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Supporting Energy Efficiency in Smart Generation Grids Through ICT

Thematic Network

ICT PSP Programme

BUSINESS MODELS MANAGEMENT

Prioritize requirements – Assess ICT offer/needs

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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
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
SMES	Superconducting Magnetic Energy Storage
ToU	Time of Use
TSO	Transmission System Operator
UPS	Uninterruptible Power Supply
VPP	Virtual Power Plant
VTT	Technical Research Centre of Finland
UCA	Utility Communications Architecture
WP	Work package
µ-CHP	Micro combined heat and power

Executive summary

This is the first delivered report in work package 5 of SEESGEN-ICT project and concentrates on business models which can support DER (distributed energy resources) proliferation in smart grids and on ICT tools which are needed in these business models. DER aggregation is one of the most important business activities which can speed up the proliferation of DER and thus lead to more secure and affordable power system and lower emissions. Therefore we have concentrated on this type of business. The general idea, which has been described in this report, is to collect individual DER units and providing their power generation or load adjustment services to power system participants. We also describe the possible sources of value in aggregator business, as well as how this business can benefit the society. In commercial operation part of the generated value is transferred to the owners of the DER units, thus creating an incentive for owning different types of DER.

We also selected nine business models which are either real businesses or developed in research projects and analyzed these business models from two perspectives: the current national situation of several European countries and the ICT which is needed in these business models. In the work division of the project, our work package is less technically oriented and we thus concentrated on software tools which the aggregator needs in his daily operations. For example aggregator's communication technology is dealt with in work package 4 and tools for verifying the services which DER units have provided is dealt with in work package 3. We described the business models in a structured format, so that when possible the same pieces of information are given for each business model. This helps comparison of the models a great deal. The descriptions of the business models can be found in the appendix of this report.

The comparison of different European countries from the DER aggregator's perspective was done partly by using the methodology and results obtained in the EU-DEEP project and partly as qualitative review based on the authors' expertise. The comparison revealed that UK, Germany, Nordic countries and Belgium are currently favourable countries for aggregator business. In fact, aggregators for industrial loads are active in UK, Germany and Norway. Poland, Greece and Italy are less favourable countries. This is mostly because of the regulative environment in these countries. At this stage of our work, we do not make any recommendations about possible actions which could be made to make aggregator business more attractive in these countries. Also we did not make any future projections about the situation concerning DER aggregator business in these countries.

After we studied what kind of software tools are necessary for running the aggregator business models in a competitive market, we reviewed different classes of these tools, such as forecasting and optimal scheduling. Although we were able to list and in one case even compare some existing tools, there were no resources for a comprehensive survey of existing products in this field. We tried to evaluate the overall maturity of these tool classes. We conclude that besides maturity of individual classes of tools, interoperability between the tools is equally important. The tools need to communicate with each other and on the other hand the aggregator can avoid vendor lock-in if he can use a modular tool package with standard interfaces.

We also studied the aggregator's market communication, especially the ebIX (European forum for energy business information exchange) model, which is used in standardized information exchange between power system participants in some European countries. The results of this work will be reported later.

1 Introduction

A number of studies have been made about the existing demand response potential in different customer segments. There exists a significant amount of potential demand response but so far it remains untapped. Small and medium-sized electricity consumers are insulated from the price fluctuations on the wholesale market. Most retail rates are changed only periodically and are time-invariant or contain a few time-of-use tariff zones. Such prices are not very useful in exhorting the consumers to help the system. Similarly, the fit-and-forget way to install distributed generation results in lower-than-possible profitability and less than optimal use of the network.

SEESGEN-ICT work package 5 aims at exploring requirements and barriers to the deployment of business models needed to support implementation of energy efficiency services and DER in a competitive market; and also analysing what kind of ICT solutions and methods are already available to support these business models and what kind of research/developments are still required. What do we mean by “business model”? There are different definitions for the term. Business model is generically intended as a framework for the management of the commercial relationships among market entities for creating value to the whole chain of the electricity market. In SEESGEN-ICT it is intended as a logic of creating value (such as profits to the company, tax income, benefits to consumers, power quality and improved environment), including description of the stakeholders and of their roles and the most important transactions. The core ingredients of a business model are:

- actors, such as different companies involved and their roles;
- products, services, such as load modification in certain load area;
- contractual relationships between the actors, including pricing and penalties;
- transactions and flows between the actors: energy flow, information flow, economic flow;
- enabling technologies (non-ICT and ICT), such as sufficient communication links;
- values/benefits for the actors, such as ability to integrate distributed and uncontrolled generation;
- drivers and barriers to the implementation, such as regulatory constraints, to the adoption.

What kind of business models would support the implementation of EE and proliferation of DER? The business models which we focus in our work are those which concern the *aggregator* of demand response (DR), distributed generation (DG) and distributed energy storages (DS), which we together call Distributed Energy Resources (DER). Several past and on-going research projects have proposed that there are certain business functions needed in the practical implementation of DER, which should be taken care of by someone. These functions can be taken care of by an independent organization or an existing market participant, e.g. an electricity supplier (retailer). In each case, we call this organization an aggregator. We also use the term *retailer-aggregator* when we want to emphasize the case that the aggregator also acts as retailer. *Demand response provider* is used by some people as synonym for demand aggregator. However, the term is confusing because it can also refer to the end-customers who have enabled load control. We thus define the aggregator in the following brief way:

> *An aggregator is a company who acts as intermediary between electricity end-users, who provide distributed energy resources and those power system participants who wish to exploit these services.*

Aggregators are deregulated power system participants with the main role of bringing DER on markets for the use of the other players and on the other hand providing market access to DER. Below in Section 2.1 we briefly justify the existence of the aggregator as intermediary between DER and other stakeholders in the power system. In other words, assert that the aggregator can provide added value to the electrical system.

This report has been produced in the first task of WP 5. In the first task we will find the business models which are mostly related to the topic of WP 5. This will not be done by a comprehensive survey on all existing businesses in the world but by a focused survey of business models from a few selected research projects. Existing examples of these business models, if available, will be considered. We will also consider the applicability of these business models in different national situations, considering e.g. that consumption patterns, electricity prices, network infrastructure, regulations and consumer attitudes are different in different European countries.

Also, we will consider the implications of the presence of aggregators to the ETSO/ebIX role model (European forum for energy business information exchange). The ETSO/ebIX role model describes a model of the electricity market in which all the roles and the domains are identified. In addition, the relationships among the roles are defined, in the context of market information exchange, using Unified Modelling Language (UML). The purpose is to describe electricity market business models with a specific vocabulary (made of roles and domains). A business actor can play more than one role, but such roles can be matched with those identified in the ETSO/ebIX model. In the same way the domains (distribution network, transmission network, national, international) and the transactions can be matched with those of the ETSO/ebIX model.

SEESGEN-ICT will analyze the ICT which is needed in ICT these business models. In the work division of the project, our work package is less technically oriented and we thus concentrated on software tools which the aggregator needs in his daily operations. For example aggregator's communication technology is dealt with in work package 4 and tools for verifying the services which DER units have provided is dealt with in work package 3.

2 Business models which are needed to support the introduction of DER

In this chapter we study what kind of business models the aggregator can apply profitably to support the introduction of DER. The business models do not guarantee profitability but give some necessary conditions for it. In the end, the level of profits depends on local market conditions, cost of equipment, consumer attitudes, competition etc. We selected the business models from national and European projects, which the participants of SEESGEN-ICT are familiar with.

Section 2.1 takes a closer look at the aggregator's role in supporting the introduction of DER. After this we introduce the business models which we have studied more closely in Section 2.2. The following sections then analyze these business models from different national perspectives.

2.1 Aggregator's role

The basic concept of DER aggregator was explained in the introduction. This section justifies the existence of DER aggregators, in other words, we explain what services and added value they can provide to, on the one hand, to consumers and DER owners (we also refer to the owners or occupants of locations where DG or DS has been installed as DER owners even the DG or DS unit itself was owned by someone else) and, on the other hand, to the power system.

Towards consumers and DER owners the aggregator:

1) studies which consumers or DER owners can provide demand response, distributed generation or distributed storage capacity in a profitable manner,
2) promotes and informs the aggregation service to consumers and DER owners,
3) provides financial incentives to the consumers or DER owners to provide distributed energy services and
4) in some cases installs control and communication devices at consumer's premises.

Firstly the aggregator has to develop deep knowledge about different types of consumers and their potential as providers of demand response or distributed generation. He has to know the magnitude and cost of demand response that different appliances can provide, as well as other parameters such as time span, storage characteristics and usage constraints (e.g. how many times per week control signals can be sent) of the demand response. In addition the aggregator must study how much inconvenience the control actions cause to the consumers and what kind of compensation the consumers then require.

Not all consumers can provide DER in a cost-efficient way. For example, their load flexibility may be too small or cause too much inconvenience. Alternatively the consumer may offer flexibility at a time of day or year when it is of low value. The aggregator must evaluate the above-mentioned parameters based on information of what kind of appliances the consumer has and what is their usage pattern. Tools specifically for this purpose have been developed e.g. in the EU-DEEP project. Usage constraints are sometimes born from the physical characteristics of the appliance and sometimes from the consumer's desire of convenience. The aggregator will develop an understanding of the common usage constraints and time patterns of flexibility of different types of appliances over time and may agree about them individually with each consumer.

It would be difficult for the consumer himself to evaluate the profitability of demand response provision or DG installation, especially if the consumer is a small industrial company, office or household. The aggregator thus provides a valuable service in accepting only the profitable consumers.

The aggregator has to make his offer known to the public in an easily understandable way. This is especially true when demand response provision is still a novel business. Later the aggregator does not have to educate consumers about the activity itself, but instead he will try to distinguish himself from other aggregators. If he can make a better offer to a certain group of consumers, it will be of benefit if he informs them about it in an efficient way. The advertising function of the aggregator then benefits the society as a whole.

Signals must be received, appliances controlled and measurements sent in an automated manner. The aggregator can take care of installing the proper control and communication equipment. Smart meters along with their communication and load control features can be exploited in this function. However, these features have not been standardized. Also the measurement resolution may not be high enough and time delay of load control calls may not be low enough for the aggregator's purposes.

The consumer could install the control and measurement equipment himself, for example they could be included in a building management system. A consumer may not have the expertise to make installations himself, or he may not be interested in investing into them. In this respect, aggregator's function resembles that of an energy service company (ESCO), who evaluates the profitability of an energy saving initiative, makes installations and helps with financing. However, aggregator's role is more complex. The consumer must get the proper control signals from those who request the services. The aggregator's job is to provide a link between the end-users, i.e., the providers of demand response and the buyers of demand response. Were the consumer alone to provide demand response, he should have a direct relationship with buyers of demand response services. Without an intermediary, this would lead to very many bilateral relationships. Their management is not in the interest of buyers of demand response services, such as TSO's. For example, small consumers do not have access to electricity exchange and arranging the access could be expensive.

Finally the aggregator provides financial incentives to the consumers to participate in demand response provision. These could take many forms and there are many ways to set up the business. The consumers could be rewarded by being offered an availability payment, call payment (payment for flexibility energy provided), or percentage of the aggregator's profits. The aggregator monitors the consumer's performance and rewards him accordingly.

Towards power system participants and the electricity market (see Figure 1) the aggregator

1) provides distributed energy services in different forms (different timeframes, power curve shapes and locations),
2) forecasts the needs for different types distributed energy services on different markets,
3) makes sure (together with DSO) that that the provision of services complies with the operation of distribution grids.

The aggregator actively offers the distributed energy resources to the disposal of other power system participants. This can happen through on one-to-one basis by making bilateral contracts or through organized markets by submitting offers to these markets. On the other hand, the aggregator needs to be constantly aware of the requests for demand response, coming from different power systems participants. These buyers include regulated participants such as TSO and DSO's and deregulated participants such as retailers, generators, traders and BRP's. The requests can be send directly to the aggregator if it has made a bilateral contract with the buyer. Alternatively the aggregator can receive results from clearing of organized markets, for example spot market for electricity, or he can monitor the bids on organized markets with open order books[1]. The benefit for an individual consumer or DER owner from trading on organized markets would probably be too

[1] Organized markets where the best bids and offers (asks) are published while trading is on-going.

low compared to the costs. Currently the market operators have also set rules about the minimum bids and offers, probably to limit their transaction costs.

Not only should the aggregator react on the requests ex post (afterwards). He should also try to anticipate the requests and make forecasts about them. This allows him to look further ahead and to control DER in a more profitable way. It is difficult for a single consumer to make such forecasts, although forecasts could be contracted from a third party for a fee. In any case, it would be an additional burden for the consumer.

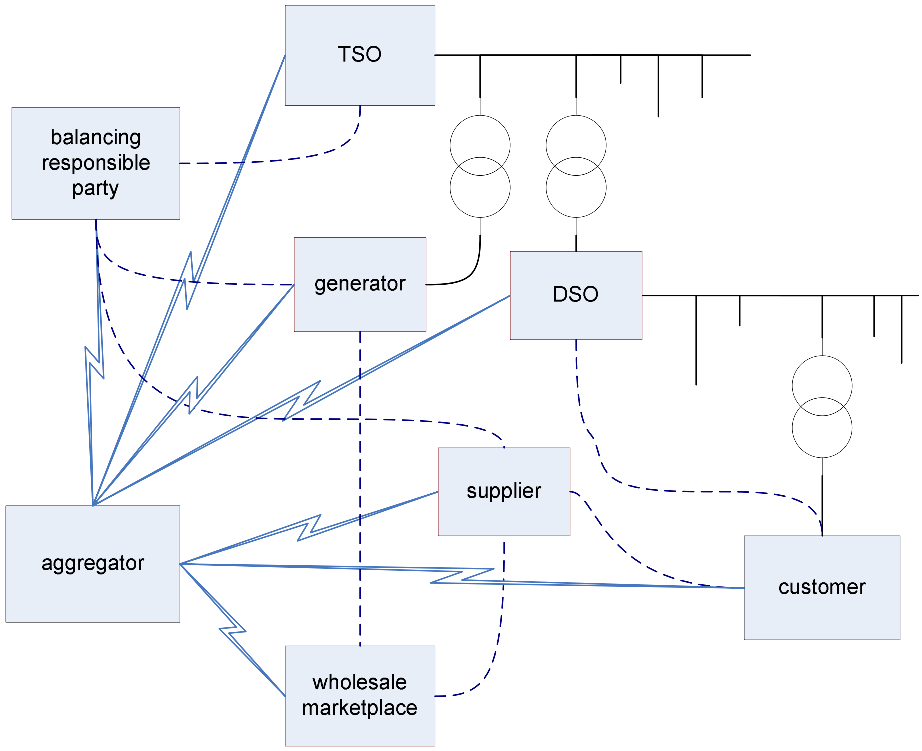

Figure 1: Actors in the key business models studied in WP5. Black lines show the electrical connections, blue lines show information and economic links (not in an exhaustive manner). The aggregator, who connects consumers to the electricity market, is shown with both its upstream (buyers of its services) and downstream communication (consumers). The dashed blue lines show some existing information and economic links

The aggregator collects together different realized and forecasted requests for distributed energy services and evaluates his contractual position, taken into account forecast of consumption based on existing retail contracts and forecast of variable-output generation. He combines the different requests and identifies their synergies. He then calculates how to best respond to these requests by load control. The aggregator can take advantage of economies of scale in controlling a large group of consumers and acquire sophisticated optimization software to support the load control decisions.

