DELIVERABLE

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SEESGEN-ICT

Supporting Energy Efficiency in Smart Generation Grids Through ICT

Thematic Network

ICT PSP Programme

BUSINESS MODELS MANAGEMENT

Identify technological and non-technological barriers; identify solutions to barriers

D5-3

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LIST OF ABBREVIATIONS

AMM	Advanced metering management
AMR	Automatic Meter Reading
ANN	Artificial Neural Network
BM	Business Model
CENELEC	European Committee for Electrotechnical Standardization
CHP	Combined Heat and Power
CCHP	Combined Cooling, Heat and Power
CVPP	Commercial Virtual Power Plant
DER	Distributed Energy Resources
DG	Distributed Generation
DR	Demand Response
DS	Distributed storage
DSM	Demand-Side Management
DSO	Distribution System Operator
EE	Energy efficiency
EN	European Standard (developed by European Committee for Standardization)
ESCO	Energy Service Company
HV	High-voltage
ICT	Information and Communication Technologies
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IT	Information Technology
LV	Low-voltage
PCC	Point of Common Coupling
PV	Photovoltaic (power generation)
RES	Renewable Energy Source
RTP	Real-time Pricing
ToU	Time of Use
TSO	Transmission System Operator
UPS	Uninterruptible Power Supply
VPP	Virtual Power Plant
VTT	Technical Research Centre of Finland
WP	Work package
µ-CHP	Micro combined heat and power

EXECUTIVE SUMMARY

This is the second report produced by work package 5 of the SEESGEN-ICT project. WP 5 concentrates on different DER aggregation business models which are necessary to support implementation of energy efficiency services and DER in a competitive market. We also study what kind of ICT solutions and methods are already available to support these business models and what kind of research/development is still required.

In this report we have gone through some specific barriers to DER aggregator business in Europe. DER aggregators are companies which act as mediators between DER and power system participants. There are many types of barriers to DER aggregation business including regulation, technology, and social acceptance. We have concentrated on barriers which are related to the ICT tools needed by DER aggregators or their large-scale implementation. We find that there are still many unsolved issues including interoperability between aggregator's internal tools and adapting the tools to different market rules and conditions. Some of the tools such as those needed for forecasting the behaviour of consumers controlled by an aggregator are not yet in a mature level. There is no commonly agreed procedure for the verification of services produced by aggregators. Consequently verification tools are also missing.

We also studied the barriers in three national situations in Poland, Germany and Italy. In these analyses we did not strictly concentrate on the aspect of ICT tools. In Poland the legislation relevant to aggregation business is not stable and thus discouraging business development. There is a lack of an explicit strategy for the development of energy markets towards the smart grid. Progress in enabling aggregation business models is slow. In Italy regulations are beginning to take aggregation into account in some cases but for low-voltage end-users regulation for demand response is still lacking. In Germany the situation is most favorable of these countries.

1 INTRODUCTION

In our previous deliverable of SEESGEN-ICT, D5-2, we described the concept of DER aggregator. An aggregator is a company who acts as intermediator between electricity end-users, who provide distributed energy resources (including demand response, distributed generation and distributed energy storages), and those power system participants who wish to exploit these services. Furthermore, we described nine different DER aggregation business models from different European countries. Some of these business models were existing businesses while others were proposed business models from research projects. We also described some of the different types of ICT tools which are needed in DER aggregation business. These were software tools needed in the internal functions of the DER aggregator.

In Europe the number of existing DER aggregators is still small. The business faces some *barriers*, which slow down its development. Barriers can be defined as potential problems for the development and acceptance of DER aggregator business. There are many types of barriers for DER aggregation business. These can be classified according to their origin into regulatory, technical, economic, social, and other groups. However, in many cases a barrier does not clearly belong to one group only. Regulatory barriers include for example minimum volume requirements to access certain organized markets or limitations to the possibility to offer aggregated resources to TSO's disposal as reserves. Regulations related to balance management can also have a great effect on aggregator business. The importance of some of these barriers was already evaluated in different European countries in our previous deliverable (Madina et al 2009).

Obvious technical barriers include the lacking infrastructure such as smart meters and appropriate communication infrastructure. In addition there are less obvious technical barriers such as the effect of active DER control on the distribution grid. In some cases aggregator actions may lead to critical network loading situations that would not occur if aggregators were not present. Technical barriers include also the lack or poor maturity of ICT tools which are needed by aggregators.

Aggregators control DER, either directly or indirectly. This can create adverse effects to both the end-users, e.g. consumers who own flexible loads, or other power system participants. These issues are included in the acceptance barrier. For example, in some regulatory regimes aggregators can cause costly imbalances to retailers, which can decrease the acceptability of aggregation activity among them. Consumers who could provide DR can in some cases perceive remote control of their appliances as a dispossession attempt.

In this task we will identify barriers related to ICT, regulation, business, and to some extent acceptance, that oppose the development, management and application of DER aggregation business models needed for energy efficient smart grids. We will use the analyzed business models described in our previous deliverable to collect the barriers, and on the other hand we try to see how the barriers affect these business models. We also try to identify possible solutions to these barriers. Solutions can include e.g. changing or harmonizing regulations, developing common procedures, promoting standards or further developing the individual ICT tools needed by aggregators.

The structure of the report is the following: in Chapter 2 we deal with barriers directly related with certain ICT tools which are necessary for the daily operation of a DER aggregator. In Chapter 3 we deal with several barriers related to implementing these tools on the large scale. In Chapter 4 we concentrate on the national situation in three European countries, Poland, Germany and Italy, and see what kind of barriers exist in these countries and how they could be solved. Chapter 5 presents a summary of the work. In the appendix we list some existing software tools which are necessary for aggregators.

2 BARRIERS TO DER AGGREGATION BUSINESS RELATED TO DIFFERENT ICT TOOLS

In this chapter we deal especially with barriers related to the ICT tools needed by an aggregator. These can include poor status of the tools or difficulties in developing them. The difficulty can arise for example from the general complexity of the problems which these tools should solve, or adapting the tools into different regulatory frameworks in different countries. On the other hand we deal also with problems in regulatory framework, contractual issues, etc. which can be alleviated using these tools. We also try to see which business models (out of the 9 which we collected in our previous task) suffer from these barriers.

2.1 Barriers related to load and price forecasting

2.1.1 *Price forecasting*

The uncertainty of the price development in the target market (for example day-ahead (DA), intra-day (ID), balancing market (BM)) in the coming period is a potential source of economic risk. E.g. firm price contracts to the customer represent an aggregator risk for being forced to purchase the sold volume at very high prices in the DA market. Price forecasting is therefore a key factor in the aggregator business.

The price forecasting methodology involves complex assessments depending on the market structure/rules in the respective system. A set of relevant tools was listed in the Deliverable D5-2..

2.1.2 *Demand response forecasting*

Estimation of the expected volume (MW) of demand response from the portfolio of customers is needed when an aggregator is selling load reduction as a balancing service to the BM. This task differs from traditional load forecasting because it's related to the reducible volume, not the total load.

DR forecasting has not been much focused so far, and there are several possibilities for further development. One is to make some kind of regression with regard to already performed controls. Another idea is to utilize the knowledge of the characteristics and location of the customer groups, selected reducible appliances etc.

The economic risk in this context is related to the obligation of selling a specified volume to the TSO. Penalties / fees might apply if the contracted capacity is not delivered when called upon.

2.1.3 *Imbalance costs*

An aggregator portfolio of end user loads targeted at the BM, might include end users related to different Balancing Responsible Parties (BRP). The imbalance cost will generally be allocated according to the + or – balance for the respective BRP's.

This might lead to a conflict with regard to who should cover the BRP imbalance cost. The problem is that the cause of the extra cost is actions by another commercial actor - in this case an aggregator selling load reduction to the BM.

The case is illustrated in the figure below. The aggregator has a contract with the TSO offering a portfolio of reducible loads to the balancing market (or as grid related load control service). He also has contracts with the end users participating. These contracts can also e.g. include Remote Load Control (RLC) systems. The challenge is, however, that every customer in the future can choose and change their retailer when ever they wish. The RLC technology and the special contract between the end user and the aggregator will, however, still be in place. The retailer is the seller of the energy which is the basis for the imbalance settlement. So, the aggregator sells a service to the

balancing market that might affect the imbalance of many BRP's. This can be very costly for the retailer if the "down"-regulation price is high.

It is in other words important that the aggregator makes sure to handle this risk up-front.

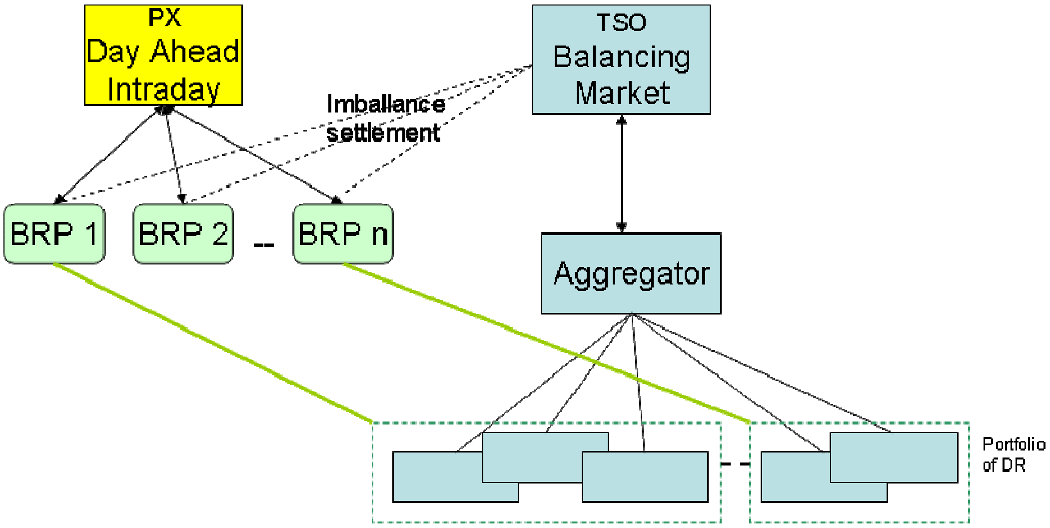

Figure 1 Aggregator customers with different BRP's.

There is no single tool that is the source to this barrier, rather a set of routines, availability of reliable data and the design of contracts.

Transparent price information and access to consumption data are the most important aspects, which both are dependent of regulatory decisions/guidelines. In the Nordic system and also in other European countries the price related to up or down regulation in the balancing market is not public before the next hour. Information of historical prices is, however, available in most systems.

Access to consumption data provides good routines for exchange with the DSOs involved and permission to use the data, which is an issue for the regulator and the consumer organizations in most countries.

2.1.4 *Aggregator ICT which can be a solution to the barrier*

As discussed above, good price and load forecasting tools will reduce the economic risk. Price forecasting can also be outsourced, which means that the forecast are bought from experts. Estimation of the reducible volume should preferably be adapted to the existing portfolio of DR.

The economic risk reflected by the uncertainties can be reduced by a set of appropriate contracts between the aggregator on one hand and the end user, BRP, TSO etc on the other.

2.1.5 *Most affected WP 5 business models and actors involved*

The discussion is somewhat general and should affect most aggregators and especially those who represent a large number of consumers. The actors involved are

- DSO: availability of consumption data
- TSO: Balance market operator - Balance market settlement
- End-user: Consumption pattern

- BRP (Balance Responsible Party): Imbalance costs

2.2 Barriers related to service verification

Negotiation, monitoring and verification of active demand services are three activities directly linked and dependent on each other, which means that whatever has been negotiated has to be measured and finally based on the measurements and the conditions of the negotiated services, the provision of the service has to be verified.

A relevant characteristic of and active demand service is that it is negotiated and contracted time before the service provision is requested and the problem for which the service is requested appears. This means that the amount of reduction is negotiated beforehand based on estimated consumptions of group of customers.

As an example to illustrate the problem, let us say that a DSO has forecasted the load in a node for a certain period in the future and he finds out that, maintaining the consumption, as forecasted, a congestion may happen. At this point the DSO calculates the reduction required to avoid the congestion and starts negotiating it with aggregators that have reduction capacity within the required area, see Figure 2.

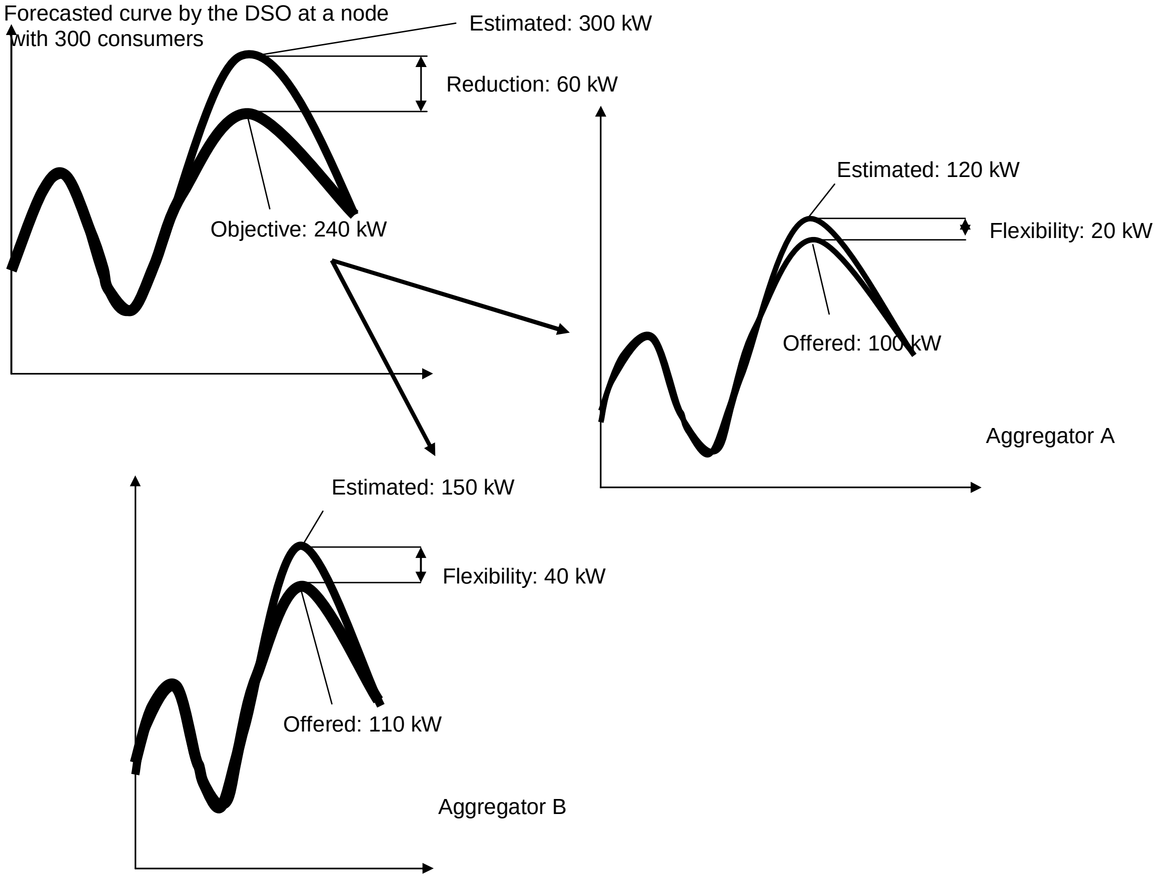

Figure 2. Active demand service provision

The aggregators prepare their bids by estimating the aggregated consumption of its consumers during the requested period and estimating, as well, their reduction capacity. A process takes place between the DSO and the aggregator until the contracts are settled.

