD products on the grid. The approach making use of Load Areas (LAs) has been adopted, where a LA is composed of consumers whose loads are equivalent from the electrical point of view.

2.1.3. Relationships between the players

The relationships between the different kinds of players which will be implied by AD are quite complex: between regulated players, between the Aggregator and the regulated parties, between the Aggregator and the other parties regarding imbalances due to AD actions.

2.1.3.1. Relationships between regulated players

Good coordination is needed between the TSO and the DSO. The DSO has to be informed of any request by TSO for AD services to the market, which could have impacts on the distribution system operation. Similarly, the TSO should be informed of any DSO request for AD services, which could have impact on the electricity system operation, and in particular on the transmission grid.

The relationship between TSO and DSO requires a good coordination between them both at the commercial level (to avoid conflicting requests or improve efficiency, provided that this coordination does not alter the market and does not raise any barriers), and at the technical level (to carry out the verification of AD proposed transactions).

2.1.3.2. Relationship between Aggregator and regulated players

Different types of relationships and information exchanges are needed between Aggregators and DSOs/TSOs in order to manage the purchase of AD products by DSO/TSO from Aggregators, the technical validation of AD actions, the management of energy payback effect, the sharing of topology/location information, the monitoring of consumer and Aggregator response.

The commercial aspect of these relationships deals with the purchase of AD products by the TSO or DSO from an Aggregator. It is defined by the characteristics of the products that the Aggregator can offer to the TSO/DSO in order to fulfil some of its needs.

As regards the technical validation of AD actions by SOs, for AD services bought by deregulated players it is the Aggregator (seller) that sends relevant information to the DSO (which, in turn, sends relevant information to TSO), while for AD services bought by regulated players the buyer (respectively TSO or DSO) has also to inform directly the other regulated party (resp. DSO or TSO).

2.1.3.3. Energy balancing and settlement

Imbalances might arise in the case where an Aggregator sells an AD product to a player who is not the retailer of the consumers contributing to the AD product. The risk appears when the retailer is able to forecast the new consumption of its active consumers and adapts accordingly. In [D1.1], cases are discussed where the same physical energy would end up being counted twice: once by the Aggregator and once by the retailer, albeit not being produced twice.

Another issue in the relationship between Aggregator and retailer is the energy payback that can occur after (and before) the provision of an AD service and which can cause both the retailer and the physical system to become unbalanced.

2.1.3.4. Other balancing issues regard metering options, load profiling and energy balance settlement

3. The Aggregator

3.1. The Aggregator / aggregation function

In the ADDRESS architecture, the Aggregator provides AD products to other players willing to buy them upon contractual agreements. Thus, the Aggregator is also called the AD provider. In order to provide the AD products, the Aggregator has a portfolio of residential and small commercial consumers where an EBox installed. The EBox has the ability to modify and coordinate the behavior of the distribution energy resource devices, based on price and volume signals sent to it by the Aggregator.

The Aggregator has to interact with different power system actors in regulated and deregulated environments with the objective of enabling AD services. The main actors that interact with the Aggregator are:

- Deregulated power system participants: These participants purchase AD products with the objective of minimizing their costs or attain other benefits. The Aggregator and other deregulated players (including the retailer if the Aggregator is not also the retailer) trade AD based services in established markets such as the day-ahead and intra-day markets. Alternatively, the AD services can be traded via bilateral contracts (see [D1.1] for more details). Depending on the characteristics of the deregulated player and the service requirements, a wide variety of bilateral contracts could be signed as alluded to in [D5.1].
- DSO/TSO – SOs play a double role in the ADDRESS architecture. Firstly, they can act as AD buyers in the electricity system. Secondly, they are in charge of verifying that AD products contracted in the market are feasible. They thus ensure through technical validation procedures that AD products trading does not cause any transmission or distribution network violations.
- EB (Consumers): In order to deliver AD products sold in the markets, the Aggregator sends price and volume signals to the EBox of the consumers in the active consumers portfolio. The signals are specifically designed to produce the needed aggregated consumption modification.
- Metering responsible party: The metering equipment consists of certified devices that provide information on consumer behavior. Aggregators should receive this information for consumers' assessment and settlement from the metering company.

The AD provider business is only viable if it is profitable for the Aggregator itself and both the active customers facilitating the service and the AD buyers soliciting the products. The responsibility of enabling this business lies mainly on the Aggregator who is in charge of:

- Forecasting energy consumption and demand flexibility by estimating the short and long term aggregated behavior of the consumers in the portfolio.
- Forecasting the prices that AD buyers will be willing to pay for the products offered in different markets. Market forecasting is crucial for the Aggregator business; particularly for the identification of non-conventional cases where AD management is most profitable.
- Managing markets and the portfolio of consumers with the objective of defining a profitable long term strategy based on information from the long term consumer flexibility and market prices forecasts.
- Optimizing operations by defining the bids to offer in short term markets and the price and volume

signals to be sent to the consumers in the portfolio.

- Settlement and billing to secure payments from AD buyers and pay incentives to the consumers in the portfolio.

The current market and power system environments are not optimal for the Aggregator to have the necessary level of interactions with other actors and to meet the needed operation requirements to enable efficient and profitable AD based services. Accordingly, several recommendations for the success of the Aggregator business were made based on outputs from the ADDRESS project.

3.2. Recommendations for the success of the Aggregator business

Based on insights gained from the ADDRESS project, the success of AD services from the perspective of the Aggregator can be facilitated by (i) upgrading existing market structures and rules, (ii) implementing new AD service trading, provision and charging related standards, (iii) highlighting the benefits related to AD services with the objective of engaging customers and other actors and (iv) identifying areas of research and development that can lead to further benefits associated to AD services. These four points will be discussed in the following subsections.

3.2.1. Rules and market structures

The success of AD based services will challenge the existing structure of the power market as well as the rules by which it operates. Five sets of recommendations were taken for (i) identifying AD potential in different zones, (ii) managing active customer portfolios to meet the ever changing requirements of AD buyers, (iii) upgrading current market mechanisms and possibly introducing new markets for the trade of AD products, (iv) setting a regulatory regime to account for ownership issues regarding data and infrastructure and (v) determining the balancing responsibilities of the Aggregator.

3.2.1.1. Active Demand potential depending on local conditions

A scenario approach was utilized to envision how the conceptual architecture and the ADDRESS concepts could evolve in a number, four to be precise, of realistic European settings (Southern City; Southern Countryside; Northern Suburban Village; Mid-Latitude High-Rise Community).

Based on the study, it was established that four factors are key for the elaboration of scenarios when assessing the potential evolution of an ADDRESS future in a given area, namely (i) the geography of the area (climatic and general weather conditions); (ii) the characteristics and the density of consumers in the area; (iii) the electricity industry infrastructure (i.e. the generation mix and the market and regulatory context); (iv) the technological context (i.e. primarily consumer end uses and network technologies). It is recommended to use these factors to represent all current or future scenarios of the AD potential in given zones.

3.2.1.2. Portfolio strategy of the aggregating entity

The Aggregator will face the challenge of adapting its portfolio strategy by identifying the highest AD potential, selecting the most relevant AD consumers and targeting the most suitable AD purchasers in a variety of contexts, such as geographical, social, industrial and regulatory, among others.

The development of a long term portfolio of AD purchasers is challenging for the Aggregator, as it involves anticipating the evolution of all relevant elements. In order to face this challenge, the Aggregator is recommended to consolidate a diversified portfolio of consumers. There are two main reasons for this. Firstly, because the capabilities in terms of flexibility of specific consumers will not exactly match the requirements of an AD purchaser. Secondly, because the Aggregator will not know with certainty the exact amount of flexibility the consumers can provide when the service is requested. Aggregators operating in several areas might optimize their portfolios over the different areas to minimize their sensitivity lo local conditions. The consumer portfolio will have to be constantly adapted to the needs of AD purchasers on the long run by recruiting new consumers into the program.

The Aggregator will have to anticipate, identify and analyze risks associated to competition with other Aggregators and penalties related to AD products non delivery, among others. It also has to diversify its offers to AD purchasers or active consumers in order to generate a complementary source of revenue.

3.2.1.3. Market issues

The existing power sector environment comprises a variety of market mechanisms for the trade of services with different natures (e.g. energy, reserves and capacity), characteristics (e.g. accessibility) and time frames (e.g. long and short term and real time). The trading requirements related to AD management could be met by adapting existing markets or creating new mechanisms such as local and regional markets.

Existing market mechanisms are flexible and sophisticated. In organized wholesale markets, trades can be made based on hourly, block, linked and time flexible bids. In addition, calls for tenders and bilateral contracts are available for services that cannot be exchanged on the aforementioned market mechanisms. Only minor changes and adaptations to the current market would be needed for an Aggregator to provide AD management based services.

The major obstacle in existing markets for the trading of AD management based services is the minimum size of the products required to participate in the market, which can be too large for the Aggregators to provide. This obstacle could be circumvented with minor changes in the market organization such as by allowing AD Aggregators grouping (e.g. in France, small players have the possibility to contract with a BRP). This pooling could provide benefits for Aggregator's costs; particularly fixed costs reductions. A reduction of the minimum requirements for AD based services to participate in the market may not present significant technical challenge; however, it would result in increased communications and data storage requirements.

As part of this project, different types of new markets such as local markets, flexibility markets and CRP markets were envisioned and their corresponding operation mechanisms were proposed. Nevertheless, such markets are highly complex and require a radical system evolution. In accordance, it is recommended to adapt existing markets in order to allow the Aggregators to participate rather than integrating this new layer of complexity.

3.2.1.4. Regulatory issues

Regulatory issues associated to AD management (e.g. price controls, consumer protection, or fair competition in the non-regulated elements of the AD business models) can (and should) be incorporated into existing rules rather than creating new specific regulations. Nevertheless, other topics such as data and infrastructure ownership and data exchange fees need to be addressed specifically.

Regarding data 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, specific data would be sent to either both actors or to only one of them. Accordingly, separate data channels may be required.

As for the infrastructure, it is proposed that the main AD interface (the EBox) should be deregulated. In this context, rules must be defined in regard to (i) the contractual terms under which the interface is provided by the retailer/Aggregator, which must protect consumers and also facilitate switching and (ii) the standardization of the interface that should also facilitate switching.

Aggregators will need to send information to retailers and vice versa in order to guarantee fair competition: the regulator shall then either define which data are necessary to be exchanged free of charge between them or propose an agreement.

3.2.1.5. Rights and duties of the Active Demand provider including balancing responsibility

AD providers must have the same rights and duties as other deregulated players in order to be accepted as market players. The Aggregator must have the right to provide energy and reserve products in every market place, as well as the duty to be related to a Balancing Responsible Party, which is crucial for the security of the electric system. The general principle of balancing responsibility is that every injection in or off-take of the power system should be notified to the TSO by a BRP who is responsible for the access point or for the energy/power flows. Then, imbalances are settled. Therefore, the balancing responsibility of an Aggregator would involve (i) the measurement of energy generated or consumed in the BRP's perimeter, and (ii) management of payback effects.

An Aggregator may operate with several access points managed by a single or several BRPs. In the former case when there is a single BRP for one access point, for example if the AD provider is also the retailer of the AD consumer, there is no problem because the energy consumed and the AD energy provided are in the same perimeter. In the latter case when there are two BRP for one consumer, the responsibility of each has to be clearly defined (e.g. via an agreed method). Based on insights gained from this project, it is recommended that TSOs, DSOs, Aggregators and retailers work together to agree on a method of imbalance measurement. Such a method could be based on building a baseline of consumption for different control groups. This method could be also used to measure the energy postponed or payback effect.