The aggregator also makes sure that the load control decisions do not cause problems for the electrical network. One possibility is that he does this *validation* by consulting system operators (DSO's and TSO). The aggregator sends his planned schedules for DER control to concerned DSO's with information about the involved network nodes. The DSO's then evaluate if power quality constraints will be violated by the load control actions and send the validation result back to the aggregator.

We mentioned that the aggregator can provide distributed energy services in different forms, differing e.g. in timeframe, options and location. Different types of distributed energy services can be required on different markets. What markets can the aggregator participate, or what services could he provide? This depends on

1) local market rules, which may set restrictions on the participation of aggregated DER,
2) activation time of DER, which can in some cases be excessive,
3) verification of the provision of the service, which can sometimes be problematic.

Of course, it is also possible that while possible, it is not profitable to provide some services or to participate some market. Table 1 lists some services and markets which the aggregator can provide or participate. Trading on organized markets means selling the resources on day-ahead and intra-day spot markets for power. Conversely, the aggregator can also buy electricity for DES and storage-type DR when it is cheapest. The aggregator thus tries to obtain the best price on market, whether he has to sell or buy. At the same time he helps other consumers by shaving the peak prices on the market.

In Table 1 frequency control includes all load and generation adjustments performed after gate closure, i.e. the point of time when power system participants have to report their final generation and trading plans. These can take several forms, which vary from country to country. Also the balancing market (balancing mechanism) is included in this group.

Service \ time horizon	< one minute	15 minutes	1 hour	1 day	1 year
Trading energy on organized markets			DR, DG, DS	DR, DG, DS	
Frequency control (primary, secondary, tertiary)	local automated DG, local automated DR	Centralized signals to DG and DR	DR, DG, DS		
Meeting system peak load					EE, DR, DG
Portfolio balancing		DR, DG, DS	DR,DG, DS		
Relief of network congestion		DR, DG, DS	DR, DG, DS	DR, DG, DS	

Table 1: Some classes of services and markets which the aggregator can provide or participate (DS = distributed storages).

Portfolio balancing can also be called reduction of imbalance charges. The aggregator may have to monitor his own power balance, i.e., that the power purchased and generated match the amount of power sold and consumed within his portfolio of supply (retail) and trading contracts. Deviation from zero-imbalance normally leads to obligation to pay imbalance charges. The aggregator can in some cases engage DER to reduce the imbalance charges and thus create added value for himself and the consumers.

2.2 The selected aggregator business models

In the following we briefly describe the aggregator business models which we have selected for our study. These have chosen from national and European projects which are familiar to the participants. We have also studied descriptions of some existing aggregators but generally more analysis is available about the business models developed in research projects. More information in structured format about the models is given in the appendix. The selected business models were:

Refer to Appendix for the detailed description of BMs

1. **BM 1 – Aggregating commercial and industrial demand response to balance intermittent generation**: In the business case, an electricity supplier, who is exposed to significant balancing penalties due to the presence of intermittent RES in his generation portfolio and in order to reduce his exposure, uses the demand response provided by his medium-sized industrial and commercial customers as a source of flexibility. As an alternative, he can also valorise the energy consumers' aggregated demand response by making bids and offers on the spot, balancing power markets or by participating in ancillary service tenders. Currently, only large industrial customers, whose flexible load exceeds several MW, have been of interest for Demand Response as their flexibility can be valorised via ancillary services. To achieve a similar amount of flexible power, the electricity supplier aggregates a large number of smaller flexible loads. He remotely controls the consumers' flexible electricity end uses on the basis of a clearly specified contractual framework, thus trying to maximise the benefits for his flexible customers and himself. The main question asked when studying this business model is: Down to which power level is it profitable to aggregate demand flexibility in order to reduce wind-related imbalances? (Bourgain et al. 2009).
2. **BM 2 – Integrating residential scale flexible Micro-CHP into electricity markets**: The business case deals with an energy retailer in electricity and gas that aggregates flexible micro-CHP units owned by residential customers. Single micro-CHP units need to be aggregated to participate in the electricity markets. Electricity retailers are candidates for this aggregation activity (acting as Virtual Power Plant operators) since they will negotiate optimal prices when selling their electricity outputs. The use of heat storages is needed to provide some flexibility in generation. The main questions asked when studying this business model are: What level of decoupling of electricity and heat production is required? What is the minimum size of a CHP unit portfolio? (Bourgain et al. 2009).
3. **BM 3 – Leveraging on the flexibility of aggregated CHP units and demand response to extend the conventional Energy Service Company business**: The business case deals with an Energy Service Company (ESCo) owning CHP units and proposing demand response contracts to its commercial customers. Installing small units at the customers' sites often allows the reduction of power losses and, possibly, higher energy efficiency. Owners of high-energy efficiency installations can apply for energy efficiency certificates, or benefit from feed-in tariffs or premium systems. The business idea is an extension of an existing CHP business model, by adding more flexibility through demand response and heat storage. In other words, the ESCo business is profitable today, down to a certain level of heat demand. Aggregating flexible loads and CHP units leads to additional sources of revenues (selling services to the TSO, avoiding balancing penalties, etc.) and therefore allow the profitability threshold to be reduced. In this case, flexibility is provided both by demand and CHP. Flexibility on CHP units is implemented through boilers and heat storage tanks installed by the ESCo at each customer site (Bourgain et al. 2009).
4. **BM 4 – The Virtual Power Plant**: The virtual power plant (VPP) is a core FENIX concept which enables the integration of distributed energy resources (DERs) into power system operation. A VPP aggregates the capacity of many diverse DERs, so that it creates a single operating profile from a composite of the parameters characterising each DER and can incorporate the impact of the network on their aggregate output. Through this concept individual DER units can gain

access and visibility across energy markets and benefit from VPP market intelligence to optimise their position and maximise revenue opportunities. Furthermore, system operation can benefit from optimal use of all available capacity connected to the grid, as well as increased efficiency of operation. The VPP makes distributed resources visible to the system operator and presents a resource that can be used for active control of electricity networks. In other words, VPP is a flexible representation of a portfolio of DER that can be used to make contracts in the wholesale market and to offer services to the system operator (Corera J. et al). Note that in our business models descriptions we have divided the Fenix business model into two. FENIX concepts were tested with two real demonstrators: one in Spain and another one in the UK. They were called Southern Scenario and Northern Scenario, respectively. The size of the DER units included in each demonstrator was quite different: in the UK, the capacities of most DER units were in the rage of kWe, while in Spain sizes were in the MW-range. Afterwards, for each Scenario, two main different cases were analysed: one without FENIX (base case) and another one with FENIX. In the business models descriptions in the appendix, for completeness, both the cases are considered and two model are described: one with strong policy pressures to integrate DER and another one in absence of these pressures. Instead in the present analysis only one aggregate model seems to be sufficient to point out the desired results.

5. **BM 5 – Ritiro Dedicato**. The "Ritiro Dedicato" is a real business case, that, in Italy, represents an alternative to direct sale to the market (bilateral contracts and wholesale market) for the DER units. It lies in simplified purchase arrangements between the GSE (Gestore dei Servizi Elettrici) and DER operators (with particular attention to Renewable Energy Sources). The DER producer who opts for Ritiro Dedicato assigns to the GSE the withdrawal (that is the purchase) of all the electricity it injects in the grid. This mechanism is thought to promote RES production by making easier the bureaucracy needed to sell energy.
6. **BM 6 – Scambio sul posto**. "Scambio sul Posto" is a real business case, that, in Italy, enables the DER producers (mainly RES, but also cogeneration plants) to inject in the grid the electricity they produce but do not use immediately and to withdraw it afterwards to satisfy their own consumption. Actually it is something like using the electrical grid as a storage.
7. **BM 7 – Network access and Power market interaction** for local production is based on a model developed in the EU project Power Generation during Loading & Unloading (PLUG) where production from ships carrying Liquefied Natural Gas (LNG) exchange power with the Nordic Power exchange in harbour. The ship acts as a DG unit and offers power to an aggregator who trades it on the Electricity Exchange (Nordpool) and the Balancing Market.
8. **BM 8 – Demand Response (DR) access to the Balancing Market** through a commercial aggregator. In this business model a DR aggregator, who also acts as balancing responsible party, makes bids both to the Norwegian Balancing Option Market and the Balancing Market. The bids are based on available power reserves aggregated from several end-users such as electrical boilers from the district heating station, stone crushers at a stone-crushing plant, ventilation plants and heating systems in buildings and reducible loads at a factory refining corn.
9. **BM 9 – Polish CHP broker**. This business models can work in the Polish energy market, which is in constant transformation process. The focal company is "broker", who operates on behalf of individual CHP units (CHP could also act as a prosumer) according to contracts. Besides the possibility to act as an aggregator of local DG, sales and service of regulatory services for the local energy market participants is also a new possibility for the broker. In addition, it is considered a variant of using not only grid NLG but also the local gas fields potential (biomass – as an alternative possibility is also considered). In the Polish model, the broker may have run as a VPP for all local DER prosumers and for his own CHP and really integrate DER into the electrical grid.

2.3 Systematic comparison of four business models in the national situation of UK, Belgium, Germany, France, Spain and Greece

One of the outcomes of the EU-DEEP project (EU-DEEP 2009a) was a methodology for performing a qualitative comparison between the conditions in different countries for a given business model. The methodology was created for performing qualitative analyses of the situation in different countries for a given business model, but also for assessing the expected situation in the different countries in the mid-term (2020) under different scenarios, as shown in (Madina et al. 2009a) and (Madina et al.2009b). The methodology was applied to three aggregation business models and the six countries under analysis were the UK, Belgium, Germany, France, Spain and Greece. The same methodology has also been applied to one aggregation business selected within the FENIX project (FENIX 2009a). In other words, although it was initially developed for its use within EU-DEEP, the methodology can be used for analysing any other aggregation business, such as the one selected in FENIX.

We should remember that when EU-DEEP was running, EU was still not officially an open market for electricity. The liberalization of the energy market in the EU started in 1996 with the Directive on the electricity internal market 96/92/EC, followed by the corresponding gas directive 98/30/EC in 1998 (the "1st. Package"). This was followed by the so called "Acceleration Directives" in 2003: 2003/54/EC for electricity and 2003/55/EC for gas. The latest step in the process so far is the "3rd package" today consisting of 5 directives/regulations:

1) ACER Regulation (EC) No 713/2009;
2) Electricity Cross-Border Regulation (EC) No 714/2009;
3) Gas Cross-Border Regulation (EC) No 715/2009;
4) Electricity Directive 2009/72/EC;
5) Gas Directive 2009/73/EC.

Appraising the profitability of a future aggregation business requires a framework capturing the diverse dimensions of regulation and energy context on the one hand, on the other hand of the flows that are exchanged: information, power, values. The services that could be designed and offered by the aggregator will depend first on the energy market and power system conditions, but also on the technology infrastructure (typically CHP and information) and on local end user habits.

The complexity of such cost and revenue model is highly related to the large number of parameters impacting the profitability of such business. It was addressed in EU-DEEP by:

- a SYSTEMATIC approach reviewing 50 parameters,
- with an UNIVERSAL 5-grade scale with a specific meaning for each scale.

Thus the complexity of all the impacting parameters is captured by a set of 50 marks in a unique scale of 1 to 5, the higher mark corresponding to the highest business potential.

Within the first task of SEESGEN-ICT WP 5 we had no possibility to estimate the future values of the 50 parameters affecting aggregator business. Thus aim of the analysis described in this document is focusing on present conditions, rather than trying to anticipate future situations, so only the first steps of the methodology will be used (Madina et al. 2009a). The steps were:

1. **Identification of critical parameters**: EU-DEEP identified 50 parameters organised into 16 clusters that significantly influence the profitability of aggregation business models (as presented in Figure 2).
2. **Compilation of present situation in the countries under analysis**: By obtaining the present status of each parameter in a given country, a profitability analysis for that country can be carried out. EU-DEEP compiled the status of six Member States (UK, Belgium, Germany, France, Spain and Greece). It is assumed that parameters related to either technology or client

behaviour do not depend on individual countries, so they are assigned the same value in all the countries.

3. **Creation of a 5-grade scale for qualitative comparison purposes**: Starting from the description of present status, a qualitative comparison can be made between the six countries in terms of aggregation business opportunities. The maximum value in the qualitative scale is linked to the most favourable condition for aggregation business, either today or in the future.
4. **Selection of the critical parameters affecting each individual business model**: Although all the parameters selected in Step 1 affect at least one business model, not all of them will affect each particular business model. As a result, for each business model, the parameters without any influence are removed from the analysis.

Due to the similarities between the cases analysed in EU-DEEP and FENIX, the same parameters and hence the same present conditions and 5-grade scales have been considered for all the cases presented in Section 2.3.1. On the contrary, each business model has its own affecting critical parameters (Step 4).