Later on, the DSO decides to use the service and makes a reduction request, the aggregators request the reduction form the consumers, who are the actors that really decrease the consumption. Then once the event has finished data has to be gathered from the smart meters and the verification takes place.

From here, it can be seen that the active demand service involves uncertainties and risks that have to be accepted by the different participants in the game: Service requesters (DSO, TSO, retailers and others), the actors offering the service (aggregators) and finally the actors providing the service (consumers). Therefore, we can say that the barriers faced by the active demand service verification process are:

- Establishment of the reference or base line consumption.
- Accuracy of the measurement.

2.2.1 *Establishment of the reference or baseline consumption*

To perform the verification an agreement is necessary between the aggregator and the DSO, or other actor requesting the service, on the reference consumption or baseline that is going to be used for comparing the measurements of the provided service. A similar mechanism should be necessary for verifying the provision of the service by the individual customers, who are the actors reducing the consumption.

This reference consumption or baseline refers to the expected consumption of the customers providing the service during a certain period of time. This reference, which is a forecast of the normal behaviour of customers can not be calculated accurately but it represents a statistical value with its associated mean values and standard deviations. The use of this reference by the different actors implies the assumption of the risks associated to it.

2.2.1.1 *The most affected business models*

All the selected models require the establishment of the reference or baseline consumption as a way to compare the measured real values with the normal profile and from there calculate the reductions achieved.

2.2.1.2 *Actors involved*

The actors involved in the establishment of the reference consumption are all the actors involved in the active demand service management, starting from the service requesters (DSO, TSO, retailers, generators), the service provider (aggregator) and the actor implementing the service (customer).

2.2.1.3 *Solutions*

The solution to this problem is the establishment of the methodology to create the reference consumption and the techniques to be used to achieve the result with the possible lowest level of uncertainty.

From a methodological point of view the following ways look possible:

- The actor requesting the service negotiates a bilateral contract with every one of the aggregators providing the service and within this negotiation process, the aggregator proposes a baseline that is being subject to the negotiation process until a final agreement about it is reached. This agreement will include the reference consumption to measure the quality of the service provided, the price to be pay for its provision and the penalties that will have to be faced by the service provider if it fails to fulfil the contract.
- The actor requesting the service performs a statistical analysis of different types of consumers and develops a reference line that is presented to the service providers

whenever an active demand service agreement is negotiated. In this case all the profiles are estimated by the service requester and the aggregator has to select the one that fits with the services that he is able to provide.

- The actor requesting the service fixes a consumption limit to the aggregators for any of the occasions in which he asks for an active demand service. In this case the aggregator gets rewarded whenever the aggregated consumption of its associated customers does not go beyond the established limit. Currently, in Spain there exist an interruptibility program that follows this approach, but the conditions to access to this market are:
  - o The consumer has to be connected to the high voltage network.
  - o The minimum reduction capacity is 5MW.
- The actor requesting the service establishes a contract with the provider in such a way that he is able to send price and volume signals to the providers. In this case the requester of the service sends incentives for reduction to the providers and expects their reaction according to some developed flexibility models. This solution implies the avoidance of the problem of establishing the reference line and translates the problem to the calculation of the flexibility models.

The proposed solutions may be valid in general but some may be preferred over the others depending on the verification level. The following verification levels can be identified:

- Verification between the service requester and the service provider: In this case the provision of the service has to be verified at an aggregated level by showing the compliance of the aggregated measures of the customers implementing the service and the aggregated reference line having been established. For this kind of verification the better approaches would be any of the three first approaches above proposed.
- Verification between the service provider and the customer implementing the service: in this case and for small customers it does not seem reasonable to try to agree on a reference consumption with a small consumer and the most appropriate means of verification would be the last approach from the above methods. This means making the contract based on clear incentives (prices for different kind of consumptions).

2.2.2 *Accuracy of the measurement*

The data to be used for the verification comes from the information gathered by the smart meter of each individual consumer, that may be aggregated to verify the fulfilment at the first level previously defined or can be taken individually to verify it at the level of the final customer.

The type of data that is considered for the verification process includes the normal consumption of the final customer and the consumption measured during the active demand event:

- The normal consumption of the final customer may be used to forecast the normal consumption of the customers and in this way facilitate the establishment of the reference consumption.
- The measured consumption during the active demand event is used to calculate the actual consumption during the event and to compare it with the agreed reference.

2.2.2.1 *The most affected business models*

All the selected models require the rules and technologies necessary to get the data required for the verification process which is described in the previous paragraph.

2.2.2.2 *Actors involved*

The actors involved in the acquisition of the data are all the actors involved in the active demand service management, starting from the service requesters (DSO, TSO, retailers, generators), the service provider (aggregator) the actor implementing the service (customers) and the actor in charge of managing the smart meter. This actor should provide the legally required data and should be able to give the data up to the level of detail requested by the service being implemented.

Acquiring data with the frequency required by the verification process of the active demand service is not feasible for the complete duration of the metering process and solutions to change the acquisition frequency and storage have to be provided.

2.2.2.3 *Solutions*

The solution to this problem is that the smart meter needs to be flexible enough to modify its data capturing process to adapt to the requirements of different applications:

- Data capture for billing: This process has to take into account prices of the different periods and store the total energy consumption for each one of those periods. This means that not very demanding features are required from the smart meter.
- Data capture for consumption forecasting: In this situation it seams that the data capture frequency should be similar to the one described in the previous situation and the information does not need to be transferred in real time, but files covering long periods could be transferred to perform these off line studies.
- Data capture for an active demand event: This process may need to acquire big amounts of data within short periods. In this case the sampling frequency could be very short on the range of few minutes. The smart meter should receive the notification of the active demand event from the aggregator, along with the required sampling frequency and it should store all the information in its database to make it available later on to the involved stake holders for verification and billing purposes. In the interruptability case of Spain, the sampling frequency required to industrial companies is of 5 minutes.

2.3 **Barriers related to operational optimization**

The subject of this section is the barriers related to aggregator operational optimization tools. To understand the barriers, an introduction to the optimization problem is first provided below. Another input to barriers analysis is the requirements which we presented for the optimization system in SEESGEN-ICT deliverable D5-2.

Operational optimization includes optimization of aggregator's day-to-day decisions concerning DER scheduling and short-term energy trading. DER scheduling optimization produces as result the signals which are finally used to control DER units, such as price and power control signals. In other words, the aggregator has to decide how to operate the portfolio of active customers to maximize its profits and produce savings to the customers. Short-term energy trading produces as result bids, or decisions about acceptance of existing bids, which are sent to organized energy markets. In addition, short-term bilateral contracts may be traded. Thus we can distinguish these two activities, the first activity regarding the management of the flexibility offered by the aggregated DER units (downstream market), the second activity regarding the aggregator’s tactics in participating in short-term the energy market and power system services (upstream market). Of course, these activities are closely connected and are thus handled in the same process. Most of the added value of aggregation comes from the ability to optimally connect the flexibility of the DER units with the wholesale market. We note that poor operational optimization procedures do not prevent DER aggregation. No operational optimization is needed for implementing some simple services. In this case, however, profitability will be poor.

Operational optimization works in the short-term, i.e. it does not look further than a few days ahead. It works on top of portfolio optimization, whose job is to decide the long-term contracts with consumers and DER owners as well as wholesale actors. These contracts are taken as inputs into operational optimization.

As mentioned above, the outputs of the optimization tool are signals to DER units and market bids. Several inputs are naturally needed and the tool must have the necessary interfaces for accessing databases containing information about

- customer status, such as offers for flexibility (supply curve), flexibility forecasts (including forecast of override), contractual constraints, calls history,
- price forecasts, such as for prices on organized power markets at different time periods, forecasts for imbalance prices,
- load forecasts and generation forecasts for different periods, in order to forecast the aggregator's own balance position,
- accepted bids and offers on different markets (results coming up from the clearing of the markets) for different time periods, as well as orders based on bilateral contracts with regulated and deregulated players for different time periods.

2.3.1 *The most affected WP 5 business models and actors involved*

Below we describe some specific barriers related to operational optimization. These barriers affect all business models where decisions about timing the control signals to different DR customer groups must be done. They include at least EU-DEEP and FENIX business models BM 1 to BM 4 as well as the Norwegian balancing market business model BM 8. Actors involved are the aggregator, consumers or other types of DER, and markets.

2.3.2 *Barriers related to the complexity of the problem*

The optimization problem is naturally modelled with discrete time steps because also markets and balancing settlement work with discrete periods (often one hour resolution). However, the balancing mechanism and certain ancillary services such as restoration reserve do not follow this time schedule. The exact rules vary by country, but for example in Finland the beginning and ending times for power supplied or consumed in the balancing mechanism can be any, with 5 minutes' resolution.

The optimization problem is inherently dynamic because current decisions affect future decisions. For example, we cannot continue to shut off air conditioning, if it already has been off for two hours. The problem is also inherently stochastic, with two kinds of randomness occurring. The first type cannot be acted upon and does not have any effect on subsequent decisions. An example is the realization of imbalance prices for certain period (assuming that it cannot be used to forecast future imbalance prices). The second type gives information which can be exploited in future decisions. An example is a change in temperature forecast for the next day. Taking the second type into account explicitly is challenging; detailed stochastic formulation is deemed to be computationally infeasible. This is because of the *curse of dimensionality*: we have to consider the effect of the current decisions in each of the possible future pathways, characterized by the realizations of all random variables considered in the model. Figure 3**Figure** shows a decision tree which illustrates how the model size quickly becomes impractical when random effects on each time step are included.

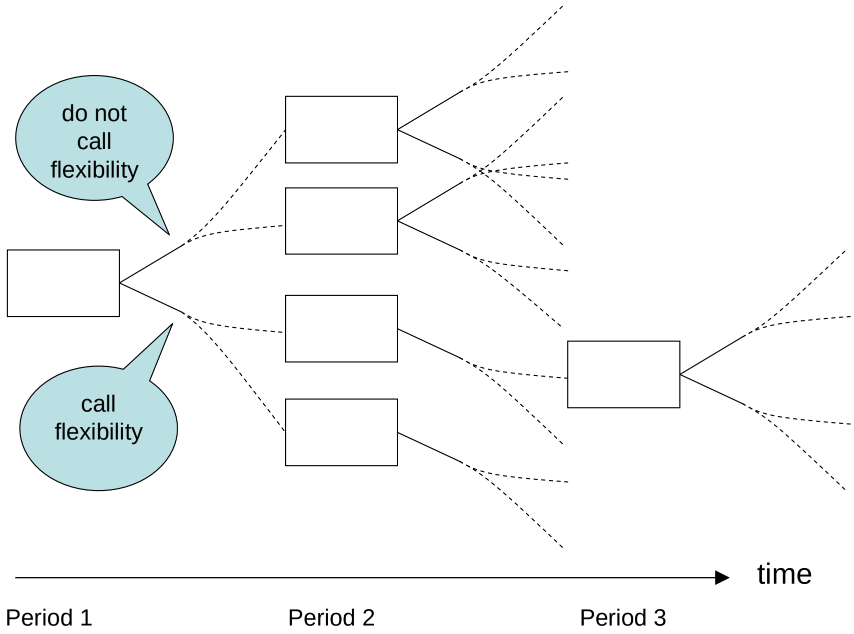

Figure 3: Illustration of the explosion of system states when during each period one binary decision (shown with solid lines) can be made, and there is a random event (shown with dotted lines), which affects subsequent decisions and random events. Here the decision can be e.g. to call load flexibility and the random event can be a change in forecast of market price.

2.3.3 *Barriers related to the handling different services and markets*

The optimization tool should be able to take into account simultaneously different types of services which the aggregator can provide to power system participants. For example, the aggregator can provide restoration reserve to the TSO, voltage control service to DSO, participate in day-ahead and intra-day power markets, participate in balancing mechanism and finally minimize his own contractual power imbalance. The different services present themselves as contracts in the optimization system. The contracts can have different specifications about timing, pricing and location of the service. The aggregator's scheduling system should then:

- identify and exploit the synergies between different contracted services and bids and
- avoid clashes between different obligations.

Also, because different markets and services run according to different time schedules, the system should be able to look ahead and take into account the possible future needs of other contracted services. For example, when an aggregator accepts to provide frequency control services (see Figure 4) several days ahead of the time of the actual delivery time, he has to compare the financial benefits of this decision to using the same DER capacity to provide other services, which are agreed closer to the delivery time.

Markets and services which aggregators can participate or provide are different in different countries. There can be differences in market timing and pricing mechanism. This presents a problem for the operational optimization software. It must be adapted to the specific regime in each country. This increases the complexity and cost of the software. Furthermore, some small and very different market areas may not be supported by commercial software for operational optimization.