The payback effect is a change in consumption that appears after or before the AD service is delivered, but in the opposite direction of the service. The payback effect should be measured as part of the service. For example, if an Aggregator generates an energy surplus by decreasing consumption and a consumption increase is expected sometime afterwards, the energy surplus and the magnitude and time of the payback have to be measured. The Aggregator will be responsible for the initial energy surplus as well as for securing additional generation to supply the payback. ADDRESS proposes for this a new type of bids in wholesale markets. Such a "payback" bid would be similar to a regular block bid but would differ in the sense that it would include positive and negative volumes. This new bid could suit to the Aggregator business. A more detailed study of the impact of such bids on the market would be required, but in first analysis they would allow a risk reduction for the providers of flexible resources, such as the Aggregator and storage provider.

3.2.2. Standards

The Aggregator business is essentially the customer business. It will only succeed if it is beneficial for both the Aggregator and customers, as well for AD buyers. In this context, the contractual relationship between actors is decisive, and clear and fair contracts are essential (view D5.1 for details on the clauses that would be required). Thus, unfair competition should be prevented by removing barriers for entry and fomenting standardization.

Standardization is important as the lack of it may prevent some Aggregators from using AD equipment installed by other Aggregators. In addition, standardization is beneficial for the wholesale market to allow the participation of small Aggregators.

In order to facilitate the standardization of the Aggregator business case, the Aggregator role definition and related use cases should be provided to the International Electrotechnical Commission (IEC). The IEC TC8 (System aspects for electrical energy supply) WG6 (generic smart grid requirements) is in charge of smart grid business requirements.

3.2.3. Engagement

The Aggregator, active consumers and other actors would be engaged with the ADDRESS concept and the associated AD services if they perceive sufficient benefits. Assessments have been carried out to ascertain whether or not there is a business from AD services. The assessment is not meant to present a detailed business plan, but to provide an order of magnitude of the potential benefits that the main players developing the AD services (i.e. active consumers and the Aggregator) can obtain.

Four AD services were assessed: Short-term load shaping to Optimize Purchase and Sales (SOPS), Management of Energy Imbalances (MEI), Load Reductions (LR) and Tertiary Reserve (TR) in the context of the electrical energy markets in Spain, Italy, Finland and Belgium (see [D5.4] for details). The value of the AD services for active customers and the Aggregator are shown in Table 3.

Potentials per service in each country (€/active consumer)				
	Spain	**Italy**	**Finland**	**Belgium**
SOPS	0.85	2.49	3.52	1.66
MEI	0.72	1.68	1.71	2.68
LR	2.49	3.18	6.35	2.42
TR	2.09	5.13	5.21	4.25
All services together	3.84	6.24	8.72	6.86

Table 3. Summary of potentials per service per year in each country

In order for the AD business to be economically feasible, these profits from AD services should suffice to pay for the investment in equipment (e.g. EB, smart plugs), as well as to provide attractive benefits to Aggregators and active consumers. The AD values alluded to in Table 3 are not high enough to enable AD based businesses under present conditions. However, there are other circumstances and AD services that can result in a stronger business case.

In the future, consumers themselves will probably buy AD enabling equipment for their own needs. For example, consumers might invest in Home Energy Management Systems to monitor and reduce their energy consumption (and/or to access new services, for example remote control of appliances, fault detection, security). Such systems could possibly be interfaced with the system of an Aggregator. Likewise, future appliances are expected to be smart, so that there will be no need to buy smart plugs, which would allow more profits from the provision of AD services to be allocated to consumers.

The assumptions used for the assessment can also affect the attractiveness of the business case. In order to see the effect that other parameters may have in the creation of AD programmes in the future, a sensitivity analysis was performed. In particular, the effect of varying electricity prices and electricity consumption levels were assessed, as Table 4 shows (view D5.4 for more details about the sensitivity analysis).

Changes in AD service potential with all the services together (€/active customer)				
	Spain		**Italy**	
	€	% Δ	€	% Δ
Base case 2010	3.83		6.24	
2010, +50% volatility	5.11	33.4%	6.99	12.2%
2010, +50% mean	5.18	35.2%	8.22	31.7%
2010, 0.1% spikes	13.72	258.2%	9.61	54.0%
Base case 2020	4.84	26.2%	7.64	22.6%
2020, +50% volatility	6.34	65.2%	8.43	35.2%
2020, +50% mean	6.08	58.5%	8.00	28.3%
2020, 0.1% spikes	16.52	330.9%	11.82	89.5%

Table 4. Results of the sensitivity analysis for different price and demand conditions

Although changes in some parameters result in higher values for AD services, the attractiveness of the business case is still low. This implies that the four energy based AD services considered thus far are unlikely to provide enough benefits to justify the ADDRESS concept. In accordance, additional AD services based on the provision of capacity rather than energy were assessed.

The capacity based AD services were assessed in the context of Spain, Belgium and the UK. In general, these services produce significantly higher benefits and require fewer service calls (e.g. less than 4h per year in the UK) than energy based AD services. However, the value of some of these services is case specific as it can be close to zero in some cases and nearly €200 in others. The expected value of several capacity based AD services can be seen in Table 5 (view D5.4 for further details).

Country	Service	Value per active customer
Spain	Power term	€29.43/year
	Interruptibility	€24.47/year
Belgium	Reserve	€17.62/year
UK	Transmission cost reduction	£4.38/year
	Distribution interconnection cost reduction	£10.73/year (from £0.24/year to £230/year)
	Distribution reinforcement cost reduction	£34.55/year (from £2.31/year to £183/year)

Table 5. Estimated value per active customer associated to the provision of capacity based AD services

Based on the insights gained from the assessment of the AD business case for Aggregators and customers, the following recommendations can be made.

The implementation of AD business models based on energy services could be feasible and attractive for Aggregators in the future if consumers possess the infrastructure to enable the services (e.g. smart devices). Nevertheless, such services are unlikely to be attractive for consumers. Thus, these business models should only be implemented in cases where the cost of AD enabling technology becomes negligible and active customers perceive little or no discomfort from providing the service.

The implementation of AD business models based on capacity services can be significantly attractive for both consumers and Aggregators under specific conditions. Thus, these business models should target potentially profitable conditions, such as the provision of capacity for actors facing high capacity charges and fixed costs, or networks approaching their operational limits and subject to significant demand growth uncertainty.

3.2.4. Future R & D

The outputs from the ADDRESS project highlight some areas of research that could be further pursued to strengthen the assessment of the Aggregator's business. In particular, the following areas of future research and development are deemed relevant.

3.2.4.1. Local markets

AD services could be traded in local markets with the objective of avoiding problems associated to location and typical network problems. Nevertheless, this is a complex option that should be more investigated. 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. Such a local market might end up yielding the same results as a call for tenders. This alternative appears too complex at present times but it might be implemented in the future and should be investigated.

3.2.4.2. Active Demand products enabling technology

The costs of AD services enabling infrastructure can be reduced through R&D. Such infrastructure would help consumers monitor and reduce their energy consumption and provide an interface with the system of an Aggregator. Likewise, R&D is expected to result in the availability of future smart appliances. The development of the aforementioned infrastructure and devices would significantly benefit most business models associated to AD management.

3.2.4.3. Characterization of consumer flexibility

More accurate algorithms for the evaluation of customer flexibility would facilitate the efficient and economical implementation of AD products. Learning algorithms could be explored for the assessment of the flexibility characteristics of customers. The algorithms could be based on data from specific countries where AD related services have been implemented, such as incentive prices data used for load management in France since the 60s. This would improve insights regarding types of appliances used by customers and their response to incentives, as well as the volume of energy that customers would manage and the corresponding payback effect.

4. Consumers

4.1. The involvement of consumers

Consumers have a central role in the ADDRESS architecture as they provide the changes in electricity consumption required by the Aggregator. An EBox is installed in consumers home; the EBox controls the demand response, responding to price signals from the Aggregator, in accordance with the settings that the consumer has entered into the EBox. From an appliance perspective, the EBox can control: flexible loads, namely the washing machine, dish washer and clothes drier; interruptible loads, namely fridges, freezers and electric water heater; and thermal loads namely air conditioning units and electric radiators. Conceptually, the ADDRESS architecture anticipated that consumers would enter the following settings into the EBox:

- Relative importance of comfort, convenience and financial savings (user preferences)
- Time periods over which consumption flexibility would be offered (flexibility)
- Time periods over which appliances could be interrupted (interruption)
- Time periods and temperature for control of thermal appliances (thermal control)

For technical issues, however, the ADDRESS field trials did not include the full range of AD control, and the EBox functionality differed between the two test sites. The elements of the AD architecture tested in the two test sites is summarised in Table 6

ADDRESS architecture		Houat and Hoedic (France)	Castellon (Spain)
EBox settings	User preferences	Yes	Yes
	Flexibility	Yes	Yes
	Interruption	Controlled according to consumer settings	Controlled according to consumer settings
	Thermal control	No	Controlled according to consumer settings
Appliances	Flexibility	Smart washing machines, water heaters and in some cases dryer and dish washer	Washing machine; dish washer; clothes dryer
	Interruption	Electric radiators	Water heaters,fridges,freezers
	Thermal control		Air conditioning

Table 6. Overview of ADDRESS functionality in the two field test sites

4.2. Recommendations for the consumers' acceptance of the Active Demand

4.2.1. Rules and market structures

4.2.1.1. Contract between the Aggregator and the Active Demand consumer

The contract defining the relationships between an Aggregator and an AD consumer must offer the best balance between transparency and clarity to guarantee the protection of the AD consumer, whilst having sufficient flexibility to permit the development of various business models by Aggregators. Hence several groups of contractual aspects can be clustered and recommended:

- Essential clauses to fulfil general legal obligations. These are common whatever the type of product or service is exchanged and include: administrative information such as company identity and address; a clear description of payment; duration of the contract, effective date and expiry date; cases of total cancellation before the expiry date; reminder of law and arbitration; confidentiality for private data and so on.
- ADDRESS essential clauses, proposed in order to respect ADDRESS assumptions or options retained early in the project. These include: payment for monitored energy – decreased or increased - and not for the right to control directly the appliances; comfort settings; ability to use the override mode.
- Recommended but not mandatory clauses specific to each Aggregator for guaranteeing a good AD relationship. These clauses include: exclusive right; conditions of delivery, use, maintenance and repair of the EBox if supplied by the Aggregator or conditions of EBox compatibility when the AD consumer themselves provide the EBox; continuous connexion of the EBox and appliances; declaration of new appliances if the Aggregator provides other energy services; description of energy data, signals and other relevant aspects sent to AD consumer.
- Optional clauses, not considered as essential, but which can permit an increase in flexibility for each Aggregator to adapt his contracts to his own AD business model, including: payment or no payment for the EBox; penalty or no penalty for limiting excessive overriding (in case of a remuneration partly based on monitored capacity).
- Clauses dependent on the Aggregator's status. Several contractual aspects could be simplified or totally eliminated in case of an Aggregator-retailer including: declaration in case of change of retailer; declaration of new power pricing offered by the retailer. This distinction appears also relevant for the billing. In the case of an integrated Aggregator-retailer, an 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 appear 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 such as reminders of AD objectives, description of payment, billing etc. Such standardisation 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.
- The majority of the ADDRESS participants in Spain (68%) were motivated to take part in the trial to save money. Therefore, clarity in the contract – and how these savings can be made or

maximised – could be a good way to respond to this consumer interest. It is also important that contracts are simple to understand, and the implications of the different actions e.g. using the over-ride, are clear.