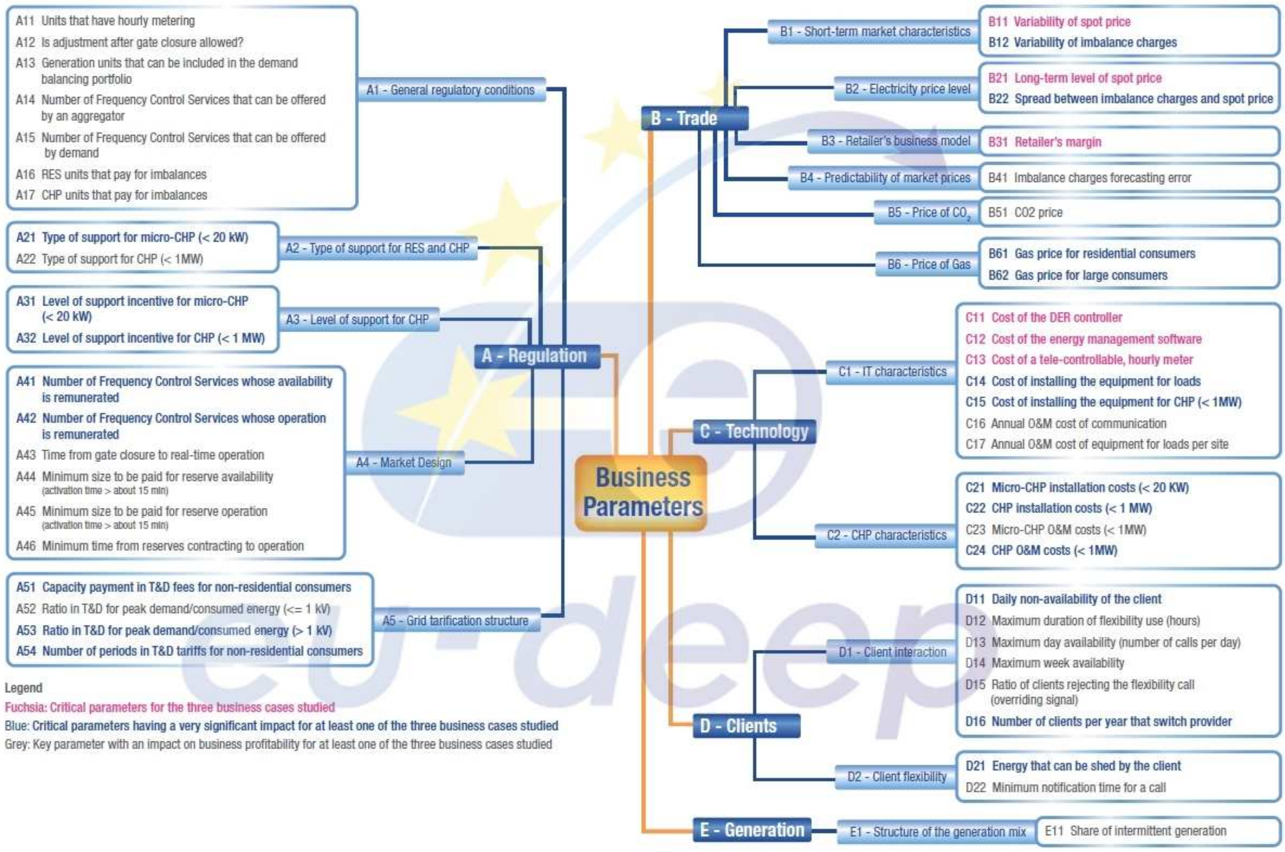

Figure 2: Spider diagram, showing the full list of parameters, clusters and groups (EU-DEEP 2009a)

2.3.1 *Results of the comparison between the four business models and six countries*

For each business model, the relevant parameters were listed and then the situation in each country is translated into the 5-grade scale, for facilitating the comparison.

Then, the average value for each-country in the 5-grade scale was calculated. As C- and D-type (i.e. technology and clients related parameters, see Figure 2) parameters are the same for all the countries, they are removed from the calculation to make the differences more clear.

Results for BM1 (Aggregating commercial and industrial demand response to balance intermittent generation) are presented in

Figure **3** and

Table **2**. The situation for BM1 is good to average in the UK, average to good in Belgium and Germany, average in France, average to bad in Spain and bad in Greece.

A11: Demand & generation units that can be included in the same balancing portfolio	4	4	5	5	3	3
A12: Number of FCS that can be offered by an aggregator	2	5	5	3	4	1
A13: Units that have hourly metering	4	4	3	3	4	3
A14: Is adjustment after GC allowed?	5	5	3	5	5	1
A15: FCS that can be offered by demand	5	4	4	3	2	1
A16: RES units that pay for imbalances	5	2	2	2	4	1
A43: Time from gate closure to real-time operation	4	4	4	4	3	2
A44: Minimum size to offer remunerated reserve availability (activation time of more than about 15 minutes)	5	4	4	1	1	2
A45: Minimum size to offer remunerated reserve operation (activation time of more than about 15 minutes)	5	4	4	4	5	2
A46: Minimum time from reserves contracting to operation	2	4	3	4	3	5
A51: Type of T&D fees for capacity	5	4	4	3	3	2
A53: Ratio in T&D for peak demand/consumed energy (> 1kV)	5	3	5	3	2	2
A54: Number of periods in T&D tariffs	5	2	1	3	3	1
B11: Variability of spot price	3	5	4	3	1	1
B12: Variability of imbalance charges	3	5	4	3	1	1
B21: Long-term level of spot price	2	2	2	2	2	2
B22: Spread between imbalance charges and spot price	2	3	5	3	2	1
B31: Retailer's margin	2	2	2	2	2	2
B41: Imbalance charges forecasting error	3	3	3	3	3	3
B51: CO2 price	2	2	2	2	2	2
C11: Cost of the DER controller	4	4	4	4	4	4
C12: Cost of the energy management software, compared to today	1	1	1	1	1	1
C13: Cost of a tele-controllable, hourly meter	2	2	2	2	2	2
C14: Cost of installing the equipment for loads	2	2	2	2	2	2
C17: Annual O&M cost of equipment for loads per site	3	3	3	3	3	3
D11: Daily non-availability of the client	5	5	5	5	5	5
D12: Maximum duration of flexibility use (hours)	4	4	4	4	4	4
D13: Maximum day availability (number of calls per day)	3	3	3	3	3	3
D14: Maximum week availability	3	3	3	3	3	3
D15: Ratio of clients rejecting the flexibility call (using the overriding signal)	3	3	3	3	3	3
D16: Number of clients per year that switch provider	3	3	3	3	3	3
D21: Energy that can be shed by the client (compared to UPV/test values)	4	4	4	4	4	4
D22: Minimum notification time for a call	5	5	5	5	5	5
E11: Share of intermittent generation	2	2	4	2	4	3

Figure 3: Cross-country comparison for BM1. Columns refer to UK, Belgium, Germany, France, Spain **and Greece in this order.**

Country	Average value
UK	3.57
Belgium	3.48
Germany	3.48
France	3.00
Spain	2.81
Greece	1.95

Table 2: Country ranking in BM1

A11: Demand & generation units that can be included in the same balancing portfolio	4	4	5	5	3	3
A12: Number of FCS that can be offered by an aggregator	2	5	5	3	4	1
A13: Units that have hourly metering	4	4	3	3	4	3
A14: Is adjustment after GC allowed?	5	5	3	5	5	1
A15: FCS that can be offered by demand	5	4	4	3	2	1
A17: CHP units that pay for imbalances	5	2	2	2	4	2
A21: Type of support for micro-CHP (kW)	5	2	4	3	3	2
A31: Level of support incentive for micro-CHP (kW)	3	2	4	3	4	3
A41: Number of FCS whose availability is remunerated	4	5	4	3	2	3
A42: Number of FCS whose operation is remunerated	5	3	3	5	3	5
A44: Minimum size to offer remunerated reserve availability (activation time of more than about 15 minutes)	5	4	4	1	1	2
A45: Minimum size to offer remunerated reserve operation (activation time of more than about 15 minutes)	5	4	4	4	5	2
A46: Minimum time from reserves contracting to operation	2	4	3	4	3	5
B11: Variability of spot price	3	5	4	3	1	1
B21: Long-term level of spot price	2	2	2	2	2	2
B31: Retailer's margin	2	2	2	2	2	2
B61: Gas price for residential consumers	3	3	3	2	1	2
C11: Cost of the DER controller	4	4	4	4	4	4
C12: Cost of the energy management software, compared to today	1	1	1	1	1	1
C13: Cost of a tele-controllable, hourly meter	2	2	2	2	2	2
C16: Annual O&M cost of communication	3	3	3	3	3	3
C21: Micro-CHP installation costs (kW)	2	2	2	2	2	2
C23: Micro-CHP O&M costs (kW)	3	3	3	3	3	3
C24: CHP O&M costs (MW)	3	3	3	3	3	3
D11: Daily non-availability of the client	5	5	5	5	5	5
D12: Maximum duration of flexibility use (hours)	4	4	4	4	4	4
D13: Maximum day availability (number of calls per day)	3	3	3	3	3	3
D14: Maximum week availability	3	3	3	3	3	3
D15: Ratio of clients rejecting the flexibility call (using the overriding signal)	3	3	3	3	3	3
D16: Number of clients per year that switch provider	3	3	3	3	3	3
D21: Energy that can be shed by the client (compared to UPV/test values)	4	4	4	4	4	4
D22: Minimum notification time for a call	5	5	5	5	5	5
E11: Share of intermittent generation	2	2	4	2	4	3

Figure 4: Cross-country comparison for BM2

Country	Average value
UK	3.67
Germany	3.50
Belgium	3.44
France	3.06
Spain	2.94
Greece	2.39

Table 3: Country ranking in BM2

Results for BM2 (Integrating residential scale flexible Micro-CHP into electricity markets) are presented in

Figure **4** and

Table **3**.The situation for BM2 is good to average in the UK, average to good in Germany and Belgium, average in France and in Spain and bad to average in Greece.

Results for BM3 (Leveraging on the flexibility of aggregated CHP units and demand response to extend the conventional Energy Service Company business) are presented in

Figure **5** and

Table **4**. The situation for BM3 is good to average in the UK, Belgium and Germany, average to good in France, average to bad in Spain and bad to average in Greece.

A11: Demand & generation units that can be included in the same balancing portfolio	4	4	5	5	3	3
A12: Number of FCS that can be offered by an aggregator	2	5	5	3	4	1
A13: Units that have hourly metering	4	4	3	3	4	3
A14: Is adjustment after GC allowed?	5	5	3	5	5	1
A15: FCS that can be offered by demand	5	4	4	3	2	1
A17: CHP units that pay for imbalances	5	2	2	2	4	2
A22: Type of support for CHP (MW)	5	5	5	3	4	2
A32: Level of support incentive for CHP (MW)	3	3	2	4	3	3
A41: Number of FCS whose availability is remunerated	4	5	4	3	2	3
A42: Number of FCS whose operation is remunerated	5	3	3	5	3	5
A43: Time from gate closure to real-time operation	4	4	4	4	3	2
A44: Minimum size to offer remunerated reserve availability (activation time of more than about 15 minutes)	5	4	4	1	1	2
A45: Minimum size to offer remunerated reserve operation (activation time of more than about 15 minutes)	5	4	4	4	5	2
A46: Minimum time from reserves contracting to operation	2	4	3	4	3	5
A51: Type of T&D fees for capacity	5	4	4	3	3	2
A52: Ratio in T&D for peak demand/consumed energy (<= 1kV)	3	2	2	2	3	3
A53: Ratio in T&D for peak demand/consumed energy (> 1kV)	5	3	5	3	2	2
A54: Number of periods in T&D tariffs	5	2	1	3	3	1
B11: Variability of spot price	3	5	4	3	1	1
B12: Variability of imbalance charges	3	5	4	3	1	1
B21: Long-term level of spot price	2	2	2	2	2	2
B22: Spread between imbalance charges and spot price	2	3	5	3	2	1
B31: Retailer's margin	2	2	2	2	2	2
B62: Gas price for large consumers	4	3	5	5	2	5
C11: Cost of the DER controller	4	4	4	4	4	4
C12: Cost of the energy management software, compared to today	1	1	1	1	1	1
C13: Cost of a tele-controllable, hourly meter	2	2	2	2	2	2
C14: Cost of installing the equipment for loads	2	2	2	2	2	2
C15: Cost of installing the equipment for CHP (MW)	1	1	1	1	1	1
C16: Annual O&M cost of communication	3	3	3	3	3	3
C17: Annual O&M cost of equipment for loads per site	3	3	3	3	3	3
C22: CHP installation costs (MW)	2	2	2	2	2	2
C24: CHP O&M costs (MW)	3	3	3	3	3	3

Figure 5: Cross-country comparison for BM3

Country	Average value
UK	3.83
Belgium	3.63
Germany	3.54
France	3.25
Spain	2.79
Greece	2.29

Table 4: Country ranking in BM3

A11: Demand & generation units that can be included in the same balancing portfolio	4	4	5	5	3	3
A12: Number of FCS that can be offered by an aggregator	2	5	5	3	4	1
A13: Units that have hourly metering	4	4	3	3	4	3
A14: Is adjustment after GC allowed?	5	5	3	5	5	1
A16: RES units that pay for imbalances	5	2	2	2	4	1
A17: CHP units that pay for imbalances	5	2	2	2	4	2
A22: Type of support for CHP (MW)	5	5	5	3	4	2
A32: Level of support incentive for CHP (MW)	3	3	2	4	3	3
A41: Number of FCS whose availability is remunerated	4	5	4	3	2	3
A42: Number of FCS whose operation is remunerated	5	3	3	5	3	5
A43: Time from gate closure to real-time operation	4	4	4	4	3	2
A44: Minimum size to offer remunerated reserve availability (activation time of more than about 15 minutes)	5	4	4	1	1	2
A45: Minimum size to offer remunerated reserve operation (activation time of more than about 15 minutes)	5	4	4	4	5	2
A46: Minimum time from reserves contracting to operation	2	4	3	4	3	5
B11: Variability of spot price	3	5	4	3	1	1
B12: Variability of imbalance charges	3	5	4	3	1	1
B21: Long-term level of spot price	2	2	2	2	2	2
B22: Spread between imbalance charges and spot price	2	3	5	3	2	1
B31: Retailer's margin	2	2	2	2	2	2
B41: Imbalance charges forecasting error	3	3	3	3	3	3
B51: CO2 price	2	2	2	2	2	2
B62: Gas price for large consumers	4	3	5	5	2	5
C11: Cost of the DER controller	4	4	4	4	4	4
C12: Cost of the energy management software, compared to today	1	1	1	1	1	1
C13: Cost of a tele-controllable, hourly meter	2	2	2	2	2	2
C15: Cost of installing the equipment for CHP (MW)	1	1	1	1	1	1
C16: Annual O&M cost of communication	3	3	3	3	3	3
C24: CHP O&M costs (MW)	3	3	3	3	3	3

Figure 6: Cross-country comparison for BM4

Country	Average value
UK	3.59
Belgium	3.59
Germany	3.45
France	3.23
Spain	2.86
Greece	2.36

Table 5: Country ranking in BM4

Results for BM4 (The Virtual Power Plant developed in FENIX project) are presented in Figure **6** and Table **5**.The situation for BM4 is good to average in the UK and Belgium, average to good in Germany and France, average to bad in Spain and bad to average in Greece.