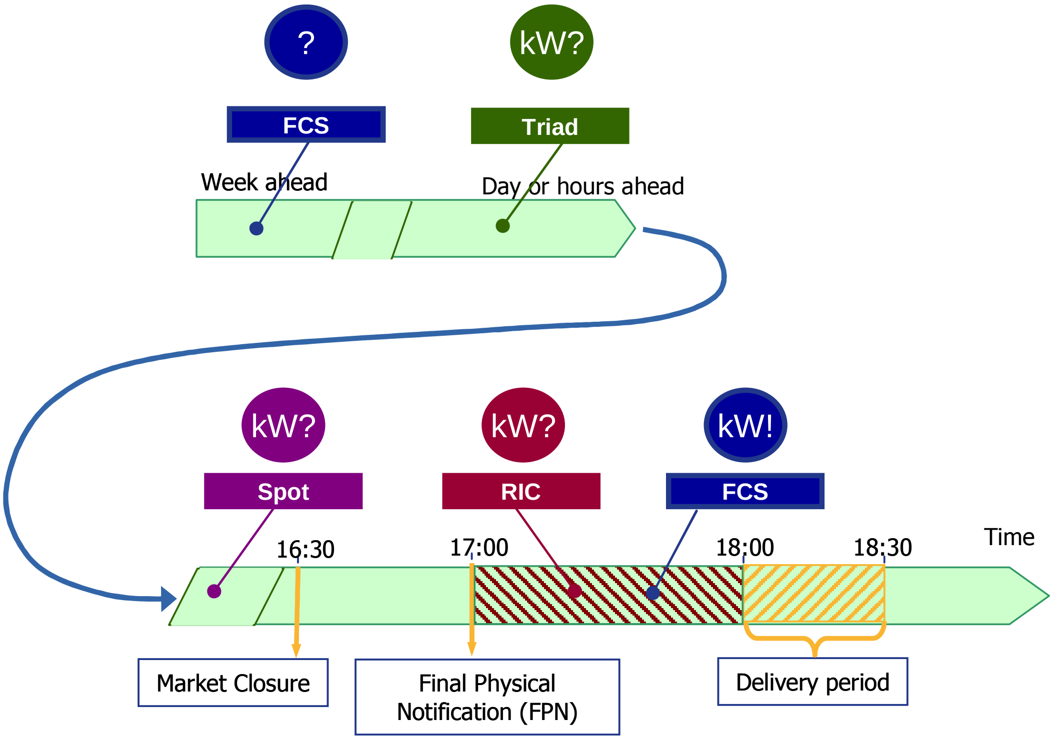

Figure 4: An example of the partially overlapping time schedules of different services and markets in Great Britain (Brecq 2008). Frequency control service (FCS) availability is first agreed with the TSO in the beginning of each week. DR can be used for reduction of transmission fees ("triad") if national peak load periods are expected. Spot trading goes on until 1:30 hours before the beginning of the delivery period. Frequency control service activation request may be received before or during the delivery period. Imbalance costs can also be reduced just before or during the delivery period (RIC).

2.3.4 *Barrier related to communicating dynamic load forecasts*

It is very important that scheduling optimization has accurate information about the controllable distributed resources, and what kind of response they can produce when sent different types of control signals. Load and response forecasts include the information about this. However, the way to handle customer load forecasts in the scheduling optimization process is not straightforward. Most controllable loads (and of course distributed energy storages) are dynamic in nature, i.e. load control in one period will also affect the load in subsequent periods. For example, if air conditioning is switched off for two hours in the morning, it may draw a higher power than normal during mid-day.

Load and response forecasting or the dynamic DER is naturally done by a different software module (modularity is a desirable property in the aggregators assortment of software) and there should be a common understanding between the different software modules about how to handle the description of the dynamic properties of DER. This is one specific example of interoperability barriers, which are discussed below in section 3.1.

3 BARRIERS ARISING FROM IMPLEMENTATION OF AGGREGATOR'S ICT TOOLS

Some barriers are related not to a specific tool, but to their implementation on large scale. An aggregator has, in principle, to be able to aggregate, through its tools, millions of end user. Moreover it must put each of them in a position to come into the aggregation without effort and it must be able to manage their information, avoiding the dangers related to privacy and cyber-security.

Therefore the following classes of general barriers have to be taken into account:

- insufficient interoperability;
- need for scalability;
- management of information;

3.1 Insufficient Interoperability

Interoperability is "*the ability of two or more systems or components to exchange information and to use the information that has been exchanged*" (IEEE 1991). As highlighted in Deliverable D5.2 business tools for aggregation need to communicate with each other and to have a common understanding about the meaning of the exchanged data. Interoperability is an important precondition also for the profitability of the business models because it would avoid vendor lock-in if the involved partners could use a modular tool package with standard interfaces.

At the moment there are many candidate standards able to cover some of aggregator's tools interoperability needs, but "*none of these standards has a complete data model for distributed energy resources, equipment condition monitoring data, geospatial location, and other information that will underpin Smart Grid technologies and applications*" (NIST 2010). In particular information describing both supply profiles and energy demand profiles need a standardized format (Hannus 2010). Also the communication layer is fragmented and often dominated by legacy and proprietary protocols.

Moreover according to (MEF 2009) "*While smart grids technologies continue to progress, without well-defined and technology-neutral interoperability standards, further innovations and opportunities for deployment at scale are limited*." It is important to notice that this lack can hinder a real opening of energy market, since it makes almost obligatory for the end-users to stay with some specific service providers (e.g. aggregator). On the other hand adoption standards would allow, for example, end-users to change their aggregator without effort.

The standardization process itself could become an obstacle: the developing of specifications could take too long a time with respect to the needs for smart grids. Moreover without a real international consensus from all the stakeholders around it, the "critical mass" will be not obtained and the standard would remain "yet another one" set of specifications, without application in the real world. (MEF 2009).

3.1.1 *The most affected WP5 business models*

All the selected business model requires communications with the aggregator in order to exchange data, to make bids and offers, to aggregate profile and so on.

The absence of standardization is evident in BM5 of D5.2 (an Italian real business case called "Ritiro Dedicato") and in BM6 (an Italian real business case called "Scambio sul posto") where the exchanged energy injection schedules (sent to the Italian company GSE) are defined in proprietary XML and in proprietary CVS formats. Furthermore in BM8 (a Norwegian real business case called "Demand Response access to the balancing market through a commercial aggregator") the disconnection of loads to get demand response disconnection requires a phone call from the TSO to the DSO.

3.1.2 *Actors involved*

All the actors that have to communicate and exchange data have to face this problem. In particular looking at the "information exchanged between the actors" paragraph for each business model in D5.2, these actors are: aggregators, end-users, TSO, DSO, market, retailers, DERs and business facilitators (as the GSE in the Italian business case).

3.1.3 *Solutions*

The key point to get interoperability is the use of **open standards**:

- **standardization** implies a standard way to ***exchange*** data (standardized protocols and data format) but also unambiguous ***understanding*** of exchanged data (common reference model and vocabulary). The adoption of standards plays a relevant role in four key aspects (De Sabbata 2010):
    1. lowering the needed investment for each actor which want take part to the business;
    2. achieving a longer life time of the adopted IT solutions; easing maintenance operations
    3. offering a reference state of art, that can act as benchmark for collaborative process to be implemented;
    4. increasing perceived benefit thanks to a large number of adopters.
- **opening** implies the involving a huge number of stakeholders to define specifications, ***broad acceptance*** of the resulting specification and availability of specifications to broad stakeholders (some standard specifications are too expensive to be bought)..

The chosen standards should also be (NIST 2010):

- based on a **transparent** deployment process, which means the opportunity for all the interested stakeholders to know the state of the process, to read the documents and to follow the discussions, to provide comments and suggestions and so on, even If they are not members of the standardization group;
- **effective** in responding to the needs;
- **not overlapped** with other existing international standards.

The **specifications should define test facilities** to validate products, in order to be sure that they were really interoperable.

In order to get a set of not overlapped open standards, they should be arranged in a **shared architecture**. After the design of this architecture a **map of the existing standards** will be necessary. The comparison between the architecture and the map will point out where the development of new standards is needed. A **harmonization** process is the last step to get the complete architecture.

Two interesting examples of this process are: the American "NIST Framework and Roadmap for Smart Grid Interoperability Standards" and the "M441 European Commission Mandate***"***.

- NIST is the USA National Institute of Standards and Technology, a non-regulatory federal agency within the U.S. Department of Commerce. Its mission is "to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology…" (NIST Web Site).

  In 2007 it was assigned to the NIST the "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems…". The way chosen by the NIST to get this result is "a three-phase plan to accelerate the identification of standards while establishing a robust framework for the longer-term evolution of the standards and establishment of testing and certification procedures" (NIST 2010). The objective of the phase 1 (*Roadmap and Smart Grid Release*) was the identification of a reference model which point out: the map of the existing standards, the needs for new standards and the action plan to develop these lacking specifications. The next phases will have the aim of evolving the roadmap *(phase 2: public-private partnership for longer term evolution*) and beginning implementation (*phase 3: testing and certification framework*) (Arnold 2009).

- The European Commission committed a mandate to CEN, CENELEC and ETSI to "create European standards that will enable interoperability of utility meters (water, gas, electricity, heat), which can then improve the means by which end users´ awareness of actual consumption can be raised in order to allow timely adaptation to their demands (commonly referred to as ´smart metering´)" (M/441 EN).

These two initiatives chart the way for the definition process of a framework of open standards, accelerating its development and getting a huge consensus on it, the first on a different national context and the second on a more focused problem and at lower level.

This way could be followed to get interoperability in the implementation of business model based on DER aggregation.

3.2 Need for Scalability

Scalability is "*a desirable property of a system, a network, or a process, which indicates its ability to either handle growing amounts of work in a graceful manner or to be readily enlarged*" (Bondi 2000). With the change of paradigm from centralized to distributed generation, there will be a dramatic escalation of the complexity of the electric systems, due to the introduction of millions of small generators dispersed on a wide area. All these new resources will have to be coordinated and managed. Therefore the traditional centralized control will be saturated quickly.

More in detail the critical points for scalability in the implementation of the aggregator's ICT tools are (SmartHouse/SmartGrid 2010):

- the difficulty of knowing in each moment the state of each distributed resource;
- the difficulty of managing large numbers of events in short time;
- the difficulty to get reply from the aggregated DER at short notice.

3.2.1 *The most affected WP5 business models*

The most affected business models, among the ones collected in SEESGEN-ICT WP 5, are the models which require real time control of loads and/or generation resources.

In particular:

- in BM1, BM2, BM3 aggregation is used also to supply balance and other ancillary services. Therefore it is a time-critical model;
- in BM5 the physical aggregator (TVPP) operates the physical aggregation of the DER within a single geographical area so it is involved in the previous three critical points about scalability. Moreover the TVPP and the CVPP units offer to the Market power and ancillary services, such as reserve, frequency response, reactive power, black start.
- In BM8 load disconnection is operated following a TSO request to the aggregator. The response requirement is 15 minutes. Therefore it is a time-critical model;

In the remaining BMs, scalability is a less critical point.

3.2.2 *Actors involved*

The aggregator is the actor that manages the huge number of resources. So it bears scalability issues. In the BM5 the aggregator which operates the physical aggregation is usually the DSO. Therefore in this case it is involved in scalability issues.

3.2.3 *Solutions*

Scalability issues have to be taken in account since the **design** phase of the ICT architecture of the aggregation, in order to choose ICT solutions addressing this issue. Also **simulation** can be useful to evaluate the chosen architecture. Moreover **scalability verification** should be planned afterwards, in order to test if scalability has to be achieved in the final system.

The main requirement related to scalability is certainly the implementation of **distributed control**, since centralized control is hardly scalable. Some interesting architectures are SOA, grid computing and MAS:

- the use of a **Service Oriented Architecture (SOA)** could warrant the scalability for message exchange between the actors. For example web services could be employed to enable decoupling between the access to service and the computation resources which provide the service itself. Instead the use of **grid computing** for data processing could address computational scalability, so that demand growing could be tackled via addition of hardware to the grid.
- Another architecture that can address distributed control and consequently scalability is the **Multi-Agent System (MAS)**. A multi-agent system is "a complex system composed of autonomous agents who, while operating on local knowledge and possessing only limited abilities, are nonetheless capable of enacting desired global behaviours" (Vidal 2001). In particular, "because multi-agent systems process data locally and only transfer results to an integration center, computation time is largely reduced, and the network bandwidth is very much reduced compared to that of a central control. Multi-agent systems also allow scalability such as when new resources, loads, or interconnections are added to the system and extensibility such as performing new tasks or communicating a new set of data that becomes available."(Tolbert 2001)

An excellent example of architecture based on MAS is given by the SmartHouse/SmartGrid project. In it agents, representing the different actors, compete on the market for resources and, at the same time, perform local control. In particular concentrators agents represent sub-clusters of DER devices. "In order to obtain scalability, concentrator agents can be added to the structure as tree nodes" (SmartHouse/SmartGrid 2010).

Anymore it is important to highlight that, because of the enormous number of resources that will be involved in aggregation it is not realistic to require a complete knowledge of the state of each resource or a perfect control of each event. A reasonable objective is that known states do not diverge too much from real states and that managed events are all the events really important for the system. (SmartHouse/SmartGrid 2010).

3.3 Management of information

The model of aggregating of DER using ICT tools generates new issues for management of information which can hinder the development of DER aggregations. These issues are related to privacy, data-ownership and cyber-security. The raising of ICT interconnection among the actors, the increasing of the complexity of the grid and of the number of entry points and paths which can be used by attackers to introduce vulnerabilities and add potential menaces for confidentiality and privacy (NIST Cyber Security 2010). More in details:

- **privacy**: the aggregation of active end users, prosumers and, in general, DER units requires that data about consumption and production of these distributed resources have to be collected, stored and analyzed in a finer granularity. The availability of these data could allow, for example, to third party to investigate the behavior of end-user and to use them for dishonest aims.
- **data ownership**: different interpretations about data ownership could bring to different repercussions on privacy. For example if data ownership were assigned to the aggregator,

this choice could hinder the achievement of privacy, but if their ownership were assigned to end-users, they could ask to the aggregator to pay for their usage, raising an economical barrier to aggregation.