- If the option of paying a fee for installation is opted for in the ADDRESS business model, it should be subject to guaranteed savings.
- Whilst automation ensures convenience, as customers are less likely to want to manage or control their responses all the time, overriding the system when needed is still important. Having options in the contract, whereby a customer does not incur penalties or loss of savings, should be included. This is useful when catering for special occasions or exceptional family circumstances for example.

4.2.1.2. Specific recommendations for Spain

In Spain, most consumers have a flat rate for the daily electricity consumption in their dwellings and although the energy market is a deregulated market, most consumers do not participate in it. To make a profit from this deregulated market, Retailers/Aggregators, will need to offer new tariffs and contracts to the consumers. In the same way, the definition of these new contracts might contemplate the possibility of paying for the demand management services offered by the consumer to the grid (incentives for increasing or reduction of the power demanded into the home during a period of time). The development of new contracts and tariffs has to be supported by a technological development of EBoxes and smart appliances that allows manage energy consumption in an automatic and optimised way, in an economically effective way.

Currently in Spain there is not a specific regulation for Smart Grids, nevertheless there are some features/issues that are regulated regarding to consumers and relationships with the rest of players involved in the system, such as:

- Obligation of installation of smart meters for all the residential consumers.
- Rules concerning to the new functionalities that should be implemented by these smart meters.
- Communications and protocols to interact with the different players.
- Integration of DER in the network and the management of these systems.
- New plans for the integration of the electric vehicles in the network.

All these laws, rules, standards should be updated and modified in order to be coherent with the new penetration of this technology in the households. The Governments should allow the Aggregators to manage the consumers' loads with additional laws, rewards, etc. in order to get win-win technology from all the agents: Aggregators, DSOs, TSOs, Generators, and Consumers.

4.2.2. Standards

The International Electrotechnical Commission (IEC) produces consensus based global standards; international standards reflect agreement on the technical characteristics of the product, service or system covered by a particular standard. IEC TC8 WG6 is in charge of smartgrid business requirements. This working group is defining generic use cases for different functional domains. These Smartgrid Domain Core Teams (DCT) are:

1. Transmission Grid management
2. Distribution Grid management / Micro Grids
3. Smart Substation Automation

4. Distributed Energy resources
5. Advanced (Smart Grid and) Metering Infrastructure
6. Smart Home / Commercial / Industrial / DR-Customer Energy Management
7. Energy Storage
8. Electric Transportation
9. Asset Management
10. Bulk generation
11. Market

AD use cases will need to be provided to IEC TC8 WG6. IEC TC8 WG6 Domain Core Team 11 (in charge of Markets related use cases) will coordinate with IEC TC57 WG16 in charge of Market Information Exchanges. IEC TC8 WG6 DCT 4 and 5 could also be contacted.

Consumer acceptance of the AD will be improved if there is also a seamless infrastructure available which will implement AD related use cases and provide required smartgrid functions. IEC TC57, IEC PC118 and ISO/IEC TC205 should provide these smartgrid functions which will enable Active Demand. Standard Development Organisations should indicate which standards have to be used and harmonized to enable active demand.

It is also important from a consumer perspective that the new technology should be implemented and developed according to standards to ensure the interoperability between all the equipment required for the demand side management.

For communications inside the house, Zigbee technology is one the most developed and accepted technology. The wireless solution allows communication between the different devices without physical works in the household. The fewer modifications the consumers have inside their houses, the more successful the technology will be. For communications outside the house (between consumer and the rest of players involved) the most used technology are via Web Services (TCP/IP). Nevertheless, some other technologies, such as radio or cell phone communications are probably best suited to the areas where the Internet access is not economically feasible.

4.2.3. Engagement

Recommendations for engagement with consumers in relation to active demand solutions such as ADDRESS can be clustered around three main areas: usability of the technology, contextual issues and communication.

4.2.3.1. Usability of the technology

- The user interface (UI) of the EBox: it is really important to have a user-friendly and simple interface for the consumer:
  - The present EBox UI is too complicated for most of the consumers. It has too many screens with too many parameters.
  - The interface should be more intuitive. The UI philosophy and menus should be inspired by other types of devices that consumers use in their everyday life like their smartphones, PC software, TV menus, etc.
- The user preferences and criteria are complicated and could be simplified. The present weighting method between three criteria is not clear and too complicated for some consumers. One proposed simplification would be to choose between 100% money saving and 100% comfort,

along with the override function.

- The control of the EBox is likely to be minimal as long as consumers are not inconvenienced or do not experience thermal discomfort. Therefore, if the automation settings are set up in collaboration with the consumer, they would be more likely to reflect the householders' needs, and the need to change them is minimised. However, once changes are required, it is important to have the usability in place to ensure ease of use and satisfaction. Those deploying the technology can learn from other sectors e.g. Internet providers, to ensure that installation of equipment in consumer's homes is carried out in a way that will minimise problems for consumers.
- To that end, clear and user-friendly instruction manuals must be provided at the on-set of installation. Accessible contact details for help desks should be provided through several media (on the website, in a handy leaflet/postcard, a fridge magnet, etc.) to make it easy for users to find the number when emergencies or disruptions occur.
- An override option, which can be easily accessed by consumers, through the EBox interface for example, is central to all issues of demand response.
- An important aspect of the technology is the interest of consumers in the consumption feedback that EBoxes or web-based dashboards can provide. The EBox should make it easy for consumers to obtain and to understand this information.
- Environmental message. Developed studies show that a sector of the society can react and modify their behaviour (their loads) if they receive a signal regarding renewable energy production during a period of the day. This could be incorporated into the EBox functionality

4.2.3.2. Contextual issues

- Protection of consumer privacy and the concerns over the intrusive aspect of the EBox system are important issues to be considered for acceptance of the solution by consumers.
- Some consumers are worried about possible impacts on health of consumers from the wireless communications inside their houses, in particular when they have children. Either it should be clearly demonstrated that wireless communications have no impact on health, or other types of communication devices should be used to overcome this concern of consumers.
- Trust in those offering an AD product is important, to ensure that consumers have confidence that their data will be protected, their privacy ensured, that contracts protect consumers and that the financial benefits from AD are fairly passed onto consumers.

4.2.3.3. Communication, dissemination and recruitment

- Local context is significant, thus it is important to understand the area in which AD is to be deployed, and the motivations for its deployment. Consumers are able to understand and engage with the benefits that AD can bring, not only to themselves in terms of potential financial benefits, but also in terms of the wider benefits such as easing network constraints arising from renewable electricity supply. Where AD is deployed to achieve a specific aim, these wider benefits should be clearly communicated. The technology can also be presented as an action that consumers can carry out in order to prevent damage to the environment.
- Some consumers are suspicious when commercial companies make claims that services will provide environmental or other wider societal benefits. AD providers could consider working with other organisations to independently quantify, and endorse, wider system benefits.
- AD can bring more benefits to consumers where it facilitates a wider understanding of energy

efficiency and consumers are motivated to change how they consume electricity. The following elements would contribute to engaging and integrating consumers with this technology:

- Educational tools: Opportunities and programs about energy efficiency.
- Direct contact with consumers: Face-to-face meetings to present the technology and collect feedback from consumers.
- Cooperation with small commercial shops: Integration of this kind of consumers to the technology and get feedback from them.
- Advertisements and promotion: To improve the willingness from new consumers and to inform them on the following - new hourly prices and more detailed energy bill; prices based on RTP, TOU, CPP; offers from demand; off-peak tariffs; seasonal tariffs; promotional tariffs.
- Direct incentives: direct reduction on the purchasing cost and encouraging shops that promote this technology.

4.2.4. Future R & D

The main objectives studied in the ADDRESS project are as follows:

- To allocate the intelligence needed in the system to be able to increase or reduce the load demand from residential consumers by managing their loads according to the real situation of the network in order to minimize the losses in the system in the short-term and medium-term and to defer capital investments in new infrastructures in the long-term.
- To minimize the energy cost of the consumers by modifying their load curves without reducing their demand.

Nonetheless, to achieve both objectives different considerations should be taken into account ensuring the successful in the integration of the equipment and their functionality. To validate these actions, first of all a correct certification of all the equipment developed for managing consumers and their loads from the communications' point of view will be needed.

Concerning the communications between the devices, not only should this communication work correctly inside the house, but also between the different players involved in the System: DSO, TSO, Aggregators, Retailers, EBoxes and loads in the houses. The following needs to be taken into account:

- The cost of the communication devices and their energy requirements have to be low. It is interesting to point out that initially, the ICT deployment costs are high, but replication in ICT generally leads to fast decreases of component cost. Thus, the efficiency savings for the customers will be linearly increasing with the number of participants.
- The installation of the communication service must be able to cover all the house area where smart devices are placed.
- Communications must ensure stability and data security.
- It must be ensured the interoperability with the rest of LAN communications coexisting into the same house area.
- It's necessary to be easy to be installed into every kind of house.

In Table 7 the main messages between consumers and DSO and Aggregator (A) are defined.

Player	Inputs	Outputs

Player	Inputs		Outputs	
Consumer	AD signal	DSO	Consumption information	DSO
	AD signal	A	Signals received	A

Table 7. Main messages from/to consumer

Devices will be needed to be developed that make possible the end-users' demand management in automatic and optimum way. The main devices that should be adapted and improved to be able to involve consumers in future of Smart Grids refer to the appliances and gadgets inside the house.

The smart appliances should be able to receive and send signals from the EBox in order to be scheduled according the requirements. The quality of these appliances will be an important feature to improve and achieve the maximum participation from consumers.

The technology in the future should be tested and assessed to have a non expensive product accessible for most end-users. All devices developed should be interoperable. For this reason manufacturers need to use standards that allow connecting devices from different brands. Furthermore devices have to be designed taking into account that they will be installed by non-experts with the intention of reducing end-users' total investment.

Related to the management of the devices' failures, it will be necessary to have a remote management service allowing shorter maintenance periods of time. AD should not cause disturbance to the consumers and their appliances.

The ADDRESS field trials have attempted to design and deploy a complex system in consumers' homes, and issues with the complexity of the ADDRESS solution have resulted in some elements of the ADDRESS solution not tested in the field for an extended period of time. Future trials may look to:

- Undertaking ethnographic research or usability experiments with users of the technology during development to ensure that interfaces are easy to understand and can be easily used by consumers to access the different functionalities required.
- Continued trialling of AD technology in the field to gain a better understanding of consumers' acceptance of the full range of AD services.
- Investigation of other, non-AD services, that the EBox can facilitate which may add to the EBox business case

5. System Operators

5.1. The role and the involvement of System Operators

With AD the electricity consumption flexibilities of domestic and small commercial consumers, including the flexibilities of micro-generation and storage that may be present at their premises, are available on the electricity market.

The behaviour of consumers, who can be at the same time producers, can be different from expected and the providers of AD products could be concentrated in such a way to determine network violations.

In this framework SOs have to ensure, anyway, a reliable operation of their networks without prejudice of the quality of energy supply. The AD product exchanges have thus to be monitored in order to meet this objective.

AD can be used by SOs to solve network operation problems as well.

In order to ensure a safe and reliable network operation, coordination is necessary among TSO and DSOs taking into account their own responsibilities and different needs and constraints of regional and local networks.

SOs control systems have to be upgraded introducing new functions to enable and exploit AD business.

The services provided by SOs to AD market, guaranteeing transparency and non discriminatory access to all involved actors, are:

- location information;
- technical validation;
- metering information (depending on the country regulation).