2.3.2 *Conclusions from the comparison*

In all the cases, UK is the country where the aggregation business models can earn more money, with marks between 3.57 and 3.83, so the situation can be defined as good to average. Main reasons are the ability of aggregation and demand to participate in electricity markets, as well as the existence of market-based support mechanisms and obligation of paying for imbalances for RES/CHP.

Belgium and Germany have average values between 3.44–3.63 and 3.45–3.54, respectively, which can be defined as average to good. In these countries, both aggregation and demand are also quite effectively integrated in electricity markets, together with good price variability. Both countries have market-based incentives for CHP, but not for RES.

France's averages vary between 3 and 3.25, that is, almost average. French regulation's strong points are the ability for aggregation and good support levels for CHP. On the contrary, demand is not so highly integrated in the market and incentives for RES and CHP are not market-based.

Spain's marks are between 2.79 and 2.94, i.e. average to bad. Spanish regulation is oriented to a good integration of RES and CHP in the market, but not so much for demand and not all aggregation possibilities are allowed. Greece is always the country where the situation is worst, with average values between 1.95 and 2.39. The reason is that Greek market liberalisation is not so advanced as in the other countries and, hence, neither the regulation is.

In general, BM3 has the highest ratings, as expected, since it is an extension of the existing ESCO business. Conditions for VPP (BM4) are also quite good in most countries, as it can be considered as an extension of the existing aggregation business. BM4 gets similar marks to BM3 in most of the countries, except in the UK, where the mark is quite lower. Belgium, Germany and France's marks are slightly lower and Spain and Greece's slightly higher. Even though, the UK is still the best country, together with Belgium.

Marks for the micro-CHP business model (BM2), are similar to BM4, except in Belgium and France, where the marks are lower. Compared to the ESCO case (BM3) marks are lower in the UK, Belgium and France, higher in Spain and similar in Germany and Greece.

As medium- and small-scale demand is not integrated in the markets yet, Demand aggregation case (BM1) gets the lowest marks in almost all the countries. The situation in the UK is quite a lot worse than in the ESCO case and similar or slightly worse than in the other two cases. In Belgium, the situation is worse than in the ESCO and VPP cases. The situation is quite worse than in the ESCO and VPP cases in France. In Spain, conditions for demand aggregation are worse than for micro-CHP aggregation. The situation for this business model is much worse than for any other case in Greece.

Table **6** summarises the average values for the six countries and in the four business cases.

	BM3	BM4	BM2	BM1
UK	3,83	3,59	3,67	3,57
Belgium	3,63	3,59	3,44	3,48
Germany	3,54	3,45	3,5	3,48
France	3,25	3,23	3,06	3
Spain	2,79	2,86	2,94	2,81
Greece	2,29	2,36	2,39	1,95

Table 6: Average marks per country and business model

2.4 The business models seen from the point of view of the Italian situation

In this subsection we will outline a summary of Italian situation from the point of view of the business models exploited in this Work Package. The main aspects that will be considered in this analysis are: regulation, electricity price, customer attitudes and DER potential.

2.4.1 *Regulation*

In Europe the energy market liberalization process has reached various level of advancement. The main stages needed to complete the liberalization are (Jamasb 2008):

- Restructuring of the market with vertical unbundling of generation, transmission, distribution and supply activities;
- Stimulation the competition on wholesale and retail market, so allowing new entry into generation and supply;
- Establishment of independent regulator and encouragement of regulation of transmission and distribution networks;
- Privatization of existing publicly owned businesses and opening of the market to new private actors.

In Italy, this process is very advanced (Giffon 2009). The vertical unbundling is actually fulfilled.

At the moment only the 40% of energy production is owned by the old monopolist (that was ENEL). The transmission and distribution networks are privatized and regulated. More precisely, the transmission network has been privatized, but is still under government control, being of national interest. Similarly, the distribution is not fully liberalized, it is regulated by means of governmental licenses. There is an independent regulator established: the AEEG (Authority for Electric Energy and Gas).

The wholesale and retail are liberalized so everyone except the DSO could access to the retail market. In this scenario the DSO cannot cover the aggregator role.

Liberalization of Italian energy market created the opportunity to build trading activities that aggregate large amount of energy purchase orders and constitute the unique interface to sale electric energy to their clients. This kind of aggregators could participate to the **wholesale Market** in place of their clients. In Italy their rising was fostered by the gradual liberalization of the market: at the beginning of the liberalization process only the larger consumer were able to access to energy market and to choose their supplier. So many little commercial clients created consortia in order to aggregate their energy purchase, so accessing to the liberalized market. When the liberalization process was completed, some of these consortia continued to work, because purchase aggregation had shown its effectiveness in getting greater bargaining power. Moreover the recent cancellation of territorial contiguity constraints for the consortium participants further fostered this kind of aggregation.

From the point of view of DR aggregation, recently the Authority took some steps forward and the regulation (Chemelli 2006) now distinguishes the instantly interruptible loads from the interruptible loads which need warning and, starting from the 2008, the latter can participate in the Dispatching Market (Autorità 2006) as reserve services (TERNA). Regulation provides also for the aggregation these interruptible loads, so that the service can furnished to the TSO in aggregated manner (Chemelli 2006).

An interesting measure was taken, in 10/16/2009, by the Italian Regulatory Authority for Electricity and Gas. The approved proposal concerns *"reserve premiums relating to the sale of virtual generation in Sardinia (**VPP – Virtual Power Plant**) in the five year period 2010-2014)"* (ARG/elt 150/09). Sardinia, being an Island, is not well connected to the national grid, so the prices there are higher than in the rest of Italy. In order to reduce them, the Authority issued a deliberation to force the two main Sardinian energy producers (ENEL and Eon) to transfer, through a public auction, virtual production capacity to third operators. These operators will become **Virtual Power Plant** and they will sell this energy as it is produced by themselves.

In this case the VPP idea is applied in order not to get DER aggregation (as, for example, in the FENIX business cases) but as a legal way to simulate the presence of real competition in the energy market in order to reduce prices in Sardinia.

A barrier to new business models in the retail and wholesale part of the supply chain could be that Italian law allows only to sell auto-produced energy to the DSO and not to the neighbours. This could hinder the building of micro-grids.

2.4.2 *Electricity price*

In Italy the electricity price to the consumer consists of the sum of (Torelli 2009) energy cost (negotiated on the market), transmission, distribution and metering tariffs (fixed by the authority) for services provided by technical monopolies and taxes and other charges (fixed by law. In spite of a presence of hydroelectric generators, Italy is one of the European countries with high production variable costs. This happens because Italy depends a lot from petroleum. Favouring competition and supporting investments, liberalization is a first step towards the mitigation of the effects of oil price fluctuations on energy cost. The deployment of new business models to stimulate DER integration could be the next step in this direction.

From the point of view of market prices, at the moment there is not a real equality between offer and demand. In a market driven system there is competition between response and demand. So in the energy market the demand (that is represented by final clients) should react to market signal (through Demand-Response, for example). Instead in Italy there are some mechanism, like Unique National Price, that twist the forming of prices on the market. For example the time-of-use tariff is based on a static division of the day in two parts that always are not synchronous with the real load curve. In fact prices should reflect the availability of energy. But there are some mechanisms that twist the market (RESCOM 2007). They are:

- the Unique National Price (PUN), that is the average of the prices in all the macro-areas in which Italy is divided and that all the consumer pay, independently from their location;
- the presence of the Unique Purchaser,(AU) that purchases energy for all the domestic clients than do not choose to pass to the liberalized market;
- the absence of tariffs for the client that really encourage or discourage energy use depending on its availability (the main tariff is the bi-hourly one that does not really consider this availability)

This represents a barrier for the implementation of new business models based on prices signals.

2.4.3 *Customer attitudes*

Since July 2007, it is possible to all clients to access to energy retail market in order to choose their energy supplier. In spite of this liberalization more than the half of domestic clients did not choose and so they remained in the so called fixed market (ENEL F.A.Q) even though the supplier change is simple and do not require intervention on the electric plant, meter change and energy interruptions, but it was sufficient to subscribe a new contract to stop the reports with the old supplier and start supplying from the new one (this thanks to the separation between supplier and DSO).

This customer reluctance indicates a certain indolence in changing habits that could be an obstacle to the implementation of the aggregator business models requiring a wider domestic customer involvement.

On the contrary, industrial customers seem to be more sensitive: Italy is the European country that has registered the greatest number of supplier changes for large industrial clients and it is at the second place (after Finland) with respect to small and medium industrial clients. This could indicate that industrial clients would also be eager to decrease this electricity bill by joining with aggregators.

2.4.4 *DER potential*

Wind and solar power grew strongly between 2007 and 2008. Italy is a south country so there is still a great solar power potential not exploited.

The micro-generation CHP systems are quite rare in Italy and are practically unknown in the residential sector (Di Santo 2008). In Italy there are 13 millions of building with 27 million of houses, 22 millions of which are heated. So there is a big potential market for micro-generation, but there are some obstacles to its diffusion:

- non-homogeneous behaviour of bodies in charge to grant the needed authorizations. In fact each of them adopts different criteria, in spite of the existence of central directives;
- useless complexity of some fulfilments;
- some constraints that flow into stoppage of mechanisms accede to funding.

Note that the low presence of micro-CHP units hinder the applicability of the second and the third Business Models drawn from Eu-Deep project (see Appendix).

2.4.5 *Smart Meter implementation*

Between 2000 and 2005, ENEL (the main Italian DSO) installed smart meters across its customer base (about 40 million homes and businesses). These Smart Meters integrate bi-directional communications (over low voltage power line), advanced power measurement and software-controllable disconnect switch in order to offers a broad range of features, including the following capabilities:

- remotely reading of consumptions;
- remotely turning power on or off to customers;
- detection of service outages and of unauthorized use of electricity.

As outlined in the business models description, the smart meter technology is one of the enabling technologies for the implementation of new business models based on the aggregation of the customers. Italy, having widely implemented smart meters, has got a good starting point for future deployments.

2.5 Applicability of the selected business models in Poland

Introduction

Poland, as an EU member has taken the challenge of providing clean, always available energy, stimulating economic development. Polish strategic objectives, following the EU policy, integrating energy and climate problems, has defined the following targets (see State Energy Policy Strategy for the 2030r, July 2008):

- Increasing security of supply, ensuring the competitiveness of the economy and the availability of affordable energy and greater production efficiency, as well as counteracting climate change and promoting environmental sustainability.
- Increasing the share of RES to 20% of total energy consumption.
- Increasing importance of high-efficiency cogeneration and DG, particularly RES.
- There is expected an intensive development of modern, diverse technologies of renewable energy sources.
- To reduce losses in the system it is necessary to connect multiple sources, including cogeneration and RES. Adaptation of ICT networks to control and manage with numerous local and renewable sources is also needed.

These are the main strategic objectives, which are based on EU Directives and have set in Poland for the next period of up to 2030.

Energy Market in Poland

Current structure of the energy market in Poland could be modelled as described in the Polish business case. The

Figure **7** presents structural model for deregulated energy trade in Poland.

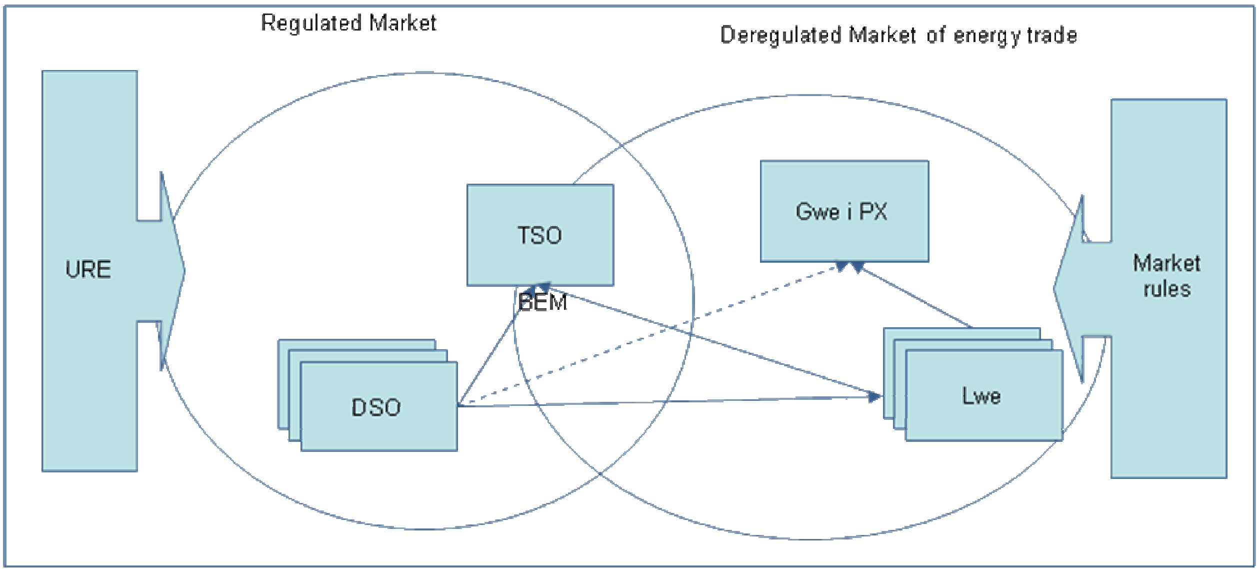

Figure 7: Structural model for energy trade in Poland.

Actor	Role and functional description
TSO	Responsible for electrical energy transmission, delivering it to regulated market, as well as for the balancing- and the day-ahead markets.)
DSO	Responsible for energy distribution and is part of a regulated market.
GWE and LWE -Wholesale Turnover Enterprises (global and local)	Both enterprises are Wholesale Turnover Enterprises (also Energy Exchange Pool- PX)) global – and local and they are responsible for energy distribution (according to source of energy) to the end consumer: for that reason they can be considered as the Aggregators (Gwe, Lwe), the term “aggregator” has not a well-defined meaning in Poland.
Technical operators and Brokers	Responsible for technical and commercial clearing of accounts and participate in the balancing market; dispatching generator units in the grid..
URE	Institution for regulation of Energy Market (Urząd Regulacji Energetyki)

Table 7: Description of main actor in the Polish energy market.

Modelling the main actors of the market, which are the Producers of energy (or RES and DER) and the end-consumers (as well as commercial / retail and technicians operators, operators of measurement, etc.), we have a full picture, which - from the standpoint of energy market liberalization in Poland - is not yet a fully competitive market.

The specificity of the Energy Market in Poland

The energy market in Poland follows the evolution of the European market taking into account the EU directives and regulations. However, this market continues to protect small end users – households, before the release of the energy price (free market prices) – due to fears of a drastic increasing of energy prices. At the same time electric power sector requires significant investments in restoration, modernization and innovation, especially in ICT supporting market development as well as in smart grids.