- **cyber-security**: the implementation of new way of communication and of new technology to realize DER aggregation inside the electric grid will bring to the creation of new and sometimes unexpected vulnerabilities in the electric system. For example an attacker could take the control of the aggregator's ICT tools and to use them to changing simultaneously and significantly power production of the DER, altering so the balancing of the grid. (DOE 2009) It has to be highlighted that cyber-security involves not only intentional attacks, but also user errors, system failures and natural calamities which could compromise the ICT infrastructure.

3.3.1 *The most affected WP5 business models*

All the collected business models need the implementation of new communications and the collection of data from end-users. So they are all affected by this barrier.

3.3.2 *Actors involved*

The end-user is the most affected by privacy problems. The aggregator, which manage end-user's data, and the end-user are involved in data ownership issues. Cyber-security concerns all the actors.

3.3.3 *Solutions*

NIST has formed a Cyber Security Working Group which is working on a strategy to address security and privacy issues in the Smart Grid (NIST Cyber Security 2010). The same steps of that strategy could be used in our restricted topic. The crucial point should be the prevention and the steps will be:

- definition of a **risk assessment** process;
- collection of security and privacy **requirements** (including analysis of standard framework to identify security gaps in existing standards);
- development of a **security architecture** (additional functionalities needed in the ICT tools to address security and privacy)

It is important to notice that there are already solutions for some of the problems related to known vulnerabilities. These solutions have to be included in this security architecture. But new vulnerabilities will arise in new aggregation business model and is important to anticipate their raising.

The defined architecture can be the base for the adoption of a development process tailored on the security requirement of aggregator's ICT tools. One example of such process is Secure Development Lifecycle (SDL) by Microsoft. An SDL is a software development process which takes into account, in every phase of software deployment, of security and privacy requirements.

It is important to evidence that management of information barriers require not only technical, but also policy responses.

Data ownership need a regulation solution taking into account rights and needs of all the involved actors and the weakness of end-user's influence compared with economical priorities of other parties. Moreover the development of technical solution requires an economical effort that could discourage the companies and the vendors. Therefore economical incentives could stimulate them to put the needed importance on security and privacy features.

4 LACK OF REGULATION

4.1 Introduction

This chapter not only describes the barriers and solutions to barriers in a close regulatory context (legislative requirements referring to Regulators as stakeholders), but chooses a more comprehensive view in terms of what is to regulate (to standardize / to harmonize) in the context of SEESGEN-ICT.

Therefore we have to identify the borderline between regulation and standardization as there are different levels in the SmartGrids:

- The technical level (e.g. covering SCADA, smart metering, communication with field equipment, communication with the HAN …)
- The business/commercial level (e.g. communication and cooperation among stakeholders (contracts, offerings, orders, invoicing, bilateral or via data hubs, as well as tariff models, pricing models, market models, fostering of investment and prosumer participation, providing incentives / cost recovery)
- On both levels cyber security and authentication is relevant

This is shown in the concept of the Energyweb in Figure 5:

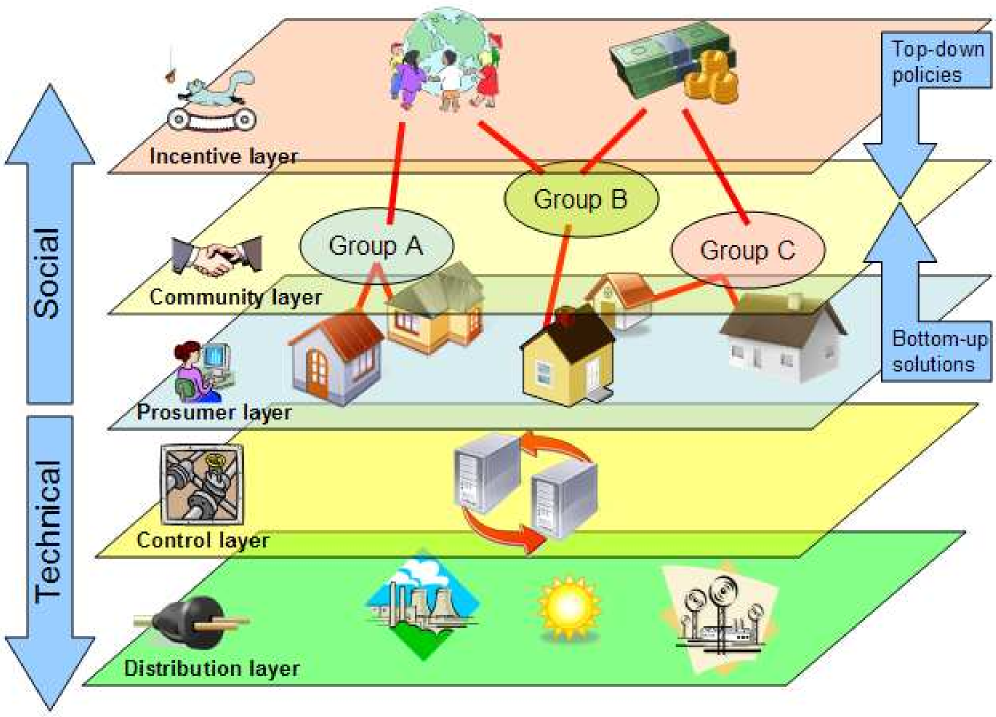

Figure 5: Different layers in the Energyweb concept [25].

Or, from an ICT application point of view, in the following chart:

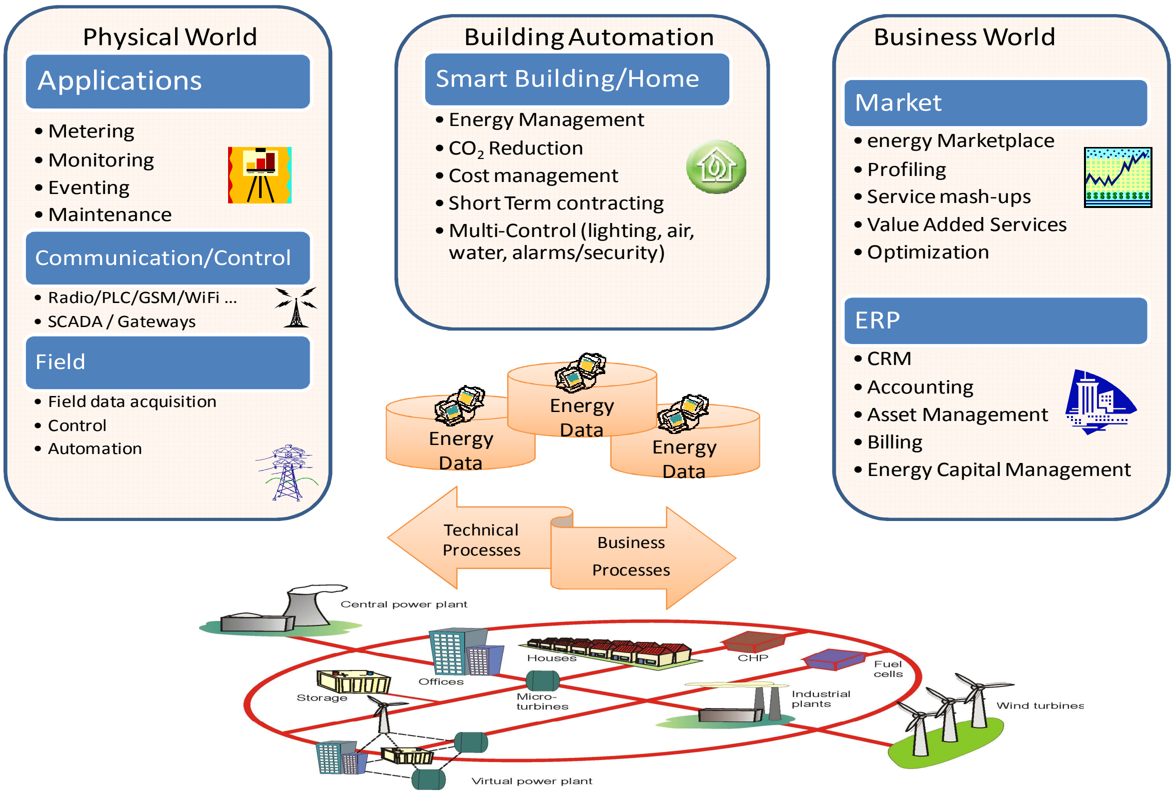

Figure 6: Information flow in physical world applications and energy markets [26].

In the first area we act fully in the world of pure standardization which is already covered and handled by the standardization bodies worldwide supported by different industry organizations like ESMIG, in the EU and NAESB in the US. Here we can see a good progress with very good results. The remaining gaps are identified and the future work is scheduled.

The main contributors / resulting documents are:

- NIST, Smart Grid Interoperability Standards [15]
- IEEE, P2030 [27]
- IEC, SmartGrid Standardization Roadmap [28]
- NIST, Guidelines for SmartGrids Cyber Security [29]
- UCAIug , Home Area Network System Requirements Specification 2.0 [31]

In the EU there is a clear Mandate to CEN/CENELEC/ETSI:

EU Mandate M/441 on Smart metering from march 2009 focusing on an open architecture for utility meters, communications protocols (bi-directional), interoperability, secure data exchange, allowing advanced information and management & control systems for consumers and suppliers. Standardization in this context does not mean imposing identical solutions on all projects in the Member States but to ensure that what a Member State may want to do in smart metering is covered by suitable standards.

This topic is further covered in detail in the section 3.1 “Insufficient Interoperability”.

A remaining main barrier here is the harmonization of the existing sets of standards (and standards to come) for the use in the EU to provide a stable framework for the software and technology vendors to develop required ICT tools and technology to secure their investments (also to enable mass production and to reduce costs which will help in the large scale deployment – reduction of economic barriers)

In the commercial area it is different, as we have to cope with completely new business models and roles in the market which have a much higher variability beside new technology. Here we are still in the phase of pilot projects like the EU project address, the e-energy model regions in Germany or the new EEGI initiative. There are several approaches that will be explored and investigated but we are still far away from "market standards".

Here we also find organizations working on standardization like ebIX (together with ENTSO-E) in the EU or OASIS in the US beside the activities of regulatory bodies like ERGEG, ACER in the EU and FERC, NERC in the US.

Their main work so far was focused on

- regulation and modelling for the liberalization of energy markets and regulations for the remaining monopole areas;
- regulations, policies and market models to foster renewable energy generation and energy efficiency;
- positioning for requirements in the SmartGrid area and for the roll out of smart meters.

Even in the above areas we are still in a state of national regulations and market models. So there are a few countries with liberalized metering markets (e.g. UK, Germany) beside regulated metering markets (which will require a different approach when it comes e.g. to implement energy services by "aggregators"). Also the rules and the extent of market communication differ from country to country with a first region (the Nordics countries) that started a process of harmonization.

In the commercial area there is even a competition between "standardization" approaches. So there is some discussion e.g. in Germany positioning ebIX "standards" against CIM. This is also mentioned in [29]; that there is an interest for further development of the (technical, asset-oriented) CIM-standard towards general market communication.

So the main question is "is the lack of regulation" a main barrier for the deployment of large scale distributed (renewable) generation storage and DSI?

In the EU taskforce on Smartgrids (EG3 on regulatory requirements) the consensus among the stakeholders was: "There is no need for new Directives or Regulation but there is a need for a harmonized and effective implementation of the 3rd Package"

This is also one finding from the conclusions on ERGEG'S public consultation on their positioning paper on smart grids [30].

4.2 "Lack" of Regulation

So the following section describes the needs for standardization/harmonization in the area of smart grids and DSI and not necessarily the needs for regulation (legislative). Even if there is no absolute need for pure legislative acts, ERGEG and ACER should support in the definition of guidelines and in the harmonization of rules derived from pilot projects and industry initiatives. This will help and promote to deploy the market models in a standardized way. This is also an experience shown in the liberalization of the German energy market. As long as there was no regulator the development and deployment of processes and tools for the market communication based on voluntary agreements among the industry took a very long time (with open end). With the support of the regulator it was a process of approximately 3 years.

What are the main areas for standardization (regulation) in the commercial area and therefore main barriers when it comes to deployment, as this will discourage market participants and consumers to participate if they have no clear vision and benefits?

- The extension and definition of new market and business models including appropriate business communication and (logical) interfaces
- The definition (regulation) of access to this new markets
- The implementation of communication hubs and central market platforms
- (Regulation) of security and privacy for the final customers
- Definition of Products and services
- Policies for fair split of costs and benefits and recommendations for funding

4.2.1 *New market models and interfaces:*

New market models and interfaces are a prerequisite to develop standardized business processes and use cases that can be used by the market participants in a highly automated way. Otherwise the business will be restricted to few manual cases (as experienced in the liberalisation of the energy market, e.g. regarding change of supplier process). In the existing business models (see first deliverable) there are already good approaches that can be used for a generalisation. An already very generic approach is given in the architectural model of the ADDRESS project [1]. Similar approaches can be compared from other R&D projects to derive a generic market model for DSI and to further develop the existing generic ebIX model.