SOs and Aggregators have also to ensure the consumers' privacy dealing with their data/information.

5.2. Recommendations for the acceptance and exploitation of Active Demand by the System Operators

5.2.1. Rules and market structures

5.2.1.1. Regulatory issues

The regulation of SOs' revenues is an important element for facilitating the penetration of AD: if SOs 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.

5.2.1.2. Coordination and technical validation of the Active Demand programme by System Operators

The coordination between SOs (TSOs and DSOs) 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 AD provider tries to sell the same product – including conditional offers - to both agents). Grid operators will also need to define location information, i.e. areas in the distribution and transmission networks (LAs), so that Aggregators will have better information on where to sell their services. The LA information allows the SOs to carry out properly the validation "disaggregating" the AD products. 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).

We have considered the issue of technical validation of AD programmes 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 the Aggregator's AD programme, whether the products are sold to regulated or unregulated players, grid operators need to define areas in the distribution (LA) and transmission networks (macro LAs).

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 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.

Several runs of the day-ahead technical validation sequence should be envisioned. It would allow the Aggregators to edit their initial submission in case of curtailment, for example, by soliciting additional LAs and avoiding others. In this regard, a "cancellation and new submission" message should be considered for the Aggregators to send to the DSO.

In case of curtailment in intraday, enough time should be available between the transmission of the DSO validation results to the Aggregator and the start time of the product delivery. In this way, the Aggregator can divide up differently its AD products among the LAs or modify the products it has sold. Corrective product submissions should be considered in intraday (e.g. submissions over additional or different LAs).

The timeline defining the time slots dedicated to the different technical validations for the AD products (SRP & CRP) in day-ahead and in intraday should be clearly fixed by the regulation in order to match the requirements of the SOs and the Aggregators. The same should be done for the interactions between the DSOs and the TSOs.

Inspired by some current practices at the transmission level, we recommend to also remain open to a market based alternative method that we have investigated. In this alternative, 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. A proper regulation would allow the SO to recover costs deriving from buying AD instead of reinforce network. 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.

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.

5.2.1.3. Control of the energy delivered/consumed in the BRP's perimeter including Active Demand

The real modification of power thanks to AD program has to be controlled by SOs. This is crucial for the security of the grid. When there is only one BRP for one active consumer, the measure of AD energy and the measure of consumer's consumption is in the same perimeter so, it is not a problem. But when there are two BRPs for one consumer, the responsibility of each have to be clearly defined. Therefore, an agreed method has to be chosen. We recommend that TSOs, DSOs, AD providers and retailers work together to agree on a method of measurement. For example, the method could be based on building a baseline of consumption thanks to control groups. This method must be also used to measure the energy postponed.

5.2.1.4. Functional requirements of a regulated player buying Active Demand services

Reliability: an important point is the reliability of energy delivery. Because the SOs are in charge of ensuring the reliable and safe operation of the network and (at least for the TSO) of balancing the system in real time, they must be totally confident in the tools they use. 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.

AD services down to the distribution level: bilateral contract appears as the easiest option preferred in case of few providers which fit for a short-term future. Call for tenders by the DSO is a second option required by regulation if there are several providers of distributed resources. However, the complexity and the reactivity ot such a process might not be appropriate for SOs needs implying very small bids with a short term delivery on a small area. In a further future, local organized markets opened to AD and power from DG could be envisioned. They will need several suppliers and buyers for achieving sufficient liquidities. They could be obtained by splitting a larger market down to the required level. But this third option is presently complex, depending on liquidities & DSO needs and is not likely at a first stage**.**

5.2.2. Standards

System operators will use more and more IEC standards. Key smartgrids standards have been indicated by IEC SG3 (Strategic Group in charge of Smartgrid Roadmap). M490 First Set of Standards working group has also indicated, end of 2012, which standards had to be used in order to get interoperability. In Europe ENTSO-E has adopted IEC CIM standard series for network operation and market operations. ENTSO-E's members are implementing CIM standards in order to improve the quality of network models and to increase the efficiency of data and model exchanges among the member TSOs and with the Secretariat. A major reason why this world-wide (IEC) standard is important for ENTSO-E is that different TSOs use different tools with different input formats for power system studies. ENTSO-E agreed on a roadmap for the implementation of future updates of the CIM-based format for exchanges of system operations and system studies.

At the European level, Network codes are going to impact TSOs business processes. DSOs will also be concerned by these Network Codes definition and more and more information exchanges will occur between TSOs and DSOs. ADDRESS has proved that IEC CIM could be used either by DSOs systems or between SOs systems and other kind of systems (Aggregator Toolbox, Market Simulator). We recommend to use IEC CIM in future European projects as a key standard.

We also recommend to write and provide a Good Working Practices Document, with tools recommendations, to any European project, to allow each project to speed up work on use cases, profile definition from CIM or any other standardized information model, message and service definition.

We recommend also to put in place a feedback mechanism between European Smartgrid Projects and SDOs in order for them to improve their standards.

5.2.3. Future R & D

The priority among the different types of validation which can be performed by the DSO in day-ahead or in intraday should be studied more in details.

In particular, on one hand the validation of a CRP in day-ahead should be a commitment from the DSO so that the Aggregator is ensured that an additional product submitted in intra-day before the CRP activation does not take the remaining flexibility. But on the other hand, a non activated CRP product pre-validated by the day-ahead technical validation could lead to curtail some SRP products submitted later while the pre-validated CRP will finally not be activated and therefore not delivered.

A way to balance the commitment related to the validation of the SRP and the CRP products should be studied so as to optimize the use of the margins for the network.

Reliable and accurate methods for assessing the baseline consumption at different aggregation levels, i.e. key locations of the network (LAs, feeder heads...) should also be researched. This information is the basis for the correct anticipation of the network behaviour in the presence of AD.

Regarding curtailment as a result of the technical validation, the DSO is entitled to curtail the AD actions without knowing economic information behind them. But other options such as market-based alternative approaches are possible. In these alternatives, the DSO could be responsible for re-dispatching the curtailed service into other network areas. This option has to be investigated.

6. Other deregulated players

6.1. The role and the involvement of other deregulated players

As described in Chapter 3, the role of the Aggregator, as the key mediator between flexible consumers and other power market participants, was investigated in great detail in the ADDRESS project.

Apart from the flexible consumers, the other deregulated participants can be categorized as follows:

- Producers (centralized and decentralized producers, with or without regulated tariffs)
- Intermediaries (retailers, production Aggregators, electricity traders and brokers, Balancing Responsible Parties - BRPs)
- Large consumers

In essence, the aforementioned deregulated players might all be to a more or less extent interested in the emerging opportunities offered by the AD services identified by the ADDRESS project to be potentially provided by Aggregators.

Their stakes or interests in flexibility in the form of AD services originates from their current business objectives and are related to business process improvements and thus increased competitiveness for instance in the fields of:

- portfolio management (e.g. AD services are an additional source of flexibility to balance the portfolio of a BRP),
- risk management (e.g. AD services could reduce the exposure to risks related to imbalances or expensive energy procurement for retailers/BRPs),
- investment strategies and/or asset management (e.g. an intelligent integration of AD services in the business processes might give additional insights for investment or upgrade decisions in generation capacity of electricity producers),
- energy procurement (e.g. AD services could be activated for consumption optimization of large consumers in line with their energy contract or for a stronger position in the contract negotiation phase).
- profitability of business (e.g. deploying and exploiting AD services in the most efficient way will lead to stronger competitiveness and thus to potential higher profitability in the long run - in perfect markets, intelligent management of the demand side could become a necessity to stay competitive in the energy markets).

It should be noted that some deregulated participants nowadays already take up a combination of different roles (e.g. generation, supply and BRP-role) and that some of them could become logical owners of aggregation activities as defined within ADDRESS. In particular, the relations and interactions between Aggregators, retailers and BRPs and the way they interface with (regulated) system operators is a major point of attention to turn the challenge of deployment and integration of AD services into the energy system and markets into success. The ADDRESS project outcome indicates that the combination of retailing, BRP and aggregating responsibilities may be interesting to deal with potential issues related to baseline definition (reference profiles), imbalances and settlement in general. As an alternative, clear agreement on monitoring service provision and related agreed contractual agreements with respect to remuneration/settlement between the aforementioned market participants is crucial.

In view of the different stakes, and of the barriers encountered, the ADDRESS project has identified some recommendations towards increasing the acceptance of this concept by deregulated players. These recommendations are described in section 6.2, and include: contractual issues, rules and market structures, measurement and validation, and regulation.

6.2. Recommendations for the acceptance and exploitation of Active Demand by other deregulated players

6.2.1. Contractual issues

6.2.1.1. The contract between an Aggregator and an Active Demand product buyer on the wholesale electricity market

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. subsection 6.2.2.3).

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 power [power min & power 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 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.

6.2.2. Rules and market structures

Recommendations for the acceptance/exploitation of AD by other deregulated players and related market structures include all types of commercial transactions that take place in order to exchange the

AD services. These include bilateral contracts, calls for tenders and, of course, organised markets. Based upon the expected evolution of the level of maturity of AD services, priorities can be set to enable the acceptance and exploitation of AD services.

It appears that existing market mechanisms are already flexible and complex. 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.

When the Aggregator and the retailer/BRP 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. Potential solutions are proposed by the ADDRESS project 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. Solutions are less complicated for an integrated Aggregator – retailer - BRP.

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.

6.2.2.1. 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 exists, 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.

6.2.2.2. 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.

6.2.2.3. CRP markets

We described 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.

6.2.3. Measurement and validation

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. But in the complex case when the AD provider is not the retailer of the active consumers and that a single consumer has two Balancing Responsible Parties, the AD provider has to declare to TSO or DSO the volumes of energy modified on these consumers and the time of modifications. This declaration is very important for the AD success because AD can be sold by the AD provider only if the retailer is still providing this same energy. So the Balancing Responsible Party of the retailer has to be responsible for this. Conversely the retailer is not responsible for providing the energy postponed. So the Balancing Responsible Party of the AD provider has to provide the postponement. This is crucial to well define the responsibility of each of these players for the security of the global balance between generation and consumption.

6.2.4. Regulation

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

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).

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 (and secure) 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 (i) define which data are necessary to be exchanged free of charge between them or (ii) propose they sign an agreement.

A second important element is the correct allocation of the costs and benefits of AD programs. Market agents should perceive the right incentives (in this case probably mostly economic ones) to make the use of AD services sufficiently appealing. Dependent on the specific country or technology, these incentives might be missing at this moment. Therefore, 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). When remuneration for AD is paid separately, this will not be an issue.

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.

6.2.5. Standards

Deregulated players interact with the markets. Therefore they should use standards defined at the international level for market definition. IEC TC8 WG6 DCT11 (SmartGrid Generic Use Cases for Markets), DCT4 (Smart Generic Use Cases for Smart Home, Business Industrial, DR customer energy management) and IEC TC57 WG16 CIM Market extensions should receive ADDRESS use cases relevant to AD and list of problems encountered by field tests regarding standards or lack of standardisation should be provided to relevant SDOs (European and/or international). At the European level the M490 working groups could also help to contact the relevant SDOs.

6.2.6. Future R & D

The future R&D needs are deduced from the observation that the development of AD services is nowadays often hampered by current regulation or market mechanisms.

Future R&D actions for enabling the acceptance and exploitation of AD by other deregulated market participants are mainly related to the integration of AD services in the “energy value network”, i.e. conceiving and testing out concrete adaptations to existing market places and market mechanisms, as well as appropriate changes to the regulatory framework, and then for a longer term investigating possible new markets for AD products trading.