The domestic system supporting RES and DER based on economic and legal instruments, are now undergoing too frequent changes (lack of stability of profitable solutions over several years) and mainly support large producers, who use the RES to meet the indicative targets for the system. Lack of the tax reliefs and convenient for preferred conditions credits.

Operating certificate of Power origin market generates too weak a finance impulse and potential investors evaluate investment risk as high; also long period of investment return in the sector is taken upon consideration.

DER potential in Poland

In Poland DER means: "generating device connected to a distribution network or directly delivering receiver using renewables as well as traditional in cogeneration" (CIGRE). In Poland nearly 20% electrical energy is delivered from CHP and 8.7% from renewables; remaining electrical energy generation comes from traditional primary energy sources, mostly brown and hard coal.

There are mainly Demand side installations and medium system solutions (from 50 MW up to 150 MW) (medium water power plants (up to 10 MW), wind farms, CHP with biomass or NG), where the Lwe (Local wholesale enterprises) serves the aggregator's role on the energy market. (to adopt the green energy from RES and DG is obligatory).

Electricity price

In Poland the consumer's electricity price consists of:

- tariffs (fixed by the authority) for services provided by technical monopolies (transmission, distribution and metering);
- taxes and other charges (fixed by law);
- energy cost (negotiated on the market- with the exception of small households, which they can (but do not) participate in TPA (third-party access rule) yet).

Unfortunately, at this moment gas prices are regulated and controlled by the authorities – so that the development of cogeneration gas is still in most cases analyzed in economic terms (the expected gains are difficult to forecast). Price barriers related to energy and heating - a continuous prices increasing, policies and legal solutions instability (due to the liberalization of the development) are still large an obstacle for investors in a new BM.

Customer attitudes

In Poland since July 2007, it is possible to all clients to access to energy retail market in order to choose their energy supplier. In spite of this liberalization more than the 60% of domestic clients did not choose TPA and so they remained in the so called fixed market. The supplier change is still not very clear procedure for all. Considering authorizations and conditions for the intrusion into the grid for new prosumers – they are still very cost full processes. Only large consumers such as companies and manufacturers have TPA rules as obliging.

Business case analysis

From the point of view of the Polish national situation the following remark can be drawn considering the applicability of the selected business models.

Business model	Points of interest	What is necessary for developing this business model in Poland?
BM 1 EU-DEEP first business model	• There is no such a type of the aggregator on Polish market. The similar role is played by Gwe and Lwe companies responsible for all energy exchange (traditional and DER energy on local and global market) • Enable of RES/DER energy deliver to the system is mandatory under Polish Energy Law • This model operates on the Polish market –however without third party market actors- -such as electricity retailers for DG	• ICT solutions: DER management systems in real time, electricity market price forecasting tools, market communication tools, smart metering, Internet and communication platforms. • Popularization of that business model based on modelling behaviour of prices for electricity from the DER, investment costs and specific business solutions. • Legal solutions to support the emergence of aggregators for local prosumers, with the popularization of the EU-DEEP project and its results in Poland are necessary. • Financial and tax incentives to this type of activity and business investment are needed • Detailed energy load consumption profile and forecasting tools are necessary
BM 2 EU-DEEP second business model	• In most cases small local CHP in Poland are build to satisfy owner or community heating needs. High level of heating in almost 6-7 month during the year is required. The number of small CHP is significant what means that they could be consider in the business model. • Polish BC is similar to this model. • Modernized medium-scale CHP (hard coal and gas fired) - can become an aggregator to ensure local delivery electricity and heat and can actively participate in the balancing and wholesale energy market.	• Legal solutions to support the emergence of aggregators for local prosumers and popularization of the EU-DEEP project and it's results in Poland.. • ICT and new technology solutions for the heat storage and modern, small-scale CHP with gas. • The introduction of financial incentives in the form of tax credits, excise duties, free prices for gas etc. • Adequate model for load forecasting based on detailed energy consumption profiles are necessary (lack of the data because of old types of meters).
BM 3 EU-DEEP third business model	• There is a similarity between this model and Polish business case but without using the heat storage. Model can be applied in Poland but not necessary with an ESCo company as an aggregator. Such role may play broker established as a business partner (management and market services) for local CHP (polish BM) • ESCO companies in Poland	• Popularization of this type of model among end-users and willing to invest ESCO is needed, or - as in the case of polish BC-common investment modernization of big supplier of gas and local, in medium scale CHP. • The boilers and heat storage units installations for each client are needed. • Required is growing demand for heating in local installation then now. • Other requirements the same like for the previously presented project (BM 2).

	mainly are focused on energy saving based on demand side. • High level of heating almost 6-7 month during the year is required in Poland.	
Italian Model: Cambio sul Posto	• In Poland DER producer is obliged to sell all energy to the grid according to the agreement prices. To satisfy his own consumption he must buy energy from the LWE in every time with different prices. • Currently in Poland there no exist examples of this type of RES producers or aggregators.	• First of all, a new and clear regulations regarding the inclusion of these sources to the grid on the principles of grid “as a storage” are needed. • ICT solutions for the management services of this type are necessary.
Norwegian Model (PLUG)	• This solution is the specificity some of the countries near sea. • In special cases (blackout in Szczecin 2009) it would be good solution for perturbations in the polish system grid and also take into account the diversification of sources of gas. • Now it seems that energy from LNG in Poland would be very expensive.	• An accurate economic analysis of costs and returns (ROI) for this business model in the situation of Polish energy market • Clear law rules regarding the possibility of diversifying sources of gas and gas prices in Poland • Free gas market in Poland
Norwegian Model (Trondheim)	• Currently in Poland there are operating this type of additional examples of activities (so-called third parties) members of wholesale energy trading-both on the stock market and the balancing-dealers (brokers) - but only for energy trading. (not heating).	• Mainly: AMR installations, ICT and management tools are needed.
Italian model (Ritiro Dedicato)	• Currently, in Poland procedures related to the production of energy from RES, clearing and agreeing of cooperation are complicated	• Law changes, changes in authorization procedures and simplifying the buying and selling rules for energy are needed,- there is a main principle.
Business Model: Fenix 1 and Fenix 2	• There is a similarity between this model and Polish business case. In Polish model, the broker may have run as a VPP for all local DER prosumers and for your own CHP.	• AMR, ICT tools and management for such virtual resolving.

Table 8: Problems in applicability of the selected business models in Poland

Conclusions

Current main legal and economic barriers for DG and RES proliferation in Poland are:

- Constant changes law in the effort to reach full deregulation do not ensure stability of the economic situation in the country (poor gas market deregulation).

- The rules governing access to the energy market make it difficult for new players to get involved.
- Most applications for DER connection are refused because of the local grid condition or accepted under condition of sharing costs of connection. In same cases the DSO shift all costs of the grid (infrastructure modernization) to the investor (there is illegal in Poland but it's a practice).
- 50 000 PLN (1000€) deposit for each MW at the beginning of the application process is required.
- Mainly small DER generators are installed to satisfy producers own consumption (wind generator of small capacity or small CHP) without selling energy to the system (demand side only).
- There are DER installations, included into the system delivering up to 7% of energy from renewable and distributed energy sources. They are built by large investors, with investment capacity.
- Today on the Polish market there is no business-as a type of Aggregator (or VPP), however, a similar role for the RES and DG, serve local and wholesale energy trading companies.
- Development of supporting technologies, including ICT for rapid development and functioning of the DER are weak and not strategically planned.
- Still little education and consumer awareness of the benefits of DER and actions to protect the environment.
- Still lack of good installation examples for the so-called. the SME investors and new business models in the field of RES and DG .
- Poor mechanisms to promote and encourage investment in DER.
- Too small expenditures of money on research and development for innovation in the electricity sector, including the development of ICT.
- The certificate of origin market does not meet its encourage role for the DER development.
- Weak systems of national financial support for small investments in DER, for example, tax alleviation, grants for the installation of small power. (eg: only this year will come into force credit relief for investments in heating water through PVC for private investors).
- The costs of AMR installation is still very high for single small customer .
- There is no reliable developed economic analysis for the construction and operation of the grid with RES and DG installed.
- Investing in the DR in Poland is a long-term process with high commission from the credit risk.
- Expansion and modernization of local distribution networks for RES and DG intrusion in Poland is needed.

General conclusion could be as follows. Poland is still not well ready to for the implementation such new advanced business models in the down-stream of the electricity supply chain (retail and wholesale). The main barriers are: being still under developing of liberalization, law and education should still be developed.

3 Aggregator’s ICT tools

In the previous chapter we explained what kind of services DER aggregators can produce, what kind of business models they can pursue and how these business models are applicable in different European countries. DER aggregators also have a great need for ICT. With DR, DG, storage and smart grid technologies we may be able to solve problems such as network congestion, high transmission losses and supply variation from variable generation, including wind power, run-of-river hydro power and CHP. It is difficult to know by 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 in operating the resources in a way that the aggregator's and (hopefully) the system's benefits are maximized. They can also show the physical effects of DER penetration on the network. Without these tools, we do not yet understand the technical ramifications and consequences of such integration, nor can we estimate the benefits from enacting policies to push integration faster.

The tools that we have considered are mainly high-level software tools, which, while not absolutely necessary, can support decisions concerning energy policy and investments and operation of DER. Some of the tools can also be connected into a larger automated system including also hardware components such as meters.

3.1 Customer-level simulations tools (e.g. load forecasting)

The aggregator may have to forecast electricity consumption of its own customers (when it acts as retailer) or the consumption in the electricity system. The former may be needed in provision of certain services or forecasting the aggregators own power balance; the latter in forecasting spot market electricity prices (depending on the forecasting method). Price forecasts are dealt with separately below. On the other hand price also affects consumption for customers who face real-time prices.

Consumption can be forecasted within various time horizons. For the aggregator's operative decisions most relevant is short-term load forecasting (STLF), which considers lead times up to one week. Generally this type of load forecasting may also be used for other power sector purposes in addition to the active demand aggregation, such as generator unit commitment, hydro-thermal coordination and network analysis functions. STLF is important for the secure and economic operation of power systems. From the aggregator point of view this is a benefit because tools for load forecasting are already available. Various mathematical methods can be used for this type of load forecasting, such as:

- linear regression models,
- time series models and
- artificial neural networks.

In recent years artificial neural networks as tool of machine learning have gained more popularity in load forecasting. Also commercial tools based on this approach are available. In this approach the user does not explicitly specify the relationship between forecasted load and other variables. However, there is a difficulty in determining the best design parameters for the neural network. Often trial and error method has to be used, which is time-consuming. A large amount of past input data (even several years) is required for this method. The data should be of good quality and cover the range of situations which are hoped to be forecasted.

3.1.1 *Experiences of load forecasting in Poland*

Department of Computer Science in the University of Lodz (ULDCS) researched Artificial Intelligence in power from the beginning of 1990's. Slowly developing electrical energy market in Poland implied growing interest in electrical load forecasting and ULDCS have investigated tools applied in load forecasting. In this research the total load of one Polish utility was forecasted with ANN and results of the forecast were compared with real consumption. However, the method can be used for load forecasts of any customer group, such as aggregator's customer portfolio. However, elasticity of consumer loads is not included in this method.

Steps for creating forecasting model (Bartkiewicz et al 2002b) were as follows:

- Comprehensive analysis of the historical dataset according to the quality of the data, resulting in rejection some parts of the dataset for further verifications;
- Selection of the appropriate forecasting method and identification of the structure of the selected model: neural networks, linear regression, ARIMA models and the hybrid neuro-fuzzy model were investigated.
- For further examination model of two-day ahead energy forecasting model consisting of 24 equations with inputs: temperature (min and max), type of the weekday coding variables has been solved using MLP (multilayered perception) neural networks with one-hidden layer and structure {13-10-1} (13 units in input layer, 10- in hidden layer and 1 output unit) (See the chaos theory approach for electrical load forecasting has been presented in by Zielinski & al 1998).
- The model has been tested for statistical evaluation of the forecast accuracy, economical effects of the forecast evaluation, identification of the customers with irregular demand cycles, Neural-genetic (GANN) model trained with financial cost function (Bartkiewicz et al 2002a) and others.

Experiences collected during the short-term load forecasting system development and at the stage of initial exploitation and comparative studies are then basis for the following conclusions:

- The presented short-term forecasting system of the electrical energy demand achieves an average accuracy around 3.5 %, but some large error values were observed, associated with sudden changes of the load caused by the irregular production cycles of the large customers. Information about such events should serve as a basis for on-line forecast corrections or demand side management activities.
- Comparison of the forecasting tools developed by various authors indicates that accuracy levels are similar.
- Accuracy of the load forecasting tools reported in bibliography equals around 1 % which results from historical data being gathered systematically, with high accuracy from a period exceeding 50 years, what allows better training of ANN. Also the number of the inputs given to the models is much higher than it was available at the time creation of the Polish model being considered; it was a set of metrological conditions, temperature forecasts, actual loads and information about predicted events influencing the electricity demand.
- Energy market development justifies links between forecasting system and decisions associated with activity on this market, through creation of the tools allowing the evaluation of the economical effects of the prepared forecasts.

3.2 Price forecasting tools

The aggregator has to forecast prices on the power markets which he participates. The level of the long term prices is of interest in order to secure the portfolio by bilateral and financial trading and the best possible knowledge of the prices in the physical markets (day-ahead, intraday and balancing market) is important information for securing the needed margins for short term trade. The main risk factor for the market players is the fluctuations that might occur in the physical markets in the next 24 hours of operation and especially related to the balancing market settlement. These prices are often determined by sudden shortage and prices might soar far above the variable cost of production. This is due to very low demand-side price elasticity and in some cases market power is also abused.

On some markets, such as Finnish (Nordpool) and German (EEX) intra-day markets, trading is continuous with open order book, i.e., the best bid and ask prices are public and continuously updated. Even in this case it is necessary to forecast prices for future periods in order to facilitate planning. For best results it is necessary to plan the scheduling of DER several days ahead. Also the prices on intra-day markets for power delivery during a specific period vary considerably with time, so the price during any moment does not give all the possible information about the future price during the next few hours. Forecasts can still provide additional information. Also forward contracts for power are traded on many marketplaces and they can help to forecast the future power price.