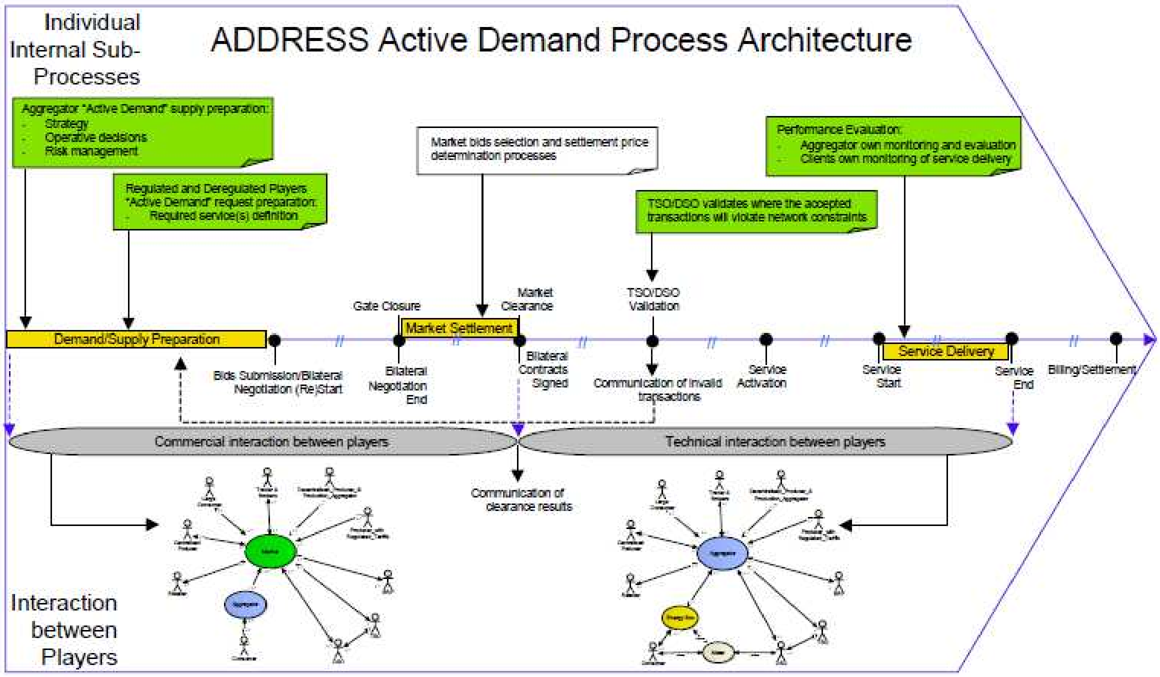

Figure 7: Commercial and technical process of active market partipation of small consumers according to ADDRESS.

Based on this model generic business cases, market processes and communication processes can be developed.

Regulatory authorities should promote maximum standardization and interoperability and establish level playing fields that encourage the market participants to work efficiently and to secure customer participation and market integrity. These interfaces should also include the access to wholesale market and the customer integration.

ADDRESS project [1] defines the market model in their commercial architecture shortly as follows:

> the commercial architecture ("contract negotiation" and "settlement" stages) deals with all the interactions, players structures, processes involved in the "negotiation" and "agreement" phase of the AD services (including the preparation of requests and offers) until the market clearance or the signature of the contracts (depending on the case). It also deals with the settlement stage after the end of the service.

Beside the market model and the communication processes there has to be also a standardization of the semantics for he exchanged messages. According to NIST [15] the main areas for standardization are:

- Common Pricing model to traverse the whole value chain including price, currency, delivery time and product definition
- Common time synchronization and management
- Common semantic model (to unify models of CIM, IEC61850, ebIX)
- Common meteorological and geospatial models
- Common scheduling mechanism

4.2.2 *The definition (regulation) of access to these new markets:*

To establish a functioning and competitive market for DSI / Aggregator services as well as distributed generation/storage that attracts new participants, the access to the market has to be defined in a non discriminatory way, so that they get access to required data (e.g. from DSO's) and to required platforms (e.g. wholesale market). This is also a matter of harmonization among the EU, as access for distributed generators (or aggregated production) is limited to the produced power in some cases (e.g. Spain).

4.2.3 *The implementation of communication hubs and central market platforms:*

To establish the appropriate market communication there has to be a guideline on the communication principle. Either bilateral which could be an approach in markets with few players or a central communication hub for many players. (in the EU we can see a trend in terms of market communication for liberalized markets towards central hubs that speed up deployment and which are easier to maintain).

4.2.4 *Regulation of security and privacy:*

This is a clear regulatory requirement. Here fundamental work is accomplished with the report from NIST: Guidelines for SmartGrids Cyber security [29]. This is a prerequisite for the consumer to decide to participate in DSI activities and for smart metering. If security and privacy is not given he might fear that his data (e.g. consumption behaviour) could be misused. In Germany for example there is a current discussion if consumers only have to provide aggregated data (e.g. ToU consumptions) instead of interval data. This could endanger the whole market model. This is also an area of enlightenment of the consumers.

4.2.5 *Policies for fair split of costs and benefits and recommendations for funding:*

This is also a clear regulatory area. The costs emerging from the introduction of new services or solutions in the grids today are mainly paid by the actor who requires these new services and who is the main beneficiary of them..

For the roll out of smart meters as one enabler of future services in the smart grids there have to be clear policies regarding who has to cover these costs and how the payback on the investment has to happen (e.g when the DSO covers the investment by considering in the incentive regulation or in cases where the consumer or the retailer owns the meter by ways of subsidising or offering clear benefits e.g. for DR-participation). A pure recovering of the investment based only on process efficiency improvement at the DSO and retailer side will not suffice. Therefore the cost/benefit analysis required from the "3rd package" at national level has to take into account a broader approach including e.g. energy savings, energy efficiency, reduced investments in grid extension as well as savings for balancing energy and based on this policies for a fair sharing of the costs have to be developed.

The above topics are also reflected in the recommendations from ERGEG in ERGEG Position Paper on Smart Grids (after public consultation and Conclusions) [30]

1. Ensure, as appropriate, a long-term stable regulatory framework and reasonable rate of return for cost-efficient grid investments;
2. Consider and further analyse decoupling between grid operators' profits and volumes of electricity they deliver taking into account the introduction of performance indicators and performance-based incentive regulation;
3. Pursue regulation of outputs as a mechanism to ensure value for money paid by network users and to investigate metrics for the quantification of the most important output effects and benefits ;
4. Promote mechanisms favouring an improved consumer awareness of their electricity use and market opportunities through actions of suppliers and other market participants and an improved engagement of network operators with their network users;
5. Encourage the deployment of Smart Grid solutions, where they are a cost-efficient alternative for existing solutions, and as a first step in this direction, to find ways of providing incentives to network companies to pursue innovative solutions where this can be considered beneficial from the viewpoint of the society;
6. Evaluate the breakdown of costs and benefits of possible demonstration projects for each stakeholder and to take decisions or give advice to decision-makers based on societal cost-benefit assessment which takes into account costs and benefits for each stakeholder and for the society as a whole;
7. Ensure dissemination of the results and lessons learned from the demonstration projects in case they are (co-)financed by additional grid tariffs or from public funds to all interested parties, including other network operators, market participants, etc.;
8. Participate in Smart Grids discussions and cooperation activities among stakeholders and especially to consider an active cooperation with European and national standardisation organisations, grid operators and manufacturers, for example on open protocols and standards for in-formation management and data exchange, in order to achieve interoperability of smart grid devices and systems;
9. Clarify the difference between regulated grid activities and market opportunities for new ser-vices under a competitive regime (e.g. aggregation of resources, Electric Vehicle (EV) recharging) and to carefully monitor and prevent the possible presence of cross-subsidies between network activities by TSO's or DSO's and market-based activities;
10. Continue the exchange of expertise at European level, in order to learn as soon as possible from best regulatory practices.

5 ANALYSIS OF BARRIERS IN THREE EUROPEAN COUNTRIES

In this chapter we take a closer look at three countries Poland, Germany and Italy, inspecting what barriers to DER aggregation business (regulatory, societal, infrastructure, etc.) exists in these countries. and what aggregator ICT would be necessary to solve these barriers and what business models (out of the 9 which we previously collected) are most affected

5.1 Barriers to DER aggregation business in Poland

5.1.1 *Description of the barriers*

a) Unstable legislation especially in the area of ownership. Juridical changes - and ownership barriers in the energy sector result in a lack of interest in development and supporting new business models in area of DSO, TSO, retailers as well as end-users. For example lack of detailed procedures/schedules and the obligations to provide hourly measurement data in a single format, in a designated, single periods to retailers from local DSO's.

b) Missing funds for new business models and DER implementation. Finance barriers in the new ICT development for energy market particularly on the DSO, retailer and prosumer level.

c) Development of the new ICT tools communication and exchange of information concerning forecasting, optimization and management of demand response.

d) Missing expanded knowledge about an energy market and new business models.

5.1.2 *ICT related barriers- immediately connected with DER aggregation (description):*

1. Optimization barriers - optimal management of energy demand in the very dynamic sources fluctuations and their activity throughout the day, also the valuation of the product which is energy (energy price) in such a dynamic aggregation environment .
2. Forecasting barriers -associated with tools for forecasting short-term aggregation in a dynamic environment.
3. 3 Portfolio management barriers - the difficulties associated with the proper building customer profiles dynamically active (variable portfolio), collect the necessary data planning and calculation of gains and losses, both globally and in the settlement of individual market participants.
4. Measuring Management barriers - Central or remote of distributed and reliable readout of measurements.
5. e-energy tools barriers- Lack of tools for management of dynamic pricing of service products on an e-energy market.
6. In Poland, no one of the models BM1 to BM4 are currently considered for implementation in their shapes because of barriers from the previously mentioned A, B and D groups.

5.1.3 *ICT and non-ICT barriers in Poland*

The following assumptions have been considered:

1. There are many other factors, each other conditioning and growing barriers to application of new business models, and thus ICT solutions in the Energy Market in Poland.
2. Below the direct barriers to development of ICT for CHP in PL model presented in earlier materials will be only considered.

5.1.4 *Non-ICT barriers:*

1. Lack of the explicit strategy for the development of EM in Poland towards the smart grid and new business models developing for intelligent smart distribution grids (Polish Strategy to 2030 does not specify the Roadmap for such tasks as: developing in the direction smart grids and demand response) is one of the passive operation in that area. There are also another reasons passiveness regulations instability, especially regulations for the functioning of the market (including energy trading), and the procedures for the consolidation and regrouping of stakeholders among existing market participants (6 energy groups consolidated) in the formation and connection of DER and demand response.
2. Designing of the CHP project, preliminary analysis of the technical infrastructure and assessment of market risks including in particular finance and ideas to develop business models (with 3 possible variants of cooperation of interested parties) including problem of funds support after two years remain without result. The project has been stopped as long as land ownership for gas connection with CHP and supporting funds will find solution.
3. Developed business model variants have been prepared also in terms of the strategy planned and proposed of a new company whose mission would be a service activity: DER aggregator and management profile of active network services for the local EM.
4. Developed and chosen model of the concept enforces:
   a) Preparation of detailed operating procedures aggregator, broker, the scope of its activity and co-producer of the power station and other DER which is the recipient of wholesale distribution company.
   b) Preparation of the workings of the company and to determine where you will create added value both for participants connected to the DER and the company itself.
   c) Preparing the technical infrastructure including AMR and AMI, the development of standards for transmission of information and communication procedures.
   d) Preparation of appropriate ICT with the purposes of billing volume and additional financial services aggregator business management systems integrated into the active market. (including tools: a flexible planning and forecasting of prices, profits and settlement of financial penalties for bad decisions etc).
   e) Take a responsibility for personally-run project and to establish rules for the financing of all these works, purchase or develop software for operational management and technical newly formed unit, also for testing a solution before the model starts.

A very slow progress in the indicated areas of work has been observed.

5.1.5 *ICT barriers:*

A major hurdle in the work of ICT for the new business models is lack of pilot plants with a similar effect in the direction of integrated management of participants in the operation of the DER aggregators and establishment of a virtual power plant.

ICT solutions and services dedicated to clearing VCPP (existing tariff-regulating market price-to-urban customers currently excludes them from active participation in the potential demand response).

The following ICT barriers exist:

1. Standards for collecting and processing vast amounts of data (e.g.: measurement, and others).
2. Exchanging vast amount of data and their protection (data security and authorizations)
3. Communication channels (independent networks, the Internet, wireless networks, use of technical infrastructure such as hourly counters, instead of induction for all market participants, two-way meters, intelligent meters and their communication with ICT systems). Should be developed the principles of communication and feedback during periods of 15-30 minutes between the aggregator and market participants

4. Forecasting energy demand and sales levels models and tools with taking into account of dynamic changes in the profiles of customers and also maintain prosumers behaviors in real time on the energy market.
5. The building and maintenance of dynamic clusters of customers and dynamic sales prices of energy. Lack of prepared portfolio management mechanisms
6. Dynamic price calculation tools- based on dynamic information received (time intervals 15-30 min) from the market
7. The operational and financial management methods, accounting for and controlling the value added for each market participant (including invoices, all financial operations including put, any time intervals).
8. The preparation and development of the e-platform access to the communication system for market participants (e.g. prosumer) by investing in the work on a solution, or purchase of already existing solutions.

When considering, e.g.: the barrier related to the forecast of the purchase and sale of electricity at peak-(preparation and implementation of a dedicated ICT aggregator DER) should be developed the implementation of two-way communication exchange (data formats) both quantitative and price data and parameters with all market participants in a very short period of time, for operational decisions, which is the immediate translation of a specified quantity of profit or loss on this operation. Thus, it is a procedural barrier (the development process and representation in the system) as well as for the technical implementation of data exchange.

5.1.6 *Summary*

There is a group of complex barriers which specifically inhibits the development work into the implementation of solutions for new business models on the energy market in Poland. Most of these barriers are the non-ICT barriers, including in particular financial and related to the knowledge of the market.

Mentioned barriers are similar with the problems and barriers existing in other countries in Europe. In the first step: the development of business processes, rules and procedures for individual market participants, including the aggregator utilities - and in the next step - the development or purchase and implement ICT solutions to enable the implementation and operation on the energy market might be a right for theirs removal.

One of the general barriers are problems with collaboration between computer scientists, systems analysts with ICT specific practitioners on the energy market who need to translate their business needs into technical. There is a very important work of business process analysts and business architects for studies of new ICT solutions.

5.2 Barriers to DER aggregation business in Germany

The situation in Germany shows some good assumptions for implementing DG into the net as. µ-CHP business is supported by the German CHP law (KWK-ModG) that remunerates CHP loads. The compensation for the electricity fed into the grid is statutory; the price depends on three steps:

- EEX Baseload-electricity Price of the last quarter
- Avoided grid costs
- CHP bonus (restricted to ten years)

The CHP owner sells the electricity to the operator, he is connected to. This can be a large scale utility like RWE or a smaller municipal utility. After the ten years for the CHP bonus end, the operator still has to buy the electricity.