Future research is clearly needed on methods for the measurement of AD actions. A fair method is crucial when the Aggregator is not the retailer and sells energy to other players. The energy sold by the Aggregator has to be delivered by the retailer. So the energy modification, including the shifting, realized by the Aggregator has to be well assessed in order to have a fair share of energy costs between the retailer and Aggregator.

In general, interoperability between different stakeholders is a major challenge. This relates to the required information exchange between regulated and deregulated market participants and the entire process to agree and establish the needed interactions between those stakeholders. Examples of those interactions are for instance:

- the interfaces between (local) distribution system operators and transmission system operators (in light of the integration of the proposed solutions in a harmonizing and coupled European market),
- the interaction between deregulated (and regulated) market participants (e.g. Aggregator-DSO/TSO, Aggregator-retailer/BRP) and definition of the appropriate responsibilities,
- future (local and global) market configurations (i.e. market facilitator/operator activities, market platform specifications, product definition, responsibilities of participants, ...) to deal with the challenges of high shares of intermittent RES and flexible and AD

R&D in this area therefore needs to be focused on developing sets of common standards or rules that will allow this interoperability.

Another related set of recommendations regarding future R&D has to do with the development of a regulatory framework that allows the birth of different business models that may cater the needs of the different agents. This regulatory framework should be therefore flexible enough to allow innovative schemes, and ideally, to even incentivise them.

7. Communications

7.1. The ADDRESS communication architecture

The ADDRESS architecture presents all possible communications entities and the appropriate interconnections between them in the form of interfaces. Generically, an interface represents a bidirectional link between entities, which fulfils the requirements from all involved actors (see Figure 4)

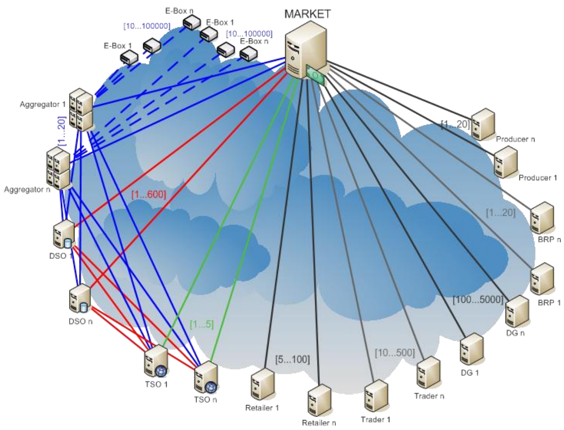


Figure 4. ADDRESS generic communications architecture between Market, Aggregator, DSO, TSO, Retailer, Trader, Distributed Generator, BRP, and EBoxes.

From the starting point (the ADDRESS role model) some clear similarities can be seen in all interfaces which are usually referred to as Business interactions (solid lines in Figure 4).

Communications in these interfaces are mainly point-to-point links so that e.g. an Aggregator has a direct, unique communication to the market on a one-to-one basis. The market itself will have to define an entry point for every actor that it interacts with.

It is understood that these networks which connect heterogeneous entities will be based mainly on third-party (Telco) fixed, always-on networks, although the access segment could also use wireless technologies (such as LMDS/MMDS and WiMAX). Some other technologies could also be taken into account for very specific entities such as small DGs.

To reach the endpoints of the system (where customer premises are located, hence called To Home) communications between the Aggregator and EBoxes are critical, this interface is highlighted in dotted lines in the architecture (see Figure 4).

The Aggregator will use either fully outsourced network infrastructure from a TelCo or a DSO, possibly based on Powerline Communications (PLC) or wireless for the last mile. As there will be many endpoints, it is a very marked point-to-multipoint topology. For such a scenario it is important to count on a manageable addressing scheme and network partitioning. A single DSO is assumed to manage up to 500,000 concentrators which in turn communicate to the endpoints. Due to the wide geographical areas covered by DSOs, both EBoxes and meters will be deployed in different sites, having different communication facilities supported by different technologies.

In the ADDRESS project, the choice was to make use of SOA and Web Services. A SOA is essentially a collection of services. Each function or business process of an actor is represented as a service - a well-defined, self-contained function, it does not depend on the context or state of other services. These services communicate with each other via connections. The communication can involve either simple data passing or it could involve two or more services coordinating some activity. Some means of connecting services to each other is needed. This may be done via Web Services, which are defined as an evolving set of protocols used to define, discover, and implement Services over the Web.

The needs, in terms of communications resources, are estimated by first considering the logical flows of data exchanged among each actor as defined in the ADDRESS model. Interactions are described in the UML service Sequence Diagram and the traffic on each connection is addressed: the nature of the (CIM XML) messages and the policy for their management. All elements are reported within a synthetic message table, see Figure 5. Starting from the message it is possible to make an estimation of the Matrix of the Offered Traffic. In Figure 6, a sample traffic table is shown, whereby some assumptions have been made in order to add the overhead protocol bits to each application payload message.

TSOack	Message Payload Short Description		
From → To (n:m)	TSO → DSO (1:6)	Note:	
Payload (Application Layer)	Data	Lenght (bit)	Note
	Parameter	256	Description
	TimeStamp	64	Standard Reference
	Sender ID	*32*	*Example:*
	Total	**352**	
Traffic	(60;60)	(Frequency Periodicity in second; Max Round Trip Time including channel and Telecommunication Interfaces in seconds)	
Priority	L		Low; High

Figure 5. Message table example.

Service	Session #	Total Payload Layer 7 (bit)		*Total Payload + Protocol Overhead L1->L4 (bit)*	
		TSO	DSO	*TSO*	*DSO*
ADDSER01	1	1000	2000	*10000*	*20000*
	2				
	n	500	400	*5000*	*4000*
	TOT	**1500**	**2400**	***15000***	***24000***

Figure 6. Matrix of the offered traffic sample.

Through the aggregation of several traffic matrices it is possible to estimate the capacity of all interconnections to be used in the communication infrastructure. To exchange messages, a message service bus with one common semantic is used between all actors.

7.2. General recommendations for communication structures

7.2.1. Standards

The methodology applied for ADDRESS could become a good working practice for other European projects. Works has been dispatched inside different Working Packages (WP) in order to specify use cases for the different business domains considered within ADDRESS project (Transmission, Distribution, Market, Consumer,…). Several teams specified use cases for:

- *Internal processes* covering specific business functions in the internal behaviors of ADDRESS Actors
- *External processes* focusing on interactions between Actors in order to convey external data required to process internal business functions of Actors.

As soon as the use cases were finalized, they were received as an input in order to specify data *interchange* format corresponding to the external interactions between ADDRESS Actors. The content of those data is called “message payload”. The specification of the format of those exchanged data between actors leads to the specification of application interfaces which have to be implemented by each actor participating in the ADDRESS business processes. In order to facilitate communication interoperability between Actors, it was decided to leverage the use of a single common semantic for external data interchanges based on international standards from IEC TC57 (such as the Common Information Model - CIM) as well as SOA) standards for the implementation of those interfaces. The objective is illustrated in Figure 7.

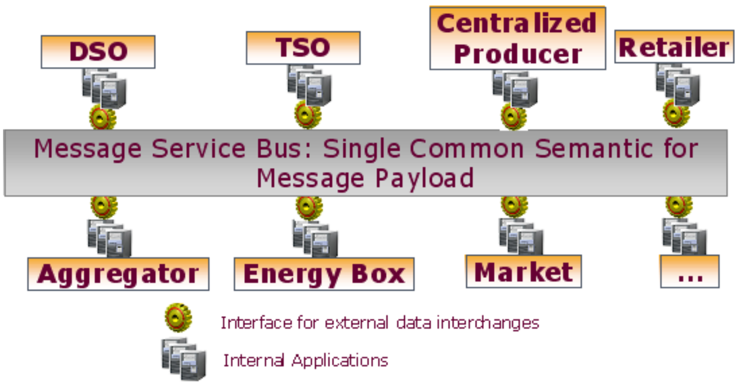


Figure 7. A single semantic for data interchanges between ADDRESS actors.

In order to leverage the use of SOA interfaces between actors, it was chosen to use XSD (XML Schema Definition) for the specification of the message payload and Web Service Description Language (WSDL) for the specification of the interface implementation. Figure 8 illustrates the approach.

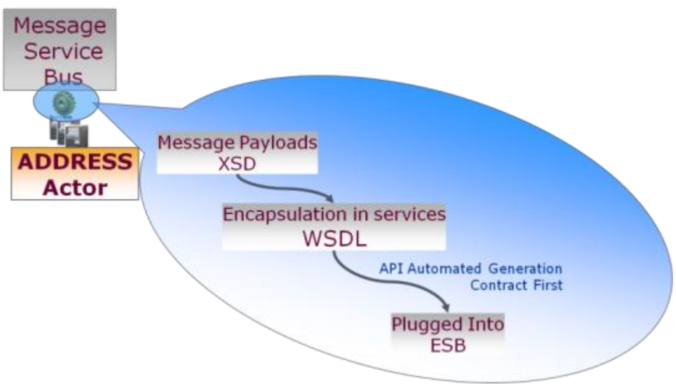


Figure 8. Building application interface API based on SOA for message payload exchanges.

Each defined message payload will have a XSD syntactic representation for the implementation.

Those XSDs are then embedded inside a service interface based on WSDL standard. From those web services definitions, Application Programming Interface (API) code for each interface can be generated in a *contract first* way meaning that the basic code API structure is generated automatically from the WSDL definition which is acting as an interface contract between applications. This API code can after be integrated and plugged into an Enterprise Service Bus (ESB) to facilitate communication and rooting of data.

7.2.1.1. Recommended methodology steps

Figure 9 illustrates the different steps to go from use case modelling down to message payload syntactic generation for the implementation of the web service interfaces.

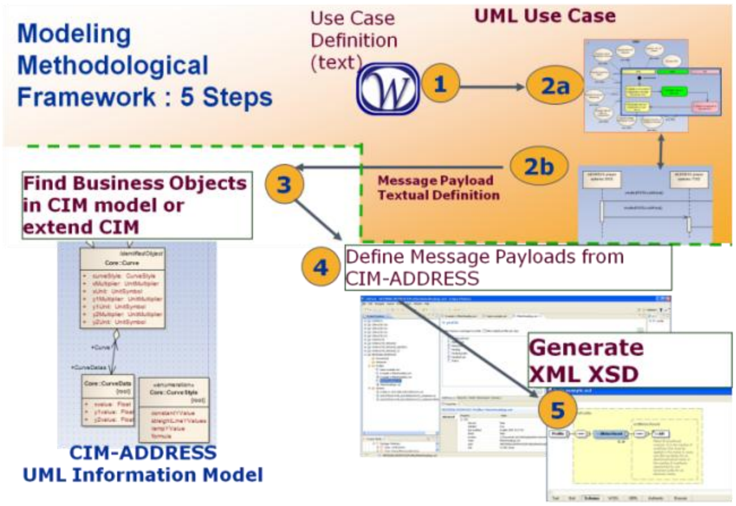


Figure 9. Methodology steps from use cases modelling down to message exchange interface deployment.

Step 1: Textual use case definition

The first step is to define textual use cases based on the business domain considered by each Work Package. In this specification, it should be addressed in particular the business requirements of the business processes, the implicated actors (Actor Role Model design), the steps of the processes, the inputs and outputs to execute the business functions. Internal functions inside the boundary of an Actor can be described but we only need definition of inputs, outputs between actors as well as the sequence flow of data in order to complete the modelling of interchanges between Actors. In order to produce textual use case definition a Word Template was defined and used. In order to give guidelines we promoted IEC Publicly Available Specification 62559. It is highly recommended to use this international standard and more specifically 62559-2 which defines the use case templates.