The larger market players and especially producers who are planning long-term investments needs dedicated models for price forecasting in their system. These models have to handle the competitive market behaviour, capture uncertainties and deal with the different risk factors. Several of the methods which are suitable for variable-output generation forecasting, such as time series techniques and multiple regression, can be used to forecast prices in short-term in electric power wholesale markets. It has been claimed (Doulai & Cahill 2001) that artificial neural networks are more suited to power price forecasting. The benefit is for example that the user does not have to specify a mathematical form for the relationship of e.g. weather and spot price. Inputs to this method can include historical spot prices, power demand, power demand forecast, temperature, cloud cover and wind speed. In addition, temperature, cloud cover and wind speed variables coming from numerical weather prediction system can be used as well as load forecast variables coming from a load forecast tool. Output of the tool could be different depending on its uses. In some cases, an expected value of the price is needed, in other cases some other parameters for the probability distribution of the price may be desired. This can be the case if DER scheduling is based on stochastic optimization.

Several aspects of competitive market behaviour can strongly influence future price evolution and they consequently need to be incorporated in the price forecasting methodology. So is the fuel cost of production, which in a hydro dominated system like the Nordic also is related to the inflow to the reservoirs and the current reservoir level. To handle the uncertainties and the stochastic data is among the challenges solved in these models. The key uncertainties in other fuel prices (coal, gas, oil) are related to the respective markets. These uncertainties are of special importance with regard to long term assessments where also future additions of generation and transmission capacity, regulatory structure and rules, future demand growth and plant operations and climate changes are relevant aspects.

The quality of the background data is important with regard to a reliable price forecasting. This means that there are players, especially large producers with a high mix of production and a geographical spread that gives them information not available for others. This fact makes availability and transparency of data a very important issue and smaller players like e.g. aggregators of residential DR should consider outsourcing of the price forecasting task.

Considering the actual tools which the aggregator needs for forecasting prices, he can in most cases use the existing tools which are currently used by power traders. Examples of existing tools used in the Nordic system include:

- The **EOPS** and **EMPS** models (SINTEF/POWEL, Norway), which are today two of the most frequently used energy and forecasting models in the Nordic electricity market.
- **ECON BID** is model aimed at studying the impact of variable wind power, thermal production and hydropower on the price level and structure, price volatility and price differences between market areas

3.3 DER scheduling and trading optimization tools

DER scheduling optimization produces as a result the signals which are finally used to control DER, such as price and power control signals. In other words, the aggregator then has to decide how to operate the portfolio of active customers to maximize its profits and produce savings to the customers. This is a complex task which requires utilization of mathematical optimization methods. Normally the optimization model has to be adapted to the rules in each electricity market, such as the details of balance management. In practise the optimization is run inside a software tool which has the necessary interfaces to sources of input data and channels to output the results. The results include both downstream results, such as requests of load control to consumers and upstream results such as the offers to sell this load reduction, either on open markets or though the aggregator's bilateral contracts.

3.3.1 *Requirements for the scheduling and trading optimization*

Several requirements can be stated for the trading and load scheduling system in order for it to be useful in practise. Firstly, it should be able to consider many different organized market segments and bilateral contracts simultaneously and their possible conflicts and synergies. For example if the aggregator sells power on organized intraday power market, it may not be able to make an offer to balance mechanism. In different countries different electricity market designs and rules have been adopted. This is true for electricity trading as well as for balance management. For example, on the spot market of the Nordic countries batch trading is used (asks and bids for the hours of the following day are submitted all at the same time), while in APX power exchange in UK trading on the spot market is continuous. In the former system there can only be one spot price for each hour, whereas in the latter price varies during the trading period. Ideally the system could handle such differences in market rules with little adaptation.

Besides contracts for one specific period, different wholesale marketplaces have designed more specialized contracts, such as flexible hour contract, which is realized for the period of highest market price if the price is higher than a specified limit. Such a product suits DER aggregator well. Similarly the system should be able to consider different customer contracts, including those consumers and DER owners who prefer to receive price profiles for flexibility well in advance, resembling real-time pricing and those who can respond to price changes (or direct control signals) with short notice.

The system should be able to look several days ahead. This is because future price and load forecasts may have implications on current decisions through contractual constraints, e.g. the consumers may not wish to reduce their load more than several times a week. In general the system should always consider the effect of all decisions on future outcomes. One such effect is the ability to call DER units later; another one would be the payback peak (higher than normal consumption after load reduction).

It should be noted that the system cannot treat each of the thousands of units in the DER portfolio individually; a personalized control strategy for DER unit is too burdensome to calculate. Similar DER units (judged by appliances and their status, contracts and location) must be grouped together and treated as larger units. Occasionally regrouping can be done if for example variance in status of appliances (e.g. indoor temperature) in the group increases because of different overriding behaviour.

The system should be possible to run in off-line mode, using historical prices, simulated price forecasts and other variables. Such possibility is necessary to evaluate alternatives such as effect of changing the DER portfolio or contracts, different optimization parameters, better forecasts, etc. Normally the system is run in online mode, which means that it must have the necessary data connections for input and output data.

3.3.2 *Existing tools*

There are existing tools which can optimize power trading on organized markets. They, however lack support for some features which are particular for DER, such as the dynamic behaviour of consumer loads in response to varying prices. Some of these tools have been listed in the appendix. In the EU-DEEP project some DER management tools used in the project were reviewed. Four of these have been listed in Table 9. Only DEMS is a commercial tool currently suited for on-line use, although Cleanpower and Flexprof could be modified for on-line use. Offpeak is an MS Excel-based tool suitable for sensitivity analysis and business planning. Based on a deterministic model developed in Visual Basic by GDF SUEZ, it aims at supporting investment decision-making and customer selection by assessing profitability generated by demand-side management in different market conditions. It simulates power only and is adaptable to different business development cases in various European countries. Because of its lightweight optimization it is markedly faster than the other tools (Ikäheimo & al 2008).

Flexprof allows an economic optimization for day-to-day operation of DER units, thus helping in investment decisions and profitable portfolio building process. As a distinction from the other tools it uses stochastic model, allowing consideration of uncertainties in loads, generation and prices. It has been developed by VTT using Matlab. CleanPower is a Matlab-based economic optimization tool for day-to-day operations in industrial sites developed by Tractebel Engineering. The model is deterministic and commodities simulated can include power, heat, cooling, steam, gas, compressed air, water, waste emissions. It supports the analysis of aggregation business cases in four different European countries. DEMS is generic deterministic tool that can be used for economic optimization (off-line simulation) as well as command and control for optimized operation of decentralized supply systems (on-line supervision). This tool has been coded by Siemens using C++ (Ikäheimo & al 2008).

The above-mentioned tools place the control intelligence at the aggregator. It is also possible that the aggregator acts only as a central coordinator, with more decision intelligence present at the consumers and DER owners. This can be useful especially in the case of small consumers because it is impossible for the aggregator to centrally plan the operation of a large amount of different kinds of customers in a detailed manner. One solution is to use price signals to control consumers and DER owners, with power control signals calculated locally. Such a tool is being developed in the ADDRESS project.

Tool	**Offpeak**	**Flexprof**	**DEMS**	**CleanPower**
Field of analysis	sensitivity analysis of business cases	support investment decisions and customer selection	support investment decisions; live usage in online mode	support investment decisions
Degree of industrialization	internal tool	intenal tool	commercial tool	internal tool
Model type	deterministic	stochastic	deterministic	deterministic
Planning horizon	½ hours	normally 24 – 48 hours	typically max 7 days ahead	specifiend number of periods (1, 6, 24 etc.)
Time resolution	½ h	user-defined	¼ h, ½ h or 1 h	user-defined
Support for energy storages	no	yes	yes	yes
Computation time for one year simulation	10 s (5 customer types, ½ hour resolution)	15 min (5 customer types, ½ hour resolution)	45 min (with 5 contracts and 10 generator units)	1 h 20 min (50 end-uses, 10 generation units and 5 exchange contracts)

Table 9: Some DER management tools which were compared in the EU-DEEP project (Ikäheimo & al 2008).

4 Summary and conclusions

DER aggregation is one of the most important business activities which can speed up the proliferation of DER and thus lead to more secure and affordable power system and lower emissions. We have explained the main idea and motivation of DER aggregator business. We have reviewed several aggregator business models, either existing businesses or ones developed in European and national research projects. Most of these business models concentrate on an aggregator who controls DER and on the other hand trades power on different types of markets and provides services on bilateral basis. In some models added value emerges also locally by e.g. optimizing the usage of μ-CHP and gas burner.

We have discussed these business models from the national point of view of several European countries, considering e.g. current regulations, consumer attitudes and DER potential. We can conclude that among the European countries which we studied, the current regulative regime is most favourable for DER aggregator business in Nordic countries, UK, Germany and Belgium and less favourable in Poland and Greece. This is mostly because of regulations and market rules, which do not favour aggregation activity. In Finland DER aggregation business was practically impossible until 2009 because of balance management legislation. There are also some differences in DER potential for different consumer types across different countries but these were not analyzed in the sources that we have used. DER potential includes items such as power which can be shed as DR, length of DR calls, possibilities and interest to install μ-CHP, etc. Naturally, this is also affected by subsidies and other incentives. At this stage, however, we are not ready to give any recommendations which could speed up aggregation business. This will be done in task 4 of this work package.

We have gone through different classes of ICT tools and methods which are necessary for a DER aggregator. These were mainly software tools which can help the aggregator, on the one hand, to perform the control of his DER portfolio and, on the other hand, developing the portfolio so that he can best respond to market demands with lowest cost. We have listed requirements for these pieces of software and also mentioned some modelling and calculation methods which can be applied. However, since few of the authors have hands-on experience about commercial software tools in these categories, we were unable to make a detailed analysis about what features are missing, let alone practical comparison between different tools. The project participants were better aware of research and development in the field of aggregator's software. We point out the need of development in the field of forecasting consumer's response to aggregator's control signals (price signals or power requests), which can be considered an extension to forecasting of variable production and loads in absence of control. Such forecasting can be done either by the aggregator or locally by the consumer. In addition we pay attention to interoperability between tools. Different tools should have a common understanding about the meaning of their input and output data and the data exchange should be technically possible. Tools interoperability is an important prerequisite for the profitable aggregator business and still needs improvement. Also, the aggregator's external interoperability between consumers and power system participants needs development and is being developed e.g. in EU-ADDRESS project.

We also point out the need of transparent data, such as prices from different markets and consumption data from consumers. This is needed for the efficient planning of the aggregator business both in the long and in the short term. From the DER point of view, the DER owner should also be able to easily compare the offers from different aggregators. Table 10 below shows the evaluated maturity of different topics related to successful DER aggregator business.

We also studied the ebIX (European forum for energy business information exchange) model, which is used in some European countries in standardized information exchange between power system participants. We have considered some possible additions to this model due to presence of DER aggregators. This work has not been finished at the time of writing this report.

Category	Topic	Maturity level
Aggregator's ICT tools	Variable-output production (e.g. wind, µ-CHP) forecasting	young/existing
	Load forecasting	mature
	Consumer's response forecasting	young
	Market price forecasting	mature
	DER operation and trading optimization	existing
	Customer portfolio optimization	Young
	Tools interoperability	Young
Aggregator business	Incentives and subsidies	young/existing
	Good, real data	young
	Customer exposure to smart rates	young

Table 10: Maturity level of some topics which influence DER aggregator business. The scale is early (R&D), young (pilots / field tests), existing (available, at least one vendor; early adopters involved), mature (widespread commercial). Partly based on IEA DSM 2008a.

As a next step we will study barriers to aggregator business and solutions to these barriers. When our resources allow, we will take into account as well France, NL or Czech Republic in our country analysis. We will also consider ICT as means to harmonize the aggregators role in Europe and standardize the related business processes.

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Appendix 1: Description of selected business models

BM 1 EU-DEEP task force 1

Part 1: case description

1. **Name of the Business Case**: Aggregating commercial and industrial demand response to balance variable-output generation
2. **Location of the Business Case (nation / project that generated the BC):** EU-DEEP project, with main focus on Great Britain
3. **Short description of the case and business rationale:** The business case deals with an energy retailer in electricity that aggregates demand response and distributed generation at commercial and small industrial customers, such as offices and waste water treatment plants. These resources must be aggregated to profitably participate in the electricity markets. Electricity retailers are candidates for this aggregation activity (acting as Virtual Power Plant operators) since they have expertise about their customers' electricity consumption and the functioning of electricity markets. The aggregator can then use DER for e.g. portfolio balancing (including variable-output generation such as wind power) and ancillary services.
4. **Actors involved (companies, organizations and so on):**

Actor	*Role*
National Grid	System operator
Elexon	imbalance settlement responsible
Gaz de France ESS	aggregator
APX Power UK	market operator (power exchange)
customers	DER Owner

5. **Their (logical) Roles in the Business Case:** Electricity consumers act as providers of demand response and distributed generation (back-up power plants). The aggregator enables the participation of such small-scale units in wholesale markets. TSO and other power market participants purchase aggregated services from the aggregator.

Role	*Description*
Consumer	The owners of flexible demand (e.g. air conditioners, chillers) connected to a distribution network, adjust their demand according to aggregator's request.
Aggregator (not defined in ebIX)	The Aggregator is a competitive market actor that aggregates a DER portfolio (generation and load) and acts to generate the best commercial value from the portfolio in the wholesale, balancing and reserves markets.

	The Aggregator also supplies energy to the DER owners.
System operator	The System Operator (SO) is responsible for stable power system operation though a transmission grid. Operation of transmission includes management of energy flows, reliability of the system and availability of system services. The SO also operates the balancing mechanism, which allows trading load reduction which can be activated with a few minutes response time. This is a one-sided uniform-price market with the TSO as central counter-party who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power. The TSO also operates power reserves market.
Imbalance Settlement Responsible	Subsidiary of SO, which calculates the power imbalance of each balance responsible party and charges them accordingly.
Market operator	Power exchange operates organized power markets with different lead times and mechanisms such as day-ahead market and intra-day power market.

6. **Product / Services and related Transactions:** DR can be used for
    - Planned balancing:
        - Reducing imbalance of the retailer-aggeregator's own balance account
        - Selling power in the power exchange
    - Network stability:
        - Selling load reduction or increase to the balance mechanism
        - Providing ancillary services to TSO
    - Reducing distribution and transmission charges

Product/Service	***Definition***
Commercial load management	Selling energy released in load reductions to the spot market.
Reduction of imbalance costs	The Aggregator adjusts customers' loads to achieve smaller power imbalance.
Triad management	The Aggregator reduces transmission charges by reducing the annual peak consumption.
Provision of frequency control services	The Aggregator sells the load reduction capability to the TSO's power reserve.