Combined with relatively high electricity prices and the purchase commitment of the DSO to buy the fed in electricity (high opportunity costs for avoided purchase) Germany seems to be in a good basic position compared to other European countries as the UK or Spain.

On the other hand there are various barriers that restrain the deployment such as

- Very high prequalification costs required by the German TSO's for each controlled site
- Single price level for imbalance penalties (EXPANDDER 2007).

5.2.1 *Non-flexible tariffs*

In the last amendment of the law of industrial energy industry (EnWG) energy supplier are legally obligated to offer demand variable tariffs to the consumer that provides the incentive to save energy.

This correlates with different difficulties for suppliers as shown below. Their customers can be divided into two groups:

1. Standard load profile customers (SLP), who are supplied in form of simplified standardized load profiles with consumptions up to 100.000 kWh per year.
2. RLM-Customers (power measured industrial consumers) with sharply balanced consumptions (consumption per year higher than 100.000 kWh).

In the RLM-Customer sector monitoring for variable tariffs doesn't display a barrier because of the already registered power measurement and the possibility for remote readout, so that all kinds of tariff models are presentable. In the SLP-Customer sector the measurement of taken electricity is carried out by the measurement of taken electrical power and in some cases by the registration of the load profiles at the metering point or by the detection of the maximum power input. I. e. there are no already given data, that can be used and this makes load variable tariffs not profitable. If it is not an end-user regarding to (§ 12 Strom NZV, the power measurement is registered every quarter of an hour.

This is statutory regarding to the German Ordinance on access to electricity grid (Stromnetzzugangsverordnung). Remote readout is legally not possible for SLP customers and only the real used electrical work is registered, because standardized load profiles have to be taken for SLP-customers (§ 12 Strom NZV) by the operator. For end consumers with low energy consumption integration and application of smart meter for a quarterly registering power measurement is improvident. Another approach could be the development of special standard load profile – adjusted to § 40 EnWG if an accordant tariff is arranged between consumer and supplier. Special standard load profiles have been created for special business customers, that rely on special requirements of the regarding branch as weekend work etc. The grid operator would have to apply this load profile (amount weighted standard load profiles that provide for the predicted or typified consumption behaviour of the customer). For the establishment of those special load profiles the suppliers would need to have the legal right to ask the operators for the usage of those standardized profiles and that is in the operator's responsibility to accord those tariffs (NABE et al 2009).

Demand variable tariffs can be either grid variable – tariffs based on high grid usage or customer variable – based on times with high numbers of consumers using electricity at the same time or system variable – in times, when a high amount of power is produced. Usually a combination of load and time variable tariffs is taken: higher load stage tariff only within a particular time period – individual tariffs for individual requirements of the customer have to be developed.

5.2.2 *Several control areas*

In Germany there are four different control areas (EON, RWE, Vattenfall and EnBW), which is a unique situation in Europe. This undermines the duty of TSO's for an ad hoc balancing, which is statutory since EEG-amendment in August 2004. (The amendment of EEG (§ 14) alleviates the avoidance of the capacity overload of the grid. The TSO have to balance the different received amounts of electricity (horizontal at once-balance), the TSO have a more balanced allocation of the necessary amounts of electricity.) The generation of a single control area would lower the demand of regulating energy. But besides this, the four control area monopolists in Germany are legally obligated to assure an optimal balanced grid organisation (BWE 2010).

5.2.3 *Multiplication of ancillary services*

According to EU-DEEP task force 1 most profits of aggregating pure loads come from provision of frequency control services to TSO. Concentrating on a single service reduces the complexity of an optimization system.

Presently, ancillary services are mainly provided by large power plants to the TSO. In the future ancillary services should be more provided by controllable distributed energy units to active distribution network operators including services as Power/Frequency control, Power/Voltage control, Congestion management, Improvement of power quality, Reduction of power losses, Black start and Islanded operation. (M. Braun, ISET, 2008).

5.2.4 *Low flexibility and balancing resolution*

German feed-in tariffs don't privilege flexibility as the electricity is sold at a fixed price whenever it is produced. This single imbalance price provides a small incentive to reduce imbalances. Further the balance management works on 15-minute resolution, but energy trading on 1-hour resolution, which should be taken into account in optimization.

5.3 Barriers to DER aggregation business in Italy

In Italy, in spite of the good advancing of energy market liberalization process [SEESGEN D5.2], the aggregation of DER is not still widely applied. However Italian regulation is beginning to take aggregation into consideration in some particular cases (mainly for medium voltage interruptible loads). This regulation on the one hand brings officially in Italy simple kinds of aggregators, on the other hand raises some regulatory and technical barriers. In order to identify these barriers it is necessary to look at this regulatory framework.

5.3.1 *Balancing Market and Offering points*

The Legislative Decree no. 79 of the 19th march 1999 liberalized the Italian energy market. In particular the article no.5 set up the GME, that is the stock company managing the energy market. Among its tasks there is the definition of the procedures for **balancing energy demand** and offer. Following this decree, the GME, on the 20th November 2000, sent to the Industry Ministry the regulation of electricity market and in it there was the definition of **Balancing Market** for real-time balancing of demand and offer.

In the balancing market actors can present simple offers. A simple offer can be:

- a sales offer, which means offering availability to increase production or to reduce withdrawal;
- a purchase offer, which means offering availability to reduce production or to increase withdrawal.

The procedure provides that the qualified units have to send their offers to the GME and then the GME communicates the collected offers to the National Transmission Network Handler (GRTN). This one validates the offers and then communicates to the GME if offers are admissible.

A simple offer is related to an **offering point**. Italy is split up in geographic zones that are collections of offering points. An offering point can coincide with a physical connection point, but in some cases it could result from aggregation. According to the Authority for Electric Energy and Gas relevant quantity of energy have to be inserted into the grid through real connection point, but small quantities can be aggregated in a single input point. In this case the input is controlled and balanced in aggregated manner, but the aggregated resources have to stay **in the same geographic region** [AEEG 111/06].

About the aggregation of demand side, according to the GME an offering point for scheduling of withdrawal of energy can be an aggregation of withdrawal points. [GME Vademecum 2009]

It is interesting also to underline that in [GME Rinnovabili 2009] it is highlighted the role of the **GSE** as aggregator for the Renewable Energy Resources, like a way to compensate the unbalancing due to the unpredictability of the single RES unit.

Barriers related:

This is a step to insert the model of aggregation in the Italian energy grid, both on the side of the production and on the side of the consumption. But the same regulation arises some barriers:

- the geographical closeness of aggregated resources represents a barrier for the CVPP, since a Commercial Virtual Power Plant aggregates resources independently from their geographical location *(barrier for the following Business Models: BM 3, BM 4)*;
- the opportunity for selling reduction of withdrawal on balancing market is a first step in the direction of demand response programs, but it is not sufficient since regulation for low voltage end users demand-response is still lacking *(barrier for D5.2: BM 1, BM 3, BM8)*;
- the role of the GSE as aggregator of RES *(see D5.2 BM 5 and BM 6)*, has the function of stimulating the diffusion of RES. But in future it could represent a barrier for private aggregator's diffusion, since, in presence of good economical conditions of GSE

aggregation, a RES unit owner could prefer it to a private aggregator. *(barrier for D5.2: BM 1, BM 2, BM 3, BM 4)*

5.3.2 *Interruptible Charge Control System*

A case in which the aggregation is defined inside a more detailed regulatory framework is the Interruptible Charge Control System (**BMI**) [Terna 2007]. The BMI is a "manual system to interrupt an electrical power charge in critical condition of the Interruptible Users of the National Transmission Network Handler (GRTN)" [Itaco].

The BMI is composed by:

- an **interface**, which enables GRTN operators to send interruption commands;
- an **executor** on a central server, which transmits commands to the Remote Terminal Units (RTU) installed nearby the interruptible users;
- a **communication network**, made of dedicated connections and based on standard protocols (as Frame Relay).

The interruptible clients have to be connected to the medium voltage grid. A client having more then ten interruptible seats (each of them with more then 1 MW of power) can aggregate these loads to get to the assigned interruptible power [Terna 2007]. In the figure below, in which there is the schema of this kind of aggregation, PVC means Permanent Virtual Circuit and UDPC is the RTU which enables the interruption nearby the client.

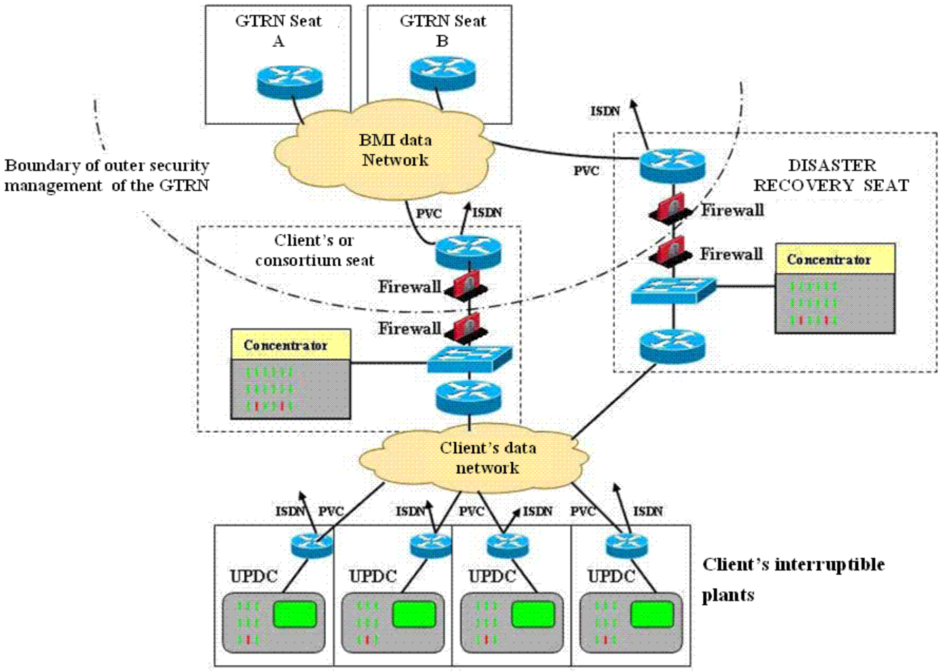

Figure 8: Aggregation of interruptible seats [Terna 2007]

Regulation, which provides the formal and technical procedures to set up this aggregation, requires a set of:

- applications (such as detailed specifications about data exchange and concentrator management that have to be supplied to the GTRN),
- requirements (such as demonstration that the concentrator does not modify the exchanged information and warranties about time needed to interrupt the overall load),

- physical implementation of the system (such as the requirement that interruption commands is wired rigidly to the interrupters separation coil without other interposed devices),
- kind of connections,
- requirements about redundancy of the connections, and so on.

Barriers related:

The aggregation defined in this case is not for commercial aims, but only to facilitate big clients that want to accede to BMI. Therefore it results only in a lower level aggregation. This is a limit that could hinder the building of more complex business models, like the ones defined in D5.2:

- the requirement for this kind of aggregation are too severe and the kind of aggregation here defined is quite different from the ones defined in D5.2 Business Models, because this aggregation model allows only to aggregate resources allowing to the same owner *(barrier for BM 1, BM 2, BM 3, BM 4)*.

5.3.3 *Instantaneous reduction of energy drawbacks*

Another interesting case was set up by the Legislative Decree no. 3 of the 25th January 2010. It instituted the service for instantaneous reduction of energy drawbacks in Italian greater islands. As highlighted in D5.2, there is a problem about energy prices in these islands (in particular in Sardinia). This decree tries to cut down energy costs for energivorous establishments of these islands, if they are disposed to instantaneously reduce their energy drawbacks in consequence of a GRTN reduction request.

As seen in the previous case, it is possible to implement an aggregation of reducible loads and specifications are very strict (similarly to previous case ones). There are requirements about information that have to be provided to the GRTN, about connection redundancy, about physical implementation of the system and so on.

Barriers related:

- the same consideration of the previous case are valid in this case *(barrier for BM 1, BM 2, BM 3, BM 4)*

5.3.4 *Measurement service*

Another regulation point is related to measurement service. In [Terna – Capitolo 5] this service is defined in details. In particular for each connection point it is defined a measures responsible subject:

- for a generation unit, the responsible is the owner;
- for drawback point, the responsible is the DSO;
- for interconnections with foreign countries, it is the GRTN, if they are connected directly to the Italian national grid, the DSO otherwise.

There are defined also technical requirements for installation and maintenance of metering devices and the architecture of data acquiring system. This is made up of a main acquiring system (**SAPR**) owned and managed by the GRTN and secondary acquiring systems (**SAS**) each of one is managed by the related measurement responsible subject.

Moreover there are defined the communication protocols for direct connections between SAPR and metering devices (IEC 1107, IEC 870-5-102 or DLMS-COSES) and an XML format (not further detailed) for the indirect connection between SAPR and metering devices. [Terna – Capitolo 5]

Barriers related:

- Among the responsible entities for measurement service there is not the aggregator. This could hinder to the aggregator to direct manage its DER units. (*barrier for all the D5.2 BMs)*
- Direct management of consumption and production data is crucial to forecast future consumption and production and without forecasting the aggregator could loose its bargaining power towards network operator *(barrier for BM 1, BM 2, BM 3, BM 4);*
- Under these conditions the aggregator could become only an administrative figure, not able to manage the technical aspects of aggregation and, therefore, not able to supply useful services to the network operator neither to DER units *(barrier for BM 1, BM 2, and BM 4b).*

5.3.5 *Privacy*

In [Terna – Capitolo 12] there is the definition of the end-users data privacy: all the information delivered from the end user to the GRTN are reserved and can not be communicated to third parties unless it occurs one of the following conditions:

- a written consent from the end user;
- the communication is crucial for management, security and reliability of the electrical supply;
- the communication is contemplated by the regulation or demanded by the judicial power.