Step 2: UML use case definition

The second step is to give a UML representation of the textual use cases defined into step 1. This graphical representation is complementary from the textual representation and facilitates the understanding and the design. Whatever the level of detail is for the UML representation, this step needs to highlight clearly sequence diagram focused on external interactions between actors (step 2b) using the IEC TC57 Working Group 14 (IEC61968-1) for the naming of message payload and related events called IEC61968 verbs. This step is really important because it is directly linked to the following methodology steps dealing with Message Payload structure definition.

In the step 2b each interaction in the sequence diagram must provide documentation for:

- The name of the message payload (Called noun in [IEC 61928-1])
- The related verb/event (following [IEC 61968-1] naming convention)
- A clear textual description of the message payload

Figure 10 illustrates IEC 61968 use case approach as used within ADDRESS project based on the textual expression of the use cases.

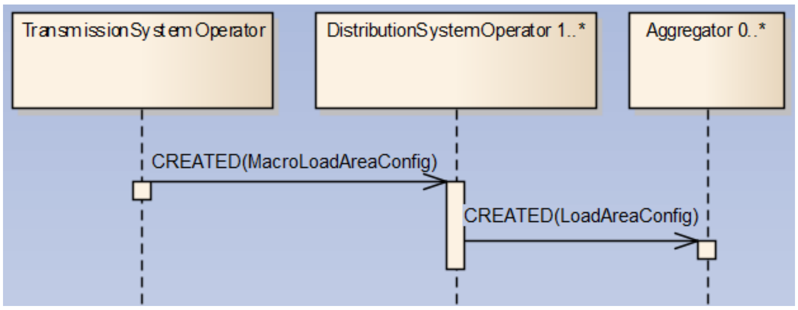


Figure 10. Example of IEC 61968 use case with Verb(Noun) notation as applied within ADDRESS project.

With this kind of UML Modelling, one clearly defines the interactions between ADDRESS Actors which are to be defined first of all. It is called the role model definition. One Actor within the project can play several roles in different business processes spread into the whole ADDRESS project.

Step 3: CIM-ADDRESS UML information model building

This step is focusing on building a common semantic on which all exchanges of data are based on. It enables to improve application interoperability and minimize the effort at the implementation side because all messages will share the same semantic.

This common semantic is called CIM-ADDRESS information Model because it is built upon the IEC TC57 CIM standards and is extended with missing concepts required for ADDRESS project. This information model is defined using UML class diagrams. In order to build this information model, the business requirements expressed in use cases specified in the previous methodology steps enable to start a *discovery process inside the CIM information Model* (CIM can be explored in UML class diagrams). For each identified flow of data (message payload), its textual content description enables to figure out if the required concepts for the message are already existing into the CIM Model.

When they do not exist into the CIM Model, the methodology step 3 is the place to model necessary extensions. Once this step is completed, *the result is an extended CIM information Model containing all required data for ADDRESS project.*

Step 4: Message payload definition

This methodology step enables to define the structure of message payloads based on the previously defined CIM-ADDRESS information Model.

Before to explain the sub-steps embedded into the methodology step 4, it's important to remind that the previously defined information model is NOT an implementation model which can be directly used inside applications or interfaces. The CIM-ADDRESS Model is a generic set of concepts along with relationships between them such as a language dictionary. From this dictionary, a grammar and rules must be defined in order to build a sentence, a text, etc and in our usage an information flow.

The methodology step 4 is exactly dealing with defining for every message payloads, the rules which needs to be respected when using the CIM-ADDRESS concepts defined in the CIM-ADDRESS Information Model. Those rules are defined by expressing restrictions upon the generic concepts from the CIM-ADDRESS Information Model. Therefore at this step, extensions of the Information Model are not allowed. The CIM-ADDRESS can only be narrowed in a sub-set of value space specific for each message payload. This expression of restrictions, constraints enable to build what is called profile in IEC TC57 reference architecture document. This profile is in other words enabling to express precisely the requirements for the message even if the message is based on a generic information model.

Then from the previously define profile related to each message, a syntactic representation can be derived. In the ADDRESS case we want to exchange XML data to facilitate web service implementations. Therefore, the choice is to derive a XML Schema XSD from the profile. The standard defining the mapping between profiles and XSD artefacts is IEC 62361-100, Naming and Design Rules or NDR.

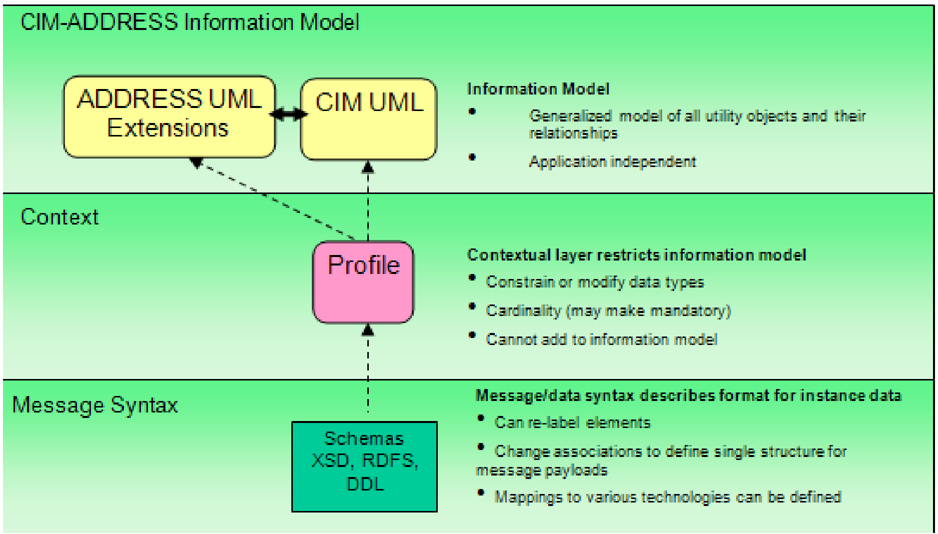


Figure 11. IEC TC57 modeling framework for ADDRESS, reference architecture inspired from UN/Cefact CCTS standards.

For detailed profiling rules, see [IEC 62325-450] standard or the emerging new standard [IEC62361-101].

In order to reduce the number of defined message payload, it may be easier to share one structure of payload between several message payloads. We call it a message type which will represent a more generic structure shared among several message payloads in the use case modelling of data flow.

Concretely in ADDRESS project, one generated XSD is representing the structure of a message type used within several identified message payloads within the process.

Step 5: IEC 61968-100 Web Service Definition embedding message payload

Once a XML schema is generated for each Message Payload, the resulting XSDs can be embedded and used for the implementation of an interface exchanging messages with external systems belonging to other Actors.

There is a close link between use cases defined in step 2b and the encapsulation of message payload XSD inside web services definition using WSDL language (Web Service Description Language). The standard [IEC 61968-100] describes into details how to link a message payload to a Web Service interface implementation from the definition of the use cases seen in step 2b.

The previously defined XSD for the message content is used to create the WSDL types linked to the operations defining the concrete interfaces of SOA applications. Figure 12 shows an example of Simple Object Access Protocol (SOAP) message based on the WSDL document-style binding.

This kind of XML data interchange is the result of the encapsulation of the XSD defined in step 3 in a WSDL file.

The business content of the message is handled inside the payload body and the payload header is filled with extra information coming from the use case modelling such as the Verb, noun, Source of the message (ADDRESS Actor). Other extra data in the Payload header are linked to the execution of the process itself (example: date and time of the creation of the message). Those XML data are embedded in the SOAP body which is as well embedded in the SOAP Envelope.

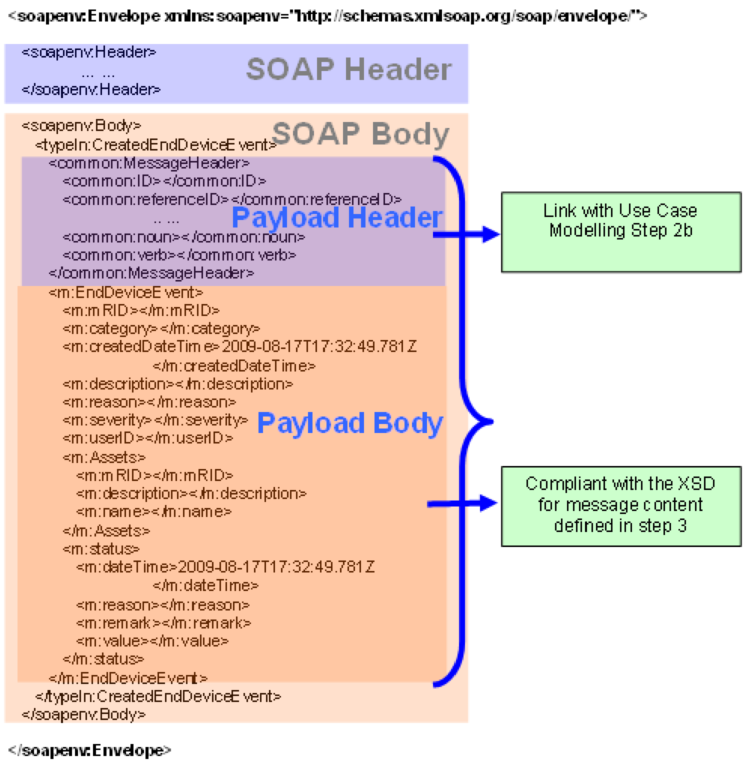


Figure 12. Example of SOAP message based on WSDL Document binding style.

7.2.2. Recommendation based on implemented field tests

Implementing the simulated prototypes based on the standards described in the methodological working framework, can draw positive conclusion on the ability to:

- Automate API code skeleton generation from the interfaces specification.
- Facilitate interoperability between ADDRESS Actors applications and independency from infrastructures constraints and choices.

Even if all possible web service frameworks are not tested in the simulated prototypes, the conclusions offer good perspectives about the use of the described standards to create interoperable and framework-independent ADDRESS implementation infrastructures. Indeed, OpenESB (started by

Sun and now owned by Oracle) and AXIS (Apache Foundation) are two reference industry-standards for SOA implementation.

Moreover, the use of web services offers the ability to reach a good level of security with additional standards directly plugged into the SOAP standards (encryption of part of the SOAP message depending on the Actor access rights, reliability of communications, etc).

If ADDRESS related projects decide to leverage the use of those standards for the real applications, there are basic concerns which are unlinked from those standard choices but which need to be covered:

- Managing namespaces for web services and message payloads: it provides a clear unique identification for each resource. Managing namespaces is often linked to the question of versioning.
- The Message Payload Header as seen in IEC61968-100 embeds extra information about the message itself such as the source of the data (identifier of actor in the Use Case), date, time of the created message, etc. All information do not need to be filled but as soon as one extra information is used, the management of its content needs to be studied.

The use cases description is detailing business requirements and rules to define business messages payloads. But in order to implement those exchanges of business messages, technical data exchange formats need to be defined such as technical acknowledgements, technical fault messages.

For a real platform depending on performance, volume of data and security, different kind of modularity could be implemented for the web service architectures:

- Number of servers per actor
- Number of services per server
- Number of operations per service
- Number of BPEL servers per actor dispatching interactions on many services inside Actor Applications….