7. **Information exchanged between the actors**: It was supposed that demand response is implemented as direct load control so that the aggregator remotely shuts down certain appliances or adjusts temperature set points. Power measurement data from consumers is sent back to the aggregator. See for example Figure 8.

8. **Energy flows between the actors (the economic path, not physical)**: The aggregator as retailer providers the consumers the electrical energy which they consume. The aggregator can buy back

part of this energy by calling demand response or dispatching distributed generation units. The aggregator can further sell this energy to TSO or power exchange. Below shown is the case for reduction of imbalance cost: aggregator buys energy from the consumer and sells this forward to imbalance responsible party (or balance responsible party) to avoid negative imbalance. The second figure shows the energy flows in case of selling the energy released in load reduction to another power market participant. Note that the energy flows do not show the physical paths of the electrical energy but rather commercial transactions, where energy flows are opposite to financial flows.

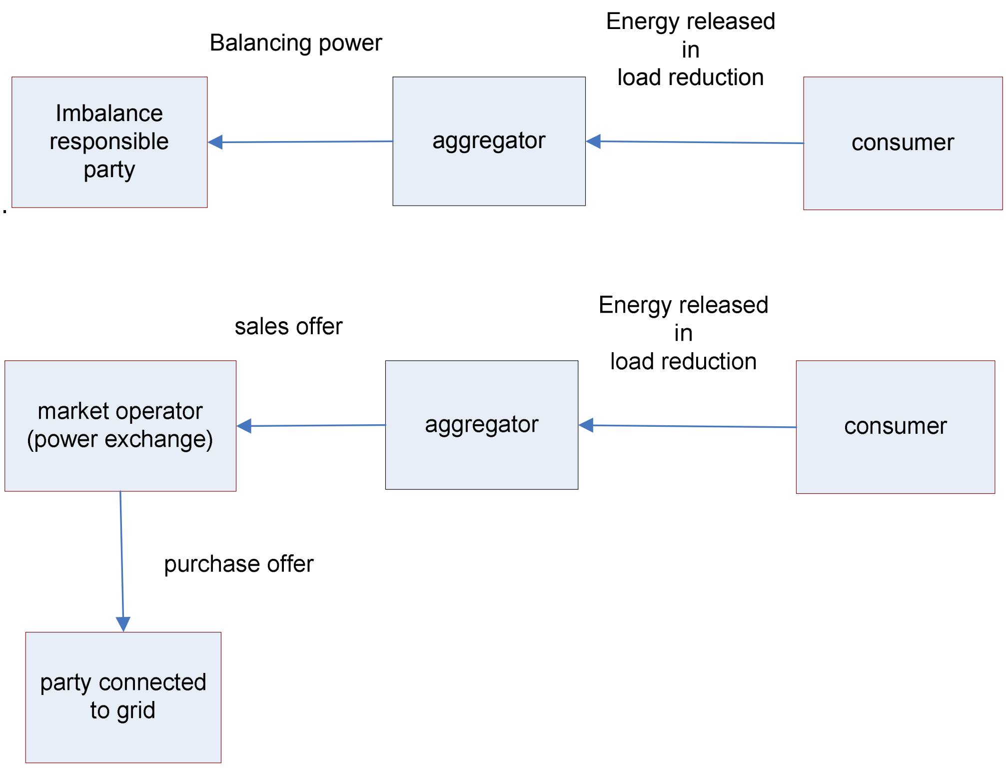


Figure 1: Some energy flows in different business models of the EU-DEEP task force 1.

9. **Economic flows between the actors**: Consumers are rewarded based on agreed prices for DR and the realized load reduction, calculated as the difference between forecasted and realized consumption. A forecasting application based on physical model of the appliance was developed. They may also get availability payment. They may be penalized for overriding DR signals. Consumers pay retail tariff. TSO pays the aggregator for providing ancillary services. Aggregator pays TSO for imbalances.

10. **Graphical description of the case (UML if possible)**

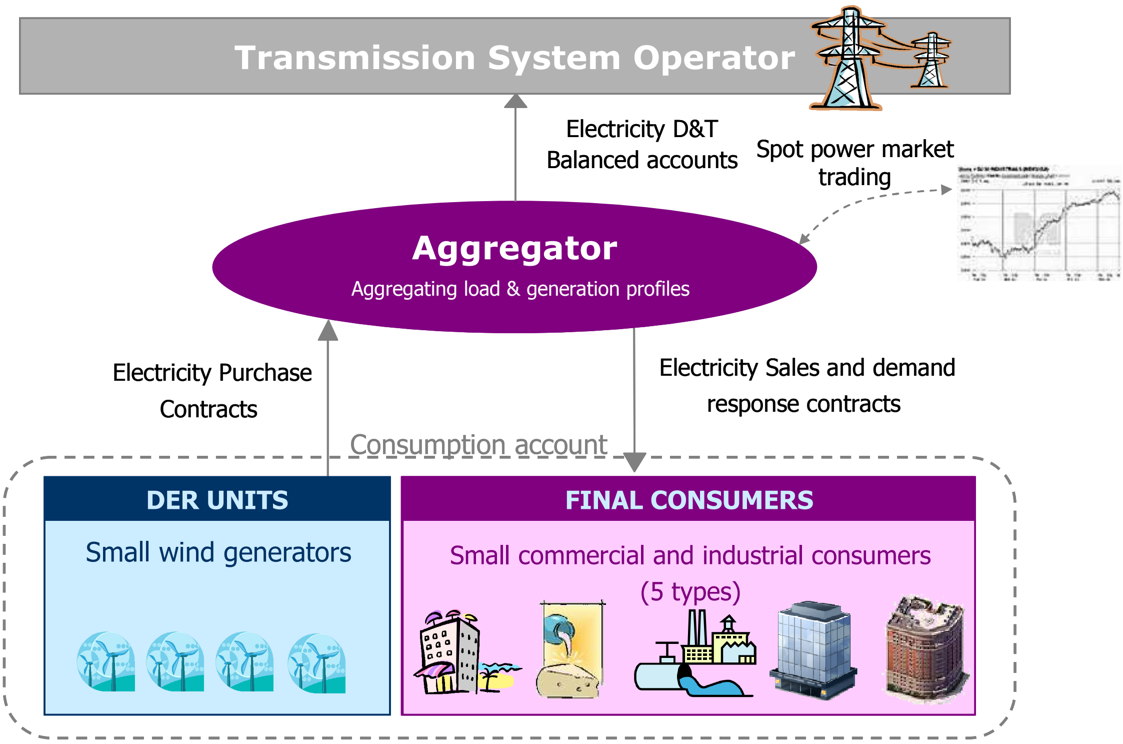


Figure 2 Simple representation of relationships between actors in EU-DEEP first business model. Consumption account refers to balance accounting, where DG and consumption is summed into one balance account and central generation into another.

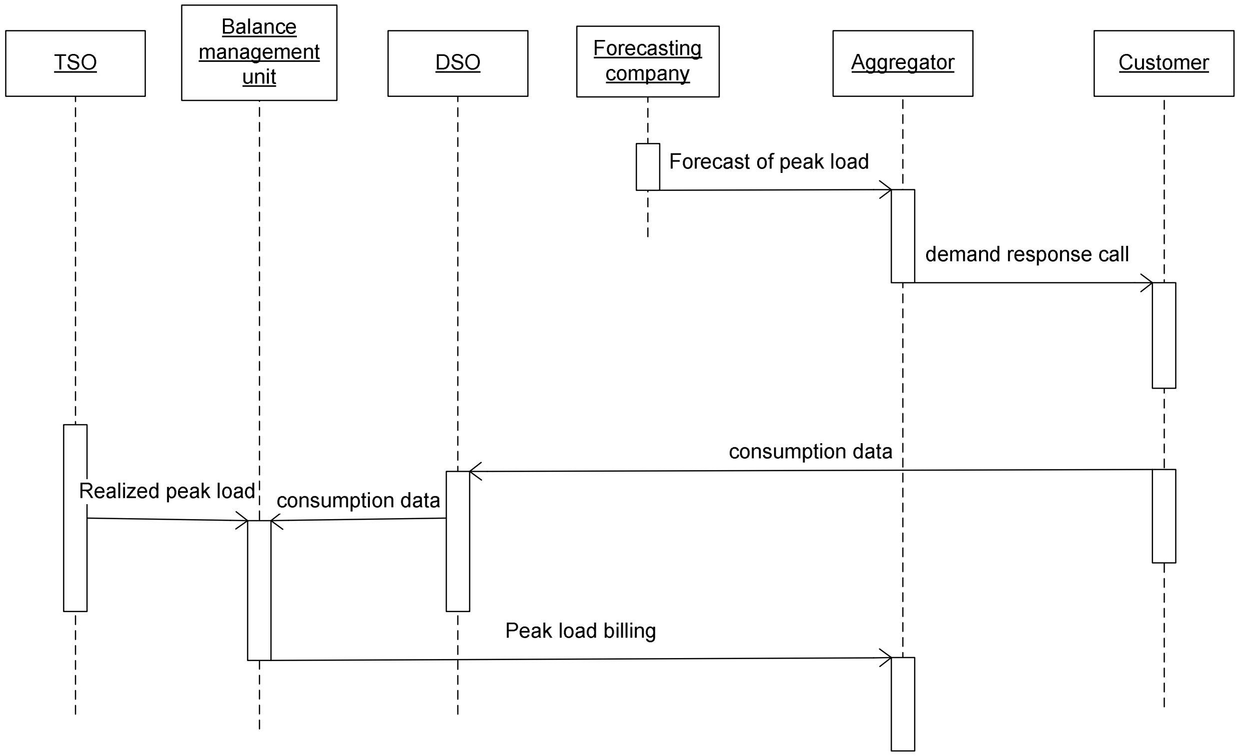


Figure 8 UML sequence diagram representation of reduction of distribution and transmission costs, in case where they depend on consumption during national peak load, by a retailer who also acts as aggregator.

Part 2: Technologies needed / Investments required

11. **Enabling technologies (non-ICT and ICT)**:DER controller, DER management system, electricity market price forecasting tools, market communication tools (e.g. to participate in power exchange)

Technology Type	***Description of functionality***	***Role by which it is used***	***Tool used***	***IPR-holders***	***Maturity level***
Scheduling software	This software produces the control signals for DER such as temperature setpoint or load disconnection request based on: - Measurement of current customer state such as temperature,	Aggregator	DEMS	Siemens	Commercial tool

	- forecasts of market prices for electricity, - forecasts of load & generation imbalance for the aggregator.				
Simulation software	This software produces experimental control signals for DER such as load reduction requests and evaluates the income generated by DER by exploiting simulations of DER response.	Aggregator	Flexprof	VTT	Experimental tool
DR response forecasting software	Simulates load behaviour based on physical models	Aggregator	Flexmod	UPV	Experimental tool
Internet to GPRS gateway	Provides the gateway from the Internet to GPRS communication.	Aggregator	External service provider	?	?
GPRS modem	Provides the communication link on the customer site	Customer			Commercial tool
Programmable logic controller	Provides run/interrupt signals to the customers appliances based on signals received by GPRS.	Customer		Siemens	Commercial tool

12. Other technologies needed

Technology name	***Description of functionality***	***Role which need it***
Market price forecasting software	Software used to forecast market prices on organized energy markets.	Aggregator

13. Related technologies available in the market or from other research projects

Technology Type	***Description of functionality***	***Role by which it is used***	***Tool used***	***IPR-holders***	***Maturity level***
Simulation	This software produces	Aggregator	Cleanpower	Tractebel	Experimental tool

software	experimental control signals for DER such as load reduction requests and evaluates the income generated by DER by exploiting simulations of DER response.	engineering

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.)**: Call signals are sent when DR is needed, but continuous communication is not required. Delay time requirement depends on the services which the aggregator offers (e.g. to TSO).
15. **Communication protocols and mediums used:** Internet, GRPS.
16. **Data format/standards: not known**

Part 3: Maturity Level operational savings, CO_2, efficiency enhancement, etc.)

17. **What is the level of commercialization**: Research project + Demonstration
18. **If it is an existing practice, what about its success?** See below

Part 4: Benefits and Obstacles

19. **Benefits to participants (economical and not; operational savings, for each actor), give quantitatively if possible:** Savings and benefits for the aggregator and consumers together 10 £ / kW of flexible load / a or more (minus costs). Depends on how much should be paid to customer for his inconvenience.
20. **Benefits to society (emissions, efficiency enhancement, etc.):** Emissions reduction, possibility to increase the amount of variable-output generation.
21. **Operational costs**: personnel, maintenance, software…
22. **Other obstacles in its implementation:** customers' fear that their operations are harmed; installations require intrusion to customer relatively low cost saving compared to the customer's electricity bill
23. **Geographical limitations**
24. **Regulation related issues**
25. **Lessons learnt:** customer should preferably have at least 50 kW of flexible power consumption.

Part 5: Bibliography

26. Where to find more information? (Web Site, Scientific Publications, etc.)

http://www.eudeep.com

BM 2 EU-DEEP Task force 2

Part 1: case description

1. **Name of the Business Case:** Integrating residential scale flexible Micro-CHP into electricity markets
2. **Location of the Business Case (nation / project that generated the BC):** EUDEEP project, Task Force 2, Germany
3. **Short description of the case and business rationale:** The business case deals with an energy retailer in electricity and gas that aggregates flexible micro-CHP units owned by residential customers. Single micro-CHP units need to be aggregated to participate in the electricity markets. Electricity retailers are candidates for this aggregation activity (acting as Virtual Power Plant operators) since they will negotiate optimal prices when selling their electricity outputs. The use of heat storages is needed to provide some flexibility in generation. The main questions asked when studying this business model are: What level of decoupling of electricity and heat production is required? What is the minimum size of a CHP unit portfolio?
4. **Actors involved (companies, organizations and so on):** This business case was implemented in one scenario

Actor	*Role*
The RWE TSO	TSO
RWE Retailer	Aggregator
Berlin DSO	DSO
GASAG	Gas Supplier
EEX	Market
Customers	DER Owner

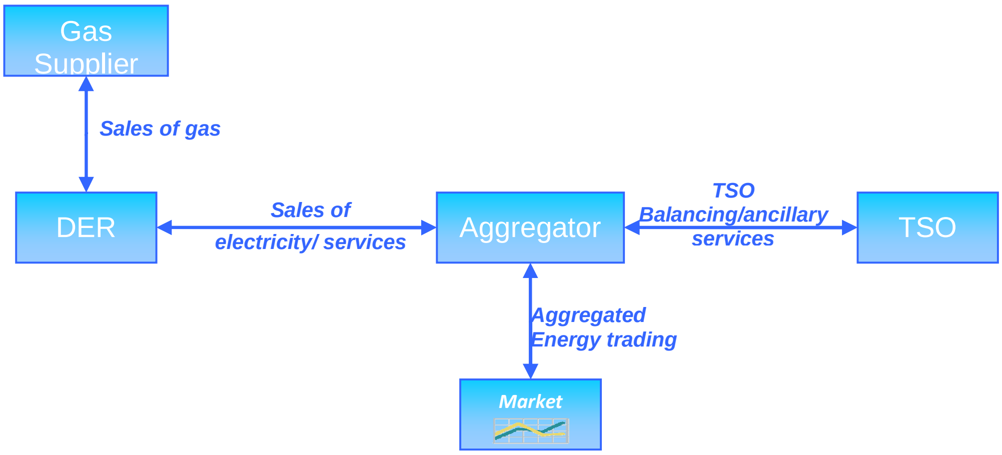
5. **Their (logical) Roles in the Business Case:** Micro-CHP owners produce heat and electricity for their own use, but they also trade part of that electricity and provide balancing services to the TSO. The aggregator enables the participation of such small-scale units in wholesale markets and supplies CHP owners with energy.