Also the Italian Privacy Guarantor states that the DSO has to inform the end-users about the communicability of their data, before transmitting these data to the vendors. [Garante 2007]

Barriers related:

- These privacy requirements could constitute an obstacle for the management of consumption and production data on the aggregator side. For example In Business Model 4b prosumers' data have to be communicated to the CVPP and then CVPP have to communicate them to the TVPP. *(barrier for D5.2: BM 1, BM 3, BM 4b, BM 8)*.

5.3.6 *Social aspects*

There is another point not related to regulation but to social barriers. On the 20th April 2010 Accenture presented an interesting study titled *Understanding Consumer Preferences in Energy Efficiency* and its conclusions was that “consumers are not willing to allow electricity providers to remotely limit the use of their home appliances as part of electricity management plans without significant rate discounts.” An interesting point about Italy is related to social pressure. Accenture states that “social pressure plays a part in encouraging consumers to enrol in electricity management programs” and that Italian respondent (as well as Brazilian ones) “were most likely to have positive impressions of consumers enrolled in electricity management programs” (85 percent of Italian respondents) [Accenture news] This point could help the overcoming of social barriers in Italy

Barriers related:

- The participation of end users is central for the business model involving demand response programs. If they refused to be involved in it, this programs would remain unapplied (barrier for D5.2: BM 1, BM 3, BM 8).

6 SUMMARY

In this report we have gone through some specific barriers to DER aggregator business in Europe. We limited ourselves to the barriers related to the ICT tools needed by an aggregator to perform its daily functionalities: forecasting, service verification and operational optimization. Price forecasting tools are existing tools which are already used on the wholesale market. Response forecasting tools attempt to forecast DER (including price-responsive consumers) output or consumption. These are currently at development stage. A challenge for these tools is the dynamic nature of many loads. Operational optimization tools take care of the daily decisions of on one hand participating in providing services to the power system participants and on the other hand controlling different consumer and DER groups. Main challenge is handling the large number of different services, contracts, consumers and DER units. The dynamic nature of consumers and some DER types also produces a challenge.

Some barriers are related not to a specific tool, but to their implementation on large scale. They are mainly:

- insufficient interoperability,
- need for scalability and
- management of information.

Interoperability is essential for the profitability of the new aggregation business models, since it can avoid vendor lock-in thus stimulating market opening and giving to end-user freedom of choice.

Standardization can be the way to get interoperability, but at the moment existent standards are not able to provide a complete framework for interoperability. At the end, the standardization process itself could become an obstacle, if it does not follow any basilar principles about opening and transparency.

The key point to get interoperability is the use of a set of not overlapped open standards arranged in a shared architecture. This process implies the design of this architecture, the building of a map of the existing standards and, basing on it, the development of the missing standards. A harmonization process should complete the process.

Scalability is another issue because of the difficulty of knowing in each moment the state of each distributed resource, of managing large numbers of events in short time and of getting reply from the aggregated DER at short notice. These issues have to be taken in account since the **design** phase of the ICT architecture of the aggregation. The main reference should be the existing ICT architectures addressing scalability like Service Oriented Architecture (SOA), Grid Computing and Multi Agent System (MAS).

It is important to highlight that it is not realistic to require a complete knowledge of the state of each resource, among the million ones involved in aggregation, or a perfect control of each event. A reasonable objective is that known states do not diverge too much from real states and that managed events are all the events really important for the system. (SmartHouse/SmartGrid 2010).

The last point is about management of information. It raises problems about privacy, data ownership and cyber-security.

There are already solutions for some of the problems related to known vulnerabilities and these have to be included in this **security architecture**. But new vulnerabilities will arise in new aggregation business model and is important to anticipate their raising. So it should be important to implement a development process tailored on the security requirement of aggregator's ICT tools

Moreover management of information barriers requires not only technical, but also policy responses. For example data ownership need a regulation solution taking into account rights and needs of all the involved actors and the weakness of end-user's influence.

We analyzed the national situation in three countries separately: in Poland, Germany and Italy. In these country analyses we allowed more freedom in analyzing the barriers and took into account for example regulatory barriers which are not linked to any of the ICT tools which we have described. It is not meaningful to only analyze the barriers related to a specific ICT tool in a specific country.

In Poland unstable legislation in the energy sector results in a lack of interest in development and support of new business models. For example there is a lack of detailed procedures/schedules and obligations to provide hourly load measurement data in a single format to retailers from local DSO's. Funds for new business models and DER implementation are missing. There is not enough funding for new ICT development particularly on the DSO, retailer and prosumer level.

In Germany the situation is favourable for DER aggregation. For example, an aggregator is able to o provide frequency control services to TSO's, which is major source of income. One notable barrier is that RES producers such as wind power generators are not required to manage their imbalances. Aggregators could provide the service of managing the imbalances directly to RES producers.

In Italy regulation is beginning to take aggregation into consideration in some particular cases. This regulation brings in Italy certain simple types of DER aggregators but, at the same time, raises some regulatory and technical barriers.

One of these cases is related with the definition of Balancing Market for real-time balancing of demand and offer. The procedure provides the option of aggregating small quantities of energy in a single input point (called offering point) so that this input is controlled and balanced in aggregated manner, but the aggregated resources have to stay **in the same geographic region** [AEEG 111/06].

Therefore this regulation is a first step in the direction of demand response programs, but it is not sufficient since regulation for low voltage end users demand-response is still lacking. Moreover the required geographical closeness raises a barrier for the creation of a commercial virtual power plant.

Another interesting case is the Interruptible Charge Control System (BMI). The BMI is a “manual system to interrupt an electrical power charge in critical condition of the Interruptible Users of the National Transmission Network Handler (GRTN)” [Itaco].

The interruptible clients have to be connected to the medium voltage grid. A client having more then ten interruptible seats can aggregate these loads to get to the assigned interruptible power [Terna 2007]. The aggregation defined in this case is not for commercial aims, but only to facilitate big clients that want to accede to BMI. Therefore it results only in a lower level aggregation. This limit could hinder the building of more complex business models, like the ones defined in D5.2.

Also regulation related to measurement service produces some critical issues in Italy because it does not include the aggregator among the responsible entities for measurement service. Under these conditions the aggregator could be not able to direct manage its DER units and could even loose its capacity of forecasting future consumption and production, so becoming only an administrative figure.

Privacy regulation could constitute a further obstacle for the management of consumption and production data on the aggregator side.

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APPENDIX: LIST OF EXISTING SOFTWARE TOOLS WHICH CAN BENEFIT THE AGGREGATOR OF DR, DG AND DISTRIBUTED ENERGY STORAGES

With DR, DG, distributed energy storages (DS) and smart grid technologies we can possibly solve problems such as network congestion, high transmission losses, supply variation from intermittent generation. It is difficult for the DER aggregator to know with manual inspection how to implement them in a way so that we achieve a good cost/benefit ratio. Analysis tools can help in making the right kind of investments at the right time. After the investment has been made, different tools can help the DER aggregator in operating the resources on day-to-day basis in a way that its own and (hopefully) the system's benefits are maximized.

Below we list some tools which can be useful in analyzing the different aspects of aggregation of DR, DG, and DS.

Energy flow calculation and market integration tools

The tools may simulate economic dispatch and electricity prices in national or international market. Transmission lines may be modelled, although the tools do not perform actual physical network simulation. Time resolution is normally one hour. Demand is taken as external variable.

Tool	USELOAD
Manufacturer	SINTEF, Norway
Description	USELOAD is a Windows program for calculation of electrical load divided into end uses. This is a new model mainly for segmenting metered time series into end-use or different customers. It is based upon load curves from national load research projects. The model uses statistical methods and handles climatic dependencies and the diversification in the load from different customers. It can also estimate the coincident peak demand in a network with selected degrees of confidence. USELOAD's origin is from the international liaison body EDEVE where load-research, demand side management and more specific consumption relations are being discussed and elucidated. The specialty of USELOAD is great flexibility, basic development of methods, and great applicability for different kinds of purposes. Detailed input data is important before the model is operative for a specific region. Typical daily load curves for i.e. lighting, heating, ventilation, hot water and other electrical appliances should be established. Based on this data, the total load curve can be calculated, divided into the hours of a day, or for a year.
Platform	Windows XP, Windows 2000
Known Users	Electricité de France; Sydkraft (Sweden); VTT (Finland); Electricity Association; and Energy Piano (Denmark)
Contact Info	Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no

Tool	EMPS (multi-area power market simulator)
Manufacturer	SINTEF, Norway
Description	The EMPS model is a stochastic model designed for long-term optimization and simulation of hydro-thermal power system operation. It allows the simulation of large hydro systems with a relatively high degree of detail. There can be subsystems and limited transmission capacity between them. The EMPS model is widely used in the Nordic countries for price forecasting. Large producers can directly employ EMPS in their scheduling decisions. E.g. following properties can be defined for hydropower plants • reservoir capacity and relationship between volume and elevation • piecewise linear relationship between plant discharge and generation • variable constraints on reservoir volume and water flow • destination for discharge and bypass discharge Also thermal plants can be included. The time step is one week and planning horizon is up to several years.
Platform	Windows XP, Windows 2000
Known Users	
Contact Info	Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no

Customer-level simulation tools

These tools include demand response forecasting (e.g. what is the maximum power reduction which is available from a certain group of customers in *k* hours). They also include heat demand forecasting for combined heat and power plants. Simulation tools for single building (for detailed analysis of micro-CHP use) or a group of buildings, or an industrial facility.

Tool	EnergyPlus
Manufacturer	U S Department of Energy
Description	EnergyPlus is a building energy simulation program for modeling building heating, cooling, lighting, ventilating, and other energy flows. It includes many innovative simulation capabilities such as time steps of less than an hour, modular systems and plant integrated with heat balance-based zone simulation, multizone air flow, thermal comfort, and photovoltaic systems. EnergyPlus is a stand-alone simulation program without a 'user friendly' graphical interface. EnergyPlus reads input and writes output as text files.

Platform	Windows 2000/XP and Linux
Known Users	
Contact Info	http://apps1.eere.energy.gov/buildings/energyplus/

	TRNSYS
Manufacturer	Solar Energy Laboratory, University of Wisconsin
Description	TRNSYS (TRaNsient SYstem Simulation Program) includes a graphical interface, a simulation engine, and a library of components that range from various building models to standard HVAC equipment to renewable energy and emerging technologies. TRNSYS also includes a method for creating new components that do not exist in the standard package. This simulation package has been used for more than 30 years for HVAC analysis and sizing, multizone airflow analyses, electric power simulation, solar design, building thermal performance, analysis of control schemes, etc.
Platform	Windows 95 or higher (98, NT, 2000, ME etc.)
Known Users	More than 500
Contact Info	Solar Energy Laboratory, University of Wisconsin 1500 Engineering Drive Madison, Wisconsin 53706 United States http://sel.me.wisc.edu/trnsys

Tool	IDA Indoor climate and energy 3.0 (version 4 in development)
Manufacturer	Equa
Description	A tool for simulation of thermal comfort and energy consumption in buildings. Includes multiple zone dynamic heat balance, including specific contributions from: sun, occupants, equipment, lights, ventilation, heating and cooling devices, surface transmissions, air leakage, cold bridges and internal objects such as furniture. The mathematical models are described in terms of equations in a formal language, NMF. It is thus possible to replace and upgrade program modules. For the end user, this means that new capabilities will be added more rapidly in response to user requests and that customized models and user interfaces can be developed. Advanced users can use IDA Simulation Environment in conjunction with IDA ICE to tailor models and user interfaces according to their own needs. This is quite an expensive program.
Platform	
Known Users	More than 900 registered users, mostly HVAC designers but also educators and

	researchers
Contact Info	Equa P.O. Box 1376 SE-172 27 Sundbyberg Sweden Tel +46 8 546 20 110 Fax: +46 8 546 20 101 info@equa.se // www.equa.se

Tool	UPV Flexmod
Manufacturer	UPV (Universidad Politécnica de Valencia)
Description	The tool can calculate the available load reduction and the following payback peak as a function of time when certain load control strategy is used (such as load reduction during morning peak, with allowed temperature drop of 1 ℃). The results are specific to certain customer. Each customer is modeled separately.
Platform	Mathworks Matlab
Availability:	It is an internal tool of UPV but UPV can provide simulation results.
Known Users	UPV, VTT (Finland)
Contact Info	Universidad Politécnica de Valencia Carlos Alvarez Bel Camino de Vera, s/n 46022 Valencia, Spain Tel.: (+34) 96 387 70 00

Tool	DER-CAM (Distributed Energy Resource Customer Adoption Model)
Manufacturer	LBL – Lawrence Berkeley National Laboratory
Description	DER-CAM is an economic model of customer DER adoption implemented in the General Algebraic Modeling System (GAMS) optimization software. This model has been in development at Berkeley Lab since 2000. The objective of the model is to minimize the cost of operating on-site generation and combined heat and power (CHP) systems, either for individual customer sites or a µGrid. In other words, the focus of this work is primarily economic.
Platform	Windows, requires GAMS
Known Users	Labein (Spain)
Contact Info	MStadler@lbl.gov

Simulation and optimization tools for DR, DG and energy storage operation on the market

Below we have listed optimization tools for DR, DG and energy storage operation. We divided them according to purpose into two classes: for operational use and for assessment use. The first class includes tools, whose idea is to be used in real-time environment. They can have more detailed modelling. The tools for assessment use, on the other hand, must calculate a longer period, such as one or two years, with different values of relevant parameters. To do this quickly, their model must be simpler.

The following tools are suitable for the real-time calculation of optimal control of distributed energy resources.