7.3. Recommendations for communication structures between market players

7.3.1. Rules and market structures

Communications shall enable necessary interactions among the market participants for the exchange of technical and commercial information. The overall process for the definition of the telecommunication requirements must take into account the ADDRESS model description with all the actors, their interactions and business services defined, and the list of non-functional and telecommunication functional requirements.

The communications between the players shall satisfy the following technical requirements: performance - bandwidth (data rate) constraints and robustness (availability), supported protocols and interfaces, plug & play capabilities, QoS (quality of service), network management, firmware upgrade and security.

Requirements for the telecommunication infrastructure are related in the project to well-known and available standard protocol suites including among the others, service oriented architecture and Web Services, as well as the ISO/OSI Reference Model.

7.3.2. Standards and regulations

In ADDRESS it is assumed that the addressing schema is based on IPv4 (RFC791) because it is not yet fully replaced by IPv6 in today's networks. In future, IPv6 will be the protocol to be considered. IPv6 was developed by the IETF starting with RFC 2460.

Telecommunication standards fall in several main groups according to the media used for transmitting signals: wired (twisted pair, copper cable, optical cable), electricity cable (powerline) and radio (exploiting different frequency bands from VHF to Microwave) to implement wireless connectivity.

With respect to ADDRESS service requirements (see IR4.1) broadband PLC, based on IEEE 1901, OPERA/UPA and Homeplug AV standards, appears to be one of the most suitable options for the access segment (EBox, Concentrator, etc), together with in-home equipment based on the EN50065 standard which appears to be very consolidated for transmitting information on low voltage electrical systems, either on the utility distribution grid or within installations in consumers' premises. For xDSL, optical systems and wireless technologies, no new standards are required, taking in account that all interfaces and protocols will be used are already available up to the transport layer of ISO/OSI stack.

The main goal of regulation is to solve problems like interference and coexistence, encouraging technology and innovation for the introduction of the new services, and efficient management techniques. ADDRESS telecommunication infrastructure requires to take into account all mandatory standards related to EMC and Safety. To list relevant directives: 2006/95/ec - Low voltages Electrical Equipment (LVD), 2004/108/ec - Electromagnetic Compatibility (EMC); regulations on EMC/Immunity/safety: prEN50561-1 (in preparation), prEN50561-2 (in preparation), EN55022, EN55024, EN60870-2-1, EN60950-1, and IEC60664-1.

A liberalised and harmonised European internal energy market (IEM), both wholesale and retail can function efficiently only if its associated electronic data exchanges function in a reliable and efficient manner and are based upon common process descriptions and 'role models'. ENTSO-E's EDI working group develops and maintains numerous detailed descriptions of such models and processes, in formats which are easily understood and implemented by the software industry, partly in co-operation with other associations, in particular ebIX and EFET and in liaison with standardisation organisations like the IEC TC 57 (Power Systems Management and associated information exchange). The adoption of the ENTSO-E CIM interoperability tests and the CIM/XML-based data exchange format is a direct contribution to the ENTSO-E tasks defined by the EU. The experience gained from the process of developing and implementing CIM-based standards is directly contributing to the future network code development as data exchange processes will be part of several network codes.

At the international level, IEC TC8 Working Group 6 in charge of Smart Grid Business Requirements will validate all the Smart Grid actors that will be used in the definition of Smart Grid Use cases.

- The final ADDRESS actors should be proposed to European and International standard development organisations. In ADDRESS we leveraged the ENTSO-E-EFET-EbIX role model managed by ENTSO-E Electronic Data Interchange working group. This role model actor list has been also taken into account by M490 Sustainable Process Working Group. Nevertheless ADDRESS defined new actors/roles which are not yet officially standardized. Therefore it is important to provide ADDRESS actor list to IEC TC8 WG6, with a meaningful definition of each actor. IEC TC8 WG6 is coordinating itself with IEC TC57 working group 16 which is in charge of the CIM Market Extension (IEC 62325 standard)
- IEC TC57 is also developing an Architecture Reference Model (IEC 672357). The ADDRESS architecture concepts (technical and commercial) will have to be provided to IEC WG19 in charge of IEC 62357 architecture reference model. IEC TC57 WG19 is still working closely with

European M490 reference architecture working group and US NIST SGIP Smart Grid Architecture Committee.

7.3.3. Future R&D

Power utilities search for communications options that will result in improved operational efficiency and increased productivity as well as prepare them for Smart Grid deployment. Several considerations are in place. First, the solution must be highly reliable: in a mission-critical environment, no compromise is acceptable. Second, capital expenditures (CAPEX) and operating expenditures (OPEX) must be minimized. Finally, the network should offer the opportunity to implement new services in a rapid and cost-effective manner.

The new technologies provide utilities with the opportunity to extend traditional applications to more efficient IP and Ethernet technologies and to implement new IP-centric applications, such as: ➢ *IP-based mobile radio* ➢ *Ethernet-based supervisory control and data acquisition (SCADA)* ➢ *IP-based video surveillance* ➢ *Collaboration tools* ➢ *Voice over IP (VoIP)* ➢ *WiFi mobility*

It is expected that IP and Ethernet will be the key communications protocols for the Smart Grids. IP technology can increase operational efficiency, supporting existing critical applications while providing the benefits of the new applications.

The ideal solution is one that offers at least the same level of reliability, QoS and security as that of traditional utility communications networks while supporting the full array of both TDM and new IP/Ethernet services that are needed for core utility operations and administration. The R&D shall determine the most the advantageous communications implementation and how to proceed to achieve the best solution.

To our knowledge, ADDRESS project is the first SmartGrid European project which has leveraged the use of IEC CIM related standards. CIM Message types that have been developed by ADDRESS could be made available to IEC TC57 working group 16 and working group 14 if they are relevant for defining standard interfaces which could help to introduce AD. CIM model extensions defined in ADDRESS could also be made available towards IEC TC57 in order to include officially these extension in the CIM Model (IEC 61970-301, IEC 62325-301, 61968-11).

We are sure that in the near future, other European projects will have to use CIM and other semantic information models like 61850, DLMS-COSEM, in order to improve interoperability and integration. For use cases the IEC 62559 standard developed by IEC TC8 WG5 has to be used, and relevant use cases should be made available to international Standard Development Organisations like IEC TC8 WG6, which will help to coordinate the work done by other technical committees involved in Smart Grid related standardisation (like IEC TC57, TC69, TC13, …)

7.4. Recommendations for communication structures for Distribution System Operator

The MVCC prototype developed for the Italian field tests implements functionalities of the ADMS, DMS and Market tools.

The functionalities are implemented by an AD Server component that will run on a computer server that resides within the DSO Control Centre. The client side is based on a thin-client, which accesses some web pages that can be reached through a web browser. This allows external actors, like the Aggregators, TSO and Market, to access the AD information that is provided by the AD Server. For security considerations, the AD Server and the corresponding Web server are protected by firewalls in the MVCC.

Figure 13 shows the system architecture. The DSO MVCC is composed of the current SCADA and archives (S.A), the AD extensions, delivered by this project, which reside on separate computers.

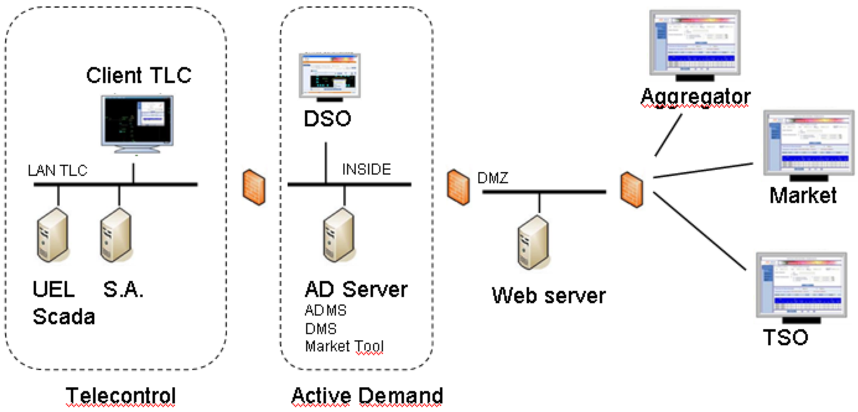


Figure 13. System Architecture of the MVCC implementation

Figure 14 represents the MVCC prototype software architecture. It shows the interfaces to the other systems of the DSO MVCC, that is the SCADA, NIS and other Information Systems, and the interfaces to external systems, like TSO, Aggregators, Market and web services to gather meteorological forecasts.

Dashed lines represent an external exchange of data (as the object flows represented through the squares and the arrows). The continuous lines, connecting the DMS with ADMS and the Market Tools in particular, represent an internal connection between the three systems within a unique actor environment (a bidirectional exchange of data and measures). The ADMS and the Market Tool, representing two distinct use cases within a unique actor activities (the DSO), can communicate just through the publication, into the ADMS, of the Market Tool results.

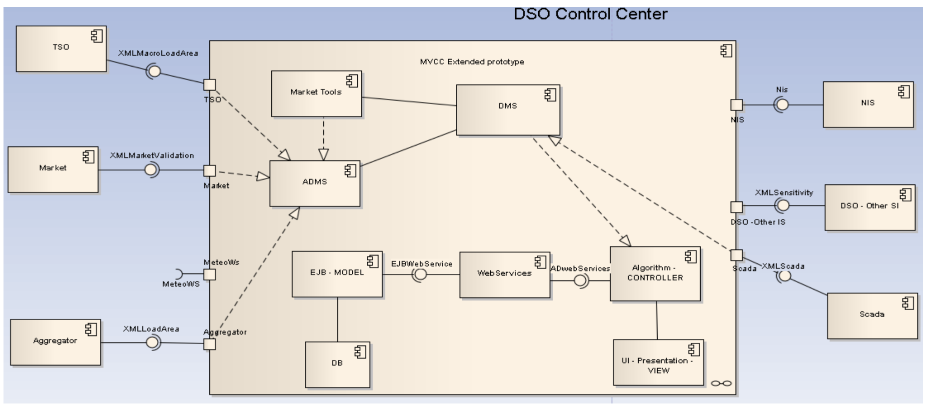


Figure 14. MVCC prototype software architecture.

Communication Standards deployed for the MVCC field test are:

- Complete TCP/IP protocol and communications for 802.3 (LAN) wired networks.
- IEC61850 communications module:

  - Common data models, compatible and extended (IEC61850-7-3 and IEC61850-7-4) and ACSI Services (IEC 61850-7-2) for Clients, MMS protocol mapping (ISO/IEC 9506 Part 1 and Part 2) and ISO/IEC 8802-3 Ethernet.
  - GOOSE services.
  - SNTP protocol clock synchronization.
  - Configurability of XML files according to SCL templates (IEC 61850-6: Substation Configuration Language).
- Modules with typical asynchronous serial protocols for communication with bay devices (level 1): PROCOME, DNP3.0, IEC 870-5-102, IEC 870-5-103, MODBUS, etc.
- Modules with asynchronous serial protocols for communications with the control center: IEC 870-5-101, IEC 870-5-104, DNP3.0, etc.

Main HW and communication interfaces deployed in the MVCC field test are:

- Ethernet ports (i.e. for network connection according to IEC-61850 and for connection to the network using IEC-60870-5-104 for communication between substations and Remote Control).
- Modems PLC.
- serial ports, BNC coaxial connector, USB port master, etc..
- CPU card with industrial temperature range.
- RAM, Internal memory (Flash), removable and expandable memory (i.e. Compact Disc-Flash).
- digital inputs and digital outputs.
- Front MMI (Keyboard and Display) and LEDs.

7.5. Recommendations for communication structures within the house

7.5.1. Standards

Communication standards within the house are numerous and well established nowadays. Both wired and wireless solutions are being utilized in inter-home communication applications, e.g. Powerline Communication (PLC), Zigbee to mention a wired and a wireless solution respectively. ADDRESS components within the house make use of such standards and do not introduce new ones.

7.5.2. Engagement

Experiences from the Spanish field test show that standard communication procedures within private home work as planned and are no bottleneck for the project.

Issues may, however, arise in specific cases. As an example consider a case from the field test in Castellon where the smart washing machine is located outside the flat on the roof balcony. Due to the concrete walls, there have been communication-related issues. Therefore, it is important to consider the (wireless) communication paths within a private house or flat. Even though standards are in place, the signal strength may pose an issue because private installation may vary drastically from one another.

The communication range of Zigbee might be too limited for some AD participants. Many communication errors have occurred during the French field tests. This protocol may be sufficient for a flat but for a house or a small commercial client it might not be powerful enough (distance, obstacles, several floors, etc.).

7.5.3. Future R&D

Communication issues are one of the main factors that limit the development of AD in far and/or isolated areas (such as islands), where however the Aggregator could have a major role. The development of information and communication technologies appears to be a key for AD development.

Moreover, the volume of data and information exchanged through communications networks is going to increase and the communication infrastructures will have to take this into account.

A very high security level for guaranteeing the privacy and the safety of consumers' data is absolutely necessary to meet at least the regulatory requirements which may be very strict depending on the country (such as in France).

It is of great importance to support a maximum number of heterogeneous communication protocols (wired as well as wireless). The issue of reliability of communication needs to be solved on an individual basis by means of e.g. signal repeaters where required.

The support of multiple communication standards may, however, have a negative impact on the cost structure of the hardware required. Over time this issue should not have a dramatic impact

8. Manufacturers

8.1. The role of manufacturers

The successful implementation of the AD strategies requires an active participation of all involved stakeholders. Approaching the residential segment it is fundamental to guarantee the acceptance and participation, among the others, of the final consumers in the proposed solutions.

The management of the electricity consumption at the consumers' premises is normally a compromise between residents' comfort and energy use. The availability of electrical devices able to interact from one side with the EBox and from the other side with the final consumer in order to properly manage the energy usage is a fundamental element to guarantee the acceptance of the AD solution by those consumers.

These smart devices will allow the final consumer to keep control of its usage while expressing the specific needs (normally time constraints on the appliances and device use) in a simple way possibly similar to the one used for operating the normal appliances and devices. These constraints are transferred to the EBox that will take into account both the users' preferences and the Smart Grids signals to optimize the time of use of the involved devices.

The presence of smart devices is also a guarantee for the Aggregator about the proper response of these electrical loads to the signals sent to the EBox.

These smart devices will then play a role as a further interface between the Aggregator and the final consumer for a proper interaction and positive dialogue able to involve it in the energy use awareness and management.

The manufacturers of these smart devices and appliances, for the above reasons, are playing a fundamental role in the success of AD strategies. They contribute to mitigate the consequences of the different price and volume profiles of electrical energy for the final consumer and to guarantee a more reliable response of the electrical loads to the Aggregator.

The role and characteristics of these smart devices have been positively explored in the ADDRESS project and a suitable proposal has been identified, specified and developed.

One of the key elements taken into account in that activity has been the interoperability of the solution. It appears clear that for a real deployment of smart devices, the definition and implementation of interoperable mechanisms and interoperable technical solutions are mandatory. This is a crucial condition for a large involvement of the manufacturers and the presence of a broad variety of smart devices attractive for the final customer. It is also linked with the fact that the real benefits of the presence of such devices could actually be perceived only when their penetration in the residential market will be relevant.

8.2. Recommendations for large scale deployment for smart appliances and smart equipment

8.2.1. Rules and market structures

To favour a large diffusion of smart devices able to concur in a successful diffusion of AD policies offered by Aggregators it is important to create the conditions for:

- Customer Involvement
  - Accurate billing and clear information on their energy consumption.
  - Guarantee full control of their appliances with the possibility to enable AD functionality.
  - In case of acceptance of AD functions, clearly define and indicate in the contract the operative conditions and rewards.
  - For the ones interested in environmentally friendly habits, make available the information about the amount of green energy available over the grid through the day to operate the appliances accordingly.
- Commercial offer
  - Implement tariff schemes or rewarding mechanisms which provide a clear benefit.
  - Define initiatives offering robust incentive for customers, rather than mandatory measures, to attract the customers on volunteer basis.
  - Define initiatives offering rewards for customers that choose smart devices (which are expected to be more expensive than standard ones).
  - Promote and inform about the benefits of smart devices indicating possible incentives at point-of-sales.
  - Technical infrastructure.
  - Develop an infrastructure based on open, flexible, secure, and interoperable communication standards.
  - Base the exchange of data among smart devices and between smart devices and EBox (and further with the Aggregator) on interoperable international standards.
  - Transfer information directly to the customer, such as Price and Volume Profiles, possible peak conditions, and renewable share of energy supplied.

Most of these aspects have been considered in the ADDRESS project and are a good starting point for a further evolution of solutions that will fully integrate and exploit the smart devices.

8.2.2. Standards

The availability of interoperable standards is a crucial element to make possible the successful commercialization of smart devices.

There is still a lack of interoperable standards to be used in AD solutions despite many initiatives trying to address this aspect. It is important to underline that this does not mean a lack of communication technologies able to support the integration of the smart devices with the other involved devices through a Local Area Network but instead a lack of interoperable Application Profiles (the part of the communication protocols that defines and describes the application part).

The communication technologies available to support connectivity in the consumer segment (i.e. Wi-Fi, ZigBee, PLC...) are suitable also for implementing AD solutions: there is no need of developing special or dedicated technologies for them.

These interoperable Application Profiles are mainly related to support the communication between the smart devices and the EBox.

The main characteristics of these interoperable standards for the integration of the smart devices should be:

- open, publicly available solutions, resulting from an agreement of all involved stakeholders, compatible with the most popular communication technologies available for the usage in residential houses;
- flexible solutions able to address an incremental integration of smart devices and support their evolution in terms of functions and available interactions;
- secure standards that will guarantee a safe exchange of information, the privacy of sensitive data and a controlled access to them;
- global solutions widely accepted in the world to favour the diffusion of common components and devices for a cost effective deployment of the AD policies.

The interoperable standards should cover the following aspects:

- Information to the customer: the possibility to inform the customer about the use of energy is fundamental for its awareness and acceptance of change of habits required by the AD strategies. The information should be made available through the EBox or the involved smart devices. It could be displayed directly on the appliances user interfaces or on connected smart interfaces.
- Control signals: these are the signals between the EBox and the smart devices to organize the device operations according to the price_&_volume signals coming from the Aggregator, the Load profile of the involved appliances and the time constraints selected for them.
- User's needs: these are the specific messages supporting the definition of the time constraints that the customer associates to the appliances it would like to activate. The messages must include the override command that the customer can activate when an unconditional start of the selected appliance is needed.

It is interesting to notice that in Europe one popular architecture to implement AD solutions is considering the presence of a energy management device like the EBox as the central element of the home environment and the key interface with the Smart Grid, whereas in North America is taking off a solution based on direct signals from the Smart Grid to the smart devices without the presence of a EBox[1]. Consequently also the proposed standards are reflecting the different approaches.

The Manufacturers are interested in global solution able to manage the regional differences in a flexible way to avoid multiplying the efforts with dedicated versions for the smart devices.

Manufacturer should be certified against IEC key standards and prove that their equipment or systems are compliant with international standards by participating to interoperability tests. Interoperability tests are a mean to prove that standards defined by SDOs are used and that different product manufacturers can interoperate.

The key European activity for the definition of a reference standard for household appliances participating in the Demand Response policies is the Cenelec CLC/TC 59X/WG 07 - Smart household appliances: the standardization work to enable domestic appliances to improve functionality through the use of network communication. Examples of network communication include smart grid, smart home and home network. This activity is in conjunction with the Cenelec CLC/TC 57/WG 01 - Smart Grid Mandate M/490 for a full interoperable integration of the smart appliances with the Smart Grid Demand Response solutions. The results of the ADDRESS project are used as inputs in those activities.

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[1] In Europe, this latter architecture is investigated too.

8.2.3. Engagement

- The possibility to carry out remotely the following activities is important and should be improved:
  - update the software,
  - make a diagnostic and implement a solution in case of a problem,
  - check the configuration of the EBox and the appliances and complete the installation of the system,
  - etc.
- The robustness of the AD devices or components must be improved both at the levels of the software and the hardware:
  - to avoid “crashing” of the software after several days or weeks,
  - to avoid breakdown or “melting” of the hardware in normal use conditions,
  - to ensure the reliability of the data transmitted to the EBox,
  - to implement an improved optimisation strategy.
- More actual smart appliances should be developed and available at reasonable prices to the consumers. The use of smart plugs should only be a temporary solution to control classical appliances before they are replaced by smart ones.
- Interoperability of communications inside houses should be improved.

8.2.4. Future R & D

The process of having smart devices integrated in AD solutions is just started and there is still an important R & D activity to be done for:

- exploiting the whole flexibility of the different categories of devices;
- creating a simpler interaction with the final customer to favour a further involvement in the process of smart use of energy;
- improving the quality of the communication link (both in terms of reliability, interoperability and flexibility) of these devices with the EBox and the other devices involved;
- better integrating the AD functionalities with the other added value services made available by the communication infrastructure;
- improving the dialogue of these devices with smart interfaces (smartphones, Pads, ...) for a shared user interface integrating the AD dialogue with the other added value interactions.

Some of these aspects will be covered inside interoperability activities that present use cases that comprise the AD scenarios identified in the ADDRESS project.

The evolution of the communication technologies should consider and take into account the specific requirements identified in the ADDRESS solution. In particular the link reliability aspects that radio communication technologies are presenting when applied in residential premises need to be better analyzed and adequate solutions identified.

The possibility to organize these developments inside a project aiming to validate interoperable solution with a large field trial campaign is strongly recommended to secure the reliability of the possible commercial initiatives derived from them.

9. Conclusions

This document has presented the recommendations on the aspects most critical for a broad acceptance of ADDRESS results.

The recommendations have been proposed as seen from the different parties involved in the ADDRESS architecture: Aggregators, Consumers, System Operators, Other deregulated parties, Communications, Manufacturers. For each category of stakeholders, the recommendations are organized into four main groups: rules and market structures, standards, engagement of stakeholders, future R&D.

10. References

[D1.1] ADDRESS Deliverable D1.1 - ADDRESS Technical and Commercial Conceptual Architectures

[D5.1] ADDRESS Deliverable D5.1 - Description of market mechanisms (regulations, economic incentives and contract structures) which enable active demand participation in the power system

[D5.4] ADDRESS Deliverable D5.4 - Report outlining business cases for Customers, Aggregators and DSOs in the scenarios detailed in WP1

[IR4.1] ADDRESS Internal Report IR4.1 - Catalogue of telecommunication requirements and communication architecture necessary to enable active demand and smart grids

11. Revisions

11.1. Revision history

Version	Date	Author	Notes
0.1	31/05/13	Arturo Losi	First release
0.2	14/06/13	Iberdola	Review
0.3	21/06/13	Arturo Losi	Updated version
0.3	28/06/2013	TM+TM	comments
0.4	12/07/2013	Arturo Losi	Updated version
0.5	19/7/2013	PC	comments
0.7	25/7/2013	Arturo Losi	Updated version
1.0	31/7/2013	PC+QMO	Final Approval