Tool	VTT KOPTI
Manufacturer	VTT Technical research centre of Finland
Description	The program optimizes the operation of power plants on hourly level for an extended period (such as one year). CHP is included in the optimization. Hydro power plants are optimized using stochastic dynamic optimization. http:/ieeexplore.ieee.org/iel3/3588/10702/00500781.pdf (look at "DEM")
Platform	MS Windows
Known Users	VTT, some Finnish generators
Contact Info	VTT Veikko Kekkonen P.O. Box 1000, FI-02044 VTT, Finland http://www.vtt.fi

Tool	DEMS (decentralized energy management system)
Manufacturer	Siemens
Description	The purpose of the DEMS (Decentralized Energy Management System) system from SIEMENS is to operate DER in an optimized way. DER may consist of a certain number of generation (converter) units, storages, flexible and inflexible demands. In addition energy/media exchange contracts and primary energy sources connected via an arbitrary energy / media flow topology are accounted for. The fields of application of the DEMS are decentralized energy supply systems of electrical utilities, industries and for facility management companies. The main functions are supervision, data archiving, forecasting (demands and renewables) and scheduling; energy exchange monitoring and optimized control of equipment (generation, storage, flexible demands). The DEMS system is not meant to be a substitute for all possible automation equipment necessary for principal operating the components of DER; there must be at least that much local automation equipment available to allow the basic operation of DER components ensuring component and personal safety in the absence of the DEMS system.

Platform	MS Windows
Known Users	several decentralized energy management projects
Contact Info	Siemens AG Austria IT Solutions and Services Program and System Engineering Utilities, Transportation and Airports SIS PSE UTA UT Gudrunstraße 11 A - 1101 Wien, Austria www.siemens.at/dems/

Tool	Gentrader and Genmanager
Manufacturer	Power Costs, Inc.
Description	PCI Gentrader is an asset optimization tool which calculates optimum schedules for hydro, gas, coal, nuclear and other fuel driven power plants. It includes run of river and pump storage optimization. PCI Gentrader is the leading optimization tool in the US and UK. It is designed to model complex portfolios of power and fuel resources, including generators, contracts, options, and ancillary services in detail. PCI Genmanager is a bidding tool, where the output from PCI Gentrader can be used to optimize bidding into a central market. PCI Gentrader optimizes either against a load obligation, market prices or a combination of the two. The main driver are the assets in the portfolio and their capabilities/characteristics. This is a typical scenario when managing a regulated portfolio of assets. PCI Genmanager tries to manage the optimization problem from the market's point of view, where the market and its products/market instruments is the driver. PCI Gentrader and PCI Genmanager is most often used together to get a complete picture of both the asset centric view and the market centric view. The prominent features of Gentrader include: • Tightly coupled unit commitment and limited fuel/emission optimization • Inclusion of long term resource constraints in short term optimization • Long term constrained production simulation by recursive adaptation • Multiple and concurrent fuel and emission limits • Multi-stage combined-cycle model • Ancillary services (Regulation Up/Down, Spinning Reserve, Non-spinning reserve, Balancing Down) • Monte Carlo simulation and stochastic risk model • Uncertainty considerations in prices, volume, and units
Platform	MS Windows, either workstation or uses PCI's central computing services
Known Users	Several power companies
Contact Info	Power Costs, Inc.

	3550 W. Robinson Suite 200 Norman, OK 73072, USA Phone: +1 405 447-6933 Fax: +1 405 360-3713 http:/www.powercosts.com

Tool	EOPS (one area power market simulator]
Manufacturer	Sintef, Norway
Description	EOPS is a stochastic model from mid- to long-term optimal scheduling and simulation of a general hydro-thermal electrical system. The main focus is in hydro power. It is mainly used for local scheduling since it is a single-area model with a single busbar and no grid. Market price is usually externally given and is treated as a stochastic variable. The producer is treated as a price taker.
Platform	
Known Users	
Contact Info	Sintef Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no

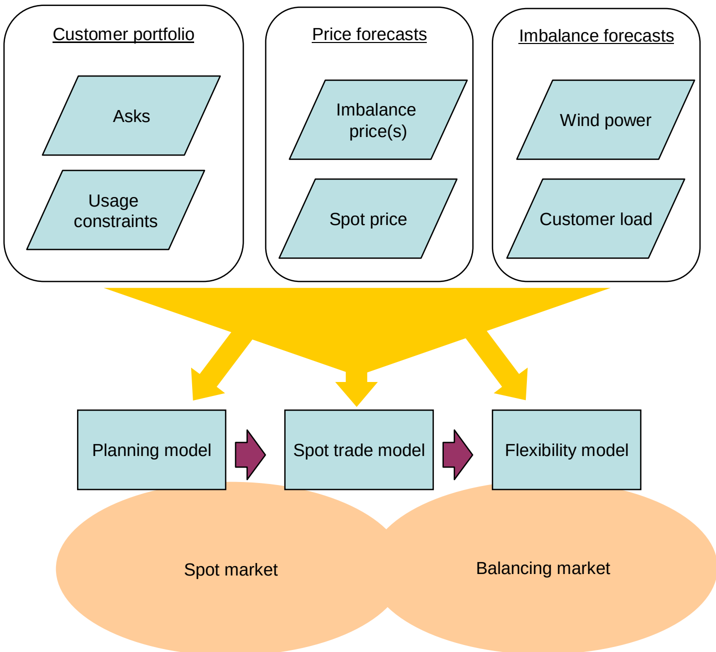
Tool	SHOP (Short-term Hydro Operation Planning) model
Manufacturer	Sintef, Norway
Description	SHOP solves the short-term (1–2 weeks) optimal schedule for individual hydro units taking account the boundary conditions provided by EOPS (see above). Unit description is more detailed, taking account e.g. production curves and head loss coefficients for penstocks. Cascaded reservoir systems can be modelled.
Platform	
Known Users	
Contact Info	Strindveien 4 7465 Trondheim Norway Phone: +47 73 59 30 00 http://www.sintef.no

Tool	BEMI control system (bi-directional energy management interface)
Manufacturer	Institut für Solare Energieversorgungstechnik ISET , Germany

Description	BEMI scheduling optimizer resides in local controller which is located in households. It receives certain information from the central control station, usually the tariff profile for the following day. Based on this information the computer calculates optimal schedules for each device in the management system using a specific algorithm for each device type. Such devices are freezers and fridges, electrical heating and warm water generation, air conditioning and ventilation, washing machines, dryers and dish washers as well as cogeneration devices. In the future this list may include uninterruptible power supplies (USV), electrically driven vehicles and photovoltaic inverters equipped with additional battery storage. Three basic types of devices must be differentiated regarding energy management: • devices with thermal or battery storage, which state-of-charge (SOC) must be maintained within a certain range • devices which carry out a fixed program with shiftable starting time (e.g. washing machine) • devices which can reduce their power at high electricity prices (e.g. a dimmable lighting) Algorithms for each device type must be designed in a way that avoids avalanching effects by switching all devices at the same time. This can be achieved by small, random shifts of switching times The optimization algorithm decides considering the preferences of the inhabitants of the building, the parameters of the devices included in the management and the information received from the central station. This means BEMI decides locally based on local and central information. No permanent online communication is required which would be necessary in a strategy with central decision and scheduling of the devices.
Platform	
Known Users	In academic use only
Contact Info	

Tool	Gaia Optimiser Energy management System
Manufacturer	Gaia Consulting oy
Description	Optimizes the schedules of small CHP plants using heuristics. Includes the price forecast model Emeforecast made by VTT.
Platform	?
Known Users	Several power companies. Is not currently marketed.
Contact Info	http://www.gaia.fi

The following tools are not built for online operation or do not take into account all the subtleties of practical use. Instead, they can have good performance in analyzing a variety of assumptions and scenarios.

Tool	Flexprof
Manufacturer	VTT Technical Research Centre of Finland
Description	Flexprof has been developed at VTT for assessing the revenues of the aggregation of demand flexibility, integrated with RES in the electricity market. Flexprof tries to simulate trading on the spot market, taking account the possibility of flexibility calls. The situation with and without flexibility can then be compared. It can dynamically allocate the flexibility calls based on market price forecasts. Flexibility allocation is done with linear programming, and the final flexibility calls are obtained with stochastic programming. Any time period can be used in the simulation. One year's simulation with six customer types takes about one hour. The model has so far been adapted to the English and German market. The picture below gives an overview of the model. There are three modules: planning model for allocating the load reduction with a few days' horizon, spot trade model for calculating spot trading, and flexibility model for the final calculation of flexibility calls. 
Platform	Mathworks Matlab® / Windows standalone
Known Users	One power company & VTT itself
Contact Info	VTT Jussi Ikäheimo

	P.O. Box 1000, FI-02044 VTT http://www.vtt.fi

Tool	Optimizer of direct control of electric heating based on market prices (VTT)
Manufacturer	VTT
Description	The tool includes a dynamic model of a building's thermal behaviour and based on this and forecasted real-time prices it can calculate the optimal program for electric heating, minimizing energy cost while keeping the indoor temperature within certain limits. The assumption is that the consumer faces real-time prices. Alternative possibility is that the supplier sells the load reductions to the spot market.
Platform	MS Windows
Availability	Proprietary. Available on request.
Known Users	VTT
Contact Info	VTT Pekka Koponen P.O. Box 1000, FI-02044 VTT http://www.vtt.fi

Tool	Offpeak
Manufacturer	Gaz de France
Description	Offpeak tool can be used for profitability assessment of DER aggregator business. Special attention has been paid to the services that DER can provide within the Great Britain power system. The heuristic-based tool can quickly estimate the profits of several years of operation using historical price data.
Platform	MS Excel
Availability	Internal tool.
Known Users	Gaz de France
Contact Info	Gaz de France Direction de la Recherche Guillaume Brecq 361 avenue du president Wilson, B.P. 33 93211 Saint Denis La Plaine Cedex France http://www.gdfsuez.com/en/groupe/innovation/

Tool	National Technical University of Athens MAS (Multi Agent Software)
Manufacturer	National Technical University of Athens

Description	Based on the distributed control paradigm. Allows agents (DER) to decide upon actions without the presence of a central controller.
Platform	Multi-platform
Known Users	
Contact Info	Antonis Tsiliakis (NTUA), atsikal@power.ece.ntua.gr

Tool	Cleanpower
Manufacturer	Tractebel Engineering
Availability	Internal tool.
Description	Optimizes CHP and DR scheduling, considers different sources of revenue such as commercial load management, reduction of imbalance costs, and provision of ancillary services.
Platform	Matlab
Known Users	?
Contact Info	Konrad Purchala, konrad.purchala@tractebel.com

Tool	Power Matcher
Manufacturer	ECN
Description	Software for price-based control of different types of DER such as shiftable loads,
Platform	
Known Users	In development stage
Contact Info	

Forecasting tools

Forecasting tools are important in optimizing the operation of DR, DG and energy storages. Their activation time is often one hour or more. At this time several important variables such as power imbalance prices, and wind power production are still undetermined. Moreover, because of production constraints, dispatching DG or calling DR at one time will cause that it cannot be used at some later time, at which it could be needed more. Having good forecasts can then help us scheduling production in the best possible way.

Forecasts can of course be extended further ahead to help also investment planning. These are commonly socioeconomic forecasts about prices and technology development. In our opinion one should be cautious with such forecasts. It is common to underestimate the confidence intervals of forecasts. Indeed, e.g. power price can easily jump to a new level because of a change in price of tradable emission permits.

The following tools can be used for wind power generation forecasting.

Tool	Cybersoft WindForecaster
Manufacturer	Cybersoft, Finland
Description	The model uses numerical weather forecasts, including wind forecasts and temperature forecasts, as well as past realized power production of wind park as input to a neural network model to generate production forecasts. http://www.cybersoft.fi/Products.aspx
Platform	
Known Users	
Contact Info	Oy Cybersoft Ab Hämeenkatu 25 B 33200 Tampere Finland

Tool	PrevedoVento
Manufacturer	GSE, Italy
Description	Part of PrevedoEnergia, a tool for forecasting power output from variable renewable energy sources for bidding on power market. PrevedoVento combines output using inputs as numerical local weather forecasts, including wind, temperature and humidity forecasts, from: • a neural model on the basis of the past realized power production of wind park • a power model on the basis of type, location, power curve of each wind turbine. PrevedoVento is operational from Jan 2008 providing GSE trading room with power daily profile forecast from 72 to 24 hours in advance. PrevedoVento power model is also offered for wind park maintenance program optimization.
Platform	O.S.: Windows; DB: Oracle
Known Users	GSE for bidding on Power exchange
Contact Info	GSE, Viale Pilsudski, 92 I 00197 Rome Italy Giancarlo Scorsoni - gscorsoni@gsel.it –www.gsel.it

Tool	PrevedoSole
Manufacturer	GSE, Italy
Description	Part of PrevedoEnergia, a tool for forecasting power output from variable renewable energy sources for bidding on power market.

	PrevedoSole predicts the power output for each PV device according to the provincial solar radiation forecast. The individual outputs are then aggregated for each of seven market zones before bidding as a zonal whole schedule. PrevedoSole is operational from Sept 2008 providing GSE trading room with power daily profile forecast from 72 to 24 hours in advance.
Platform	O.S.: Windows; DB: Oracle
Known Users	GSE for bidding on Power exchange
Contact Info	GSE, Viale Pilsudski, 92 I 00197 Rome Italy Giancarlo Scorsoni - gscorsoni@gsel.it –www.gsel.it

The following tools can be used for market price forecasting.

Tool	Inter-Regional Electric Market Model (IREMM)
Manufacturer	IREMM, Inc
Description	The IREMM model is based on demand/supply precepts, and is not a "traditional" cost-recovery plus pricing model. IREMM provides a broad-based, comprehensive view of competitive electric power markets: • Forecasts market-clearing economy energy prices, • represents all buyers and sellers within an interconnected system simultaneously, • identifies economic energy transactions, • analyzes the interaction of supply and demand in a competitive bulk power market, • is not a cost-based, franchise area-specific pricing model, • can be used to assess market power. Risk analyses can easily include fuel prices, new, retired, or out-of-service electric generation plants, changing electricity demand forecasts, transmission constraints, wheeling costs, operation and maintenance costs, environmental impacts, fuel switching, etc.
Platform	
Known Users	
Contact Info	iremm@iremm.com Tel +1 860 651-1600, fax +1 860 651-1997.

Tool	Emeforecast
Manufacturer	VTT

Description	Forecasts electricity spot market prices.
Availability	proprietary
Platform	MS Windows
Known Users	Some power companies in Finland
Contact Info	Jussi Ikäheimo, P.O. Box 1000, FI-02044 VTT http://www.vtt.fi Tel +358 20 722 111