Role	***Description***
DER Owner	The DER owners of **flexible supply** (high efficiency generation CHP units) connected to a distribution network, trade part of the electricity generated to the TSO.
Aggregator	The **Aggregator** is a competitive market actor that aggregates a DER portfolio not necessarily constrained by location and acts to generate the most favourable commercial value from the CVPP portfolio in the

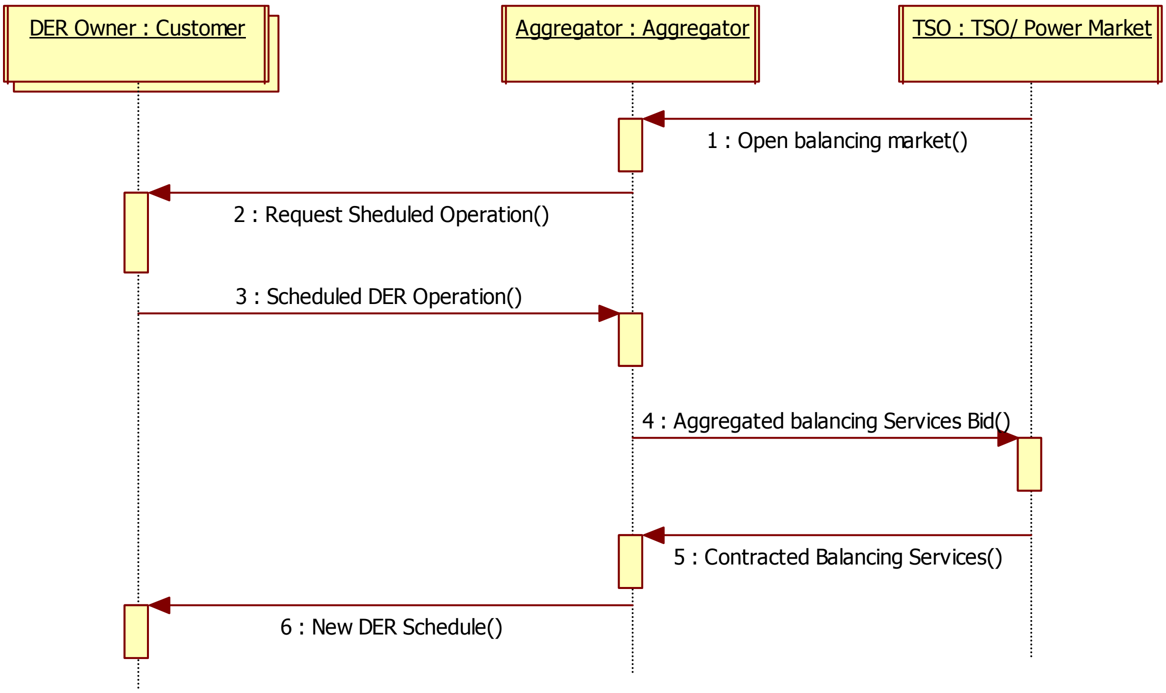
	wholesale and balancing electricity markets. This approach allows the DER owners to experience economies of scale in market participation. The Aggregator also supplies energy to the DER owners.
Gas Supplier	The **Gas Supplier** acts as a gas retailer by selling gas to the DER owners, so that they can generate heat for their own consumption and electricity either for their own consumption or for participating in the electricity market. The **Gas Supplier** could be at the same time the retailer of electricity
TSO	The Transmission System Operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators. It can act as single buyer of electricity and of balancing and additional ancillary services offered by DER.
DSO	The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers. In this Business Model the DSO it only performs the role of transporting the energy generated by DER owners.
Electricity Markets	There are different market in which the DER can be involved through the aggregator: • the wholesale market for energy commodities. This may comprise: o forward markets (based on custom-made bilateral trades); o OTC (over-the-counter) standardised bilateral trades, typically enabled by electronic bulletin boards; o day-ahead power exchanges (with a central counterparty); o intra-day adjustment power exchanges; o intra-day bilateral adjustment trades; • ancillary markets for the provision of flexibility and controllability services to system operators who are in charge of system security and system quality assurance; • real-time balancing market, that is a one-sided uniform-price market with the TSO as central counter-party who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power;

6. **Product / Services and related Transactions and contracts:** Micro-CHP owners provide electricity and flexibility to the aggregator, who trades them in the power market or with the TSO, respectively. On the other hand, the aggregator supplies micro-CHP owners with gas and with electricity when micro-CHP production is not enough to cover their demand.

Product/Service	***Definition***
Energy/ancillary services sales	The DER offers power and ancillary services, such as balancing services to the Market, through the Aggregator
DER Capacity Aggregation	The Aggregator aggregates capacity from DER units
Aggregated electricity trading	The Aggregator trades the electricity in the market and arranges the provision of ancillary services.



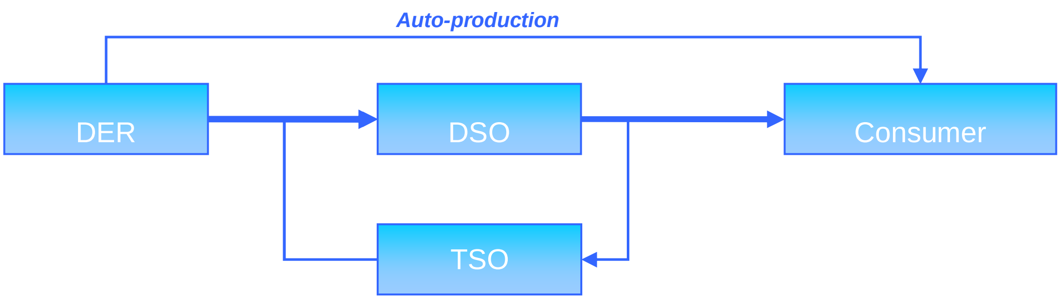
7. **Information exchanged between the actors**: The aggregator receives the opening of the balancing market and requests the schedule of operation of DER. It aggregates the available resources and contracts the balancing services with the TSO. Finally a new schedule is sent to each of the DER owners.



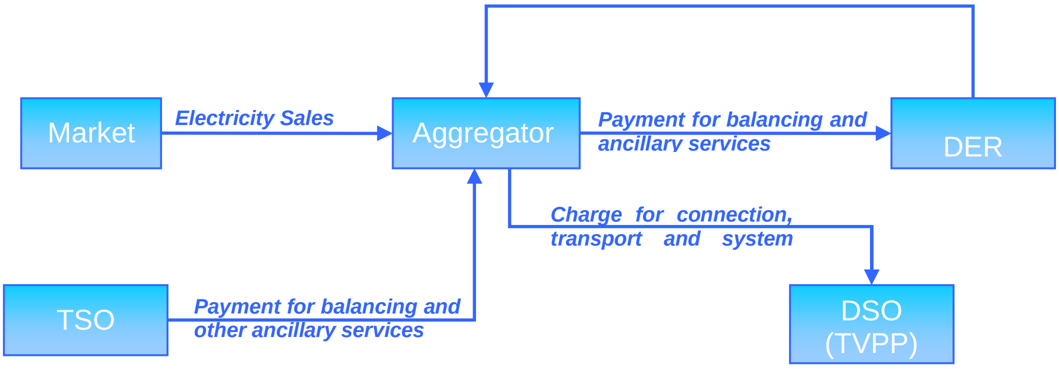
8. **Energy flows between the actors**: The electricity produced by DER units is directly delivered to the distribution network. Most of this electricity is, then, distributed to the consumers by the DSOs. If the supply exceeds demand, the surplus of electricity is delivered to the transport grid and the TSO transports it to another distribution network.

   A last significant part of this electricity goes in direct consumption: it is the auto-production of electricity made on-site by a consumer using DER units.

   All the heat produced is consumed by the DER owner or stored for a later consumption.



9. **Economic flows between the actors**: Micro-CHP unit owners pay a fee to the aggregator for managing their units and benefit from participating in day-ahead market prices, reduction of imbalance charges and provision of balancing services to the TSO, all of which are traded through the aggregator.



10. **Mapping role towards ETSO/ebIX harmonized role model**

Role	***Corresponding ebIX roles***	***ebIX definition***	***Notes***
DER	Producer	A party that produces electricity	
Aggregator	Balance Services Supplier	A party that participates in the balancing market by aggregating the energy capacity provided by several individual DER owners**.**	*The aggregators aggregates many DER units and participates (in their place) in the market, in the TSO-organized balancing market (where it exists) and plays the part of DER systems in arranging the provision of certain ancillary services.*
DSO	Grid operator	A party that operates one or more grids.	
TSO	System operator	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The TSO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	

Part 2: Technologies needed / Investments required

11. **Enabling technologies (non-ICT and ICT)**:DER controller, DER management system, electricity market price forecasting tools

Technology Type	*Description of functionality*	*Role by which it is used*	*Tools used in Fenix*	*IPR-holders*	*Maturity level*
DER CONTROLLER	It is both software and hardware. It: - It allows the DER to send a power request signal. - It collects several measurements: - water flow in the theat - outlet and inlet water - upper and lower heat storage temperature - electrical output of the µCHP - electrical power at PCC of the - calculates the site demand and the thermal power generated and demanded - passes external power request commands to the Honeywell controller - clock synchronization (with DEMS Control Center PC) - initialising and triggering the GPRS communication and current demand	DER	Inverter based equipment, stimulating real units measurements and accepting commands	Honeywell	Commercial tool
Aggregation server	Implements schedule and energy optimisation functions for DER units, so enabling the access of DER units to the market.	Aggregator	DEMS from SIEMENS	SIEMENS	Commercial tool

	- In details it is a **DEMS** (Decentralized Energy Management System) configured		Based on Siemens DEMS, it is a server that receives orders from selected customers with software to transmit electronic orders from selected Customers via the Internet using FTP. Some enhancement added to the commercial version were: aggregation/disaggregation, communication protocols, etc	Siemens	Demonstrating tool based on commercial one
			OPF is a Module of the Siemens DMS (***Spectrum***), extended to include DER reactive power output as variable for Voltage Var Control	Siemens	Demonstrating tool based on commercial one
Real time link	Provide a simple huge access to all the DER. The technology used in Task Force 2 of EU=DEEP demonstration is GPRS.	Aggregator	GSM!GPRS Modem MD730=3		Commercial

12. **Other technologies needed**

Technology name	***Description of functionality***	***Role which need it***
Market price forecasting software	Software used to forecast market prices in energy markets.	Aggregator
Smart meter	A fast implementation of smart meters will enable not only trading operations but also near real-time remote control by network operators and commercial third party, thus stimulating introduction of smart tariffs. This will lead to the adoption of smart output-based incentives and so, in an indirect way, promotion of efficient DER integration.	DSO

13. **Related technologies available in the market or from other research projects**

Technology name	***Description of functionality***	***Role by which it can be used***	***IPR-holders***	***Maturity level***
	It is an agent based Distributed Energy Management System	Aggregator	ANCO, S.A.	Demonstration tool
	Protective relay extended to give the output of the small scale generation and	DER	ZIV	Demonstration tool, based of an

	to send control signals to the DER			extension of a commercial one.
Power Matcher	It is a distributed energy system architecture and communication protocol. Takes offers and bids from remote “agents”.	CVPP	ECN	On the market

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.)**: Operation signals are sent every time optimal operation is calculated (day-ahead, intraday in case it is needed), but continuous communication is not required. Confidentiality must be ensured.
15. **Communication protocols and mediums used**: GSM/GPRS model has been used.
16. **Data format/standards**: The communications between the actors have to based on agreed formats.

Part 3: Benefits and Obstacles

17. Benefits to participants (economical and not; operational savings, for each actor)

    The DER owner benefits because it can participate in the market for offering energy in different markets and in this specific test in the Balancing market. This participation results in an economic benefit for him.

    The aggregators can take advantage of this services by participating in the balancing and other markets, using the flexibility of DER for balancing his own deviations an finally to get a higher economic benefit.
18. Benefits to society (emissions, efficiency enhancement, etc.)

    The society benefits because less expensive and less pollutant plants are used for balancing the deviations.
19. Operational costs

    The software and hardware tools previously described are necessary for the implementation of the business case.
20. Other obstacles in its implementation

    Appropriate commercial and regulatory framework.

    Standardized information and communication between VPP and relevant actors.
21. Geographical limitations
22. Regulation related issues

    Possible benefits from subsidies, minimum sizes for participating in market, etc.
23. Lessons learnt (if any)

Part 5: Bibliography

24. Where to find more information? (Web Site, Scientific Publications, etc.)

The reference Web site of the project (http://www.eu-deep.com)

BM 3 EU-DEEP task force 3

Part 1: case description

1. **Name of the Business Case:** Leveraging on the flexibility of aggregated CHP units and demand response to extend the conventional Energy Service Company business.
2. **Location of the Business Case (nation / project that generated the BC):** EUDEEP project, Task Force 3, Greece.
3. **Short description of the case and business rationale:** The business case deals with an Energy Service Company (ESCo) owning CHP units and proposing demand response contracts to its commercial customers. Installing small units at the customers' sites often allows the reduction of power losses and, possibly, higher energy efficiency. Owners of high-energy efficiency installations can apply for energy efficiency certificates, or benefit from feed-in tariffs or premium systems. The business idea is an extension of an existing CHP business model, by adding more flexibility through demand response and heat storage. In other words, the ESCo business is profitable today, down to a certain level of heat demand. Aggregating flexible loads and CHP units leads to additional sources of revenues (selling services to the TSO, avoiding balancing penalties, etc.) and therefore allow the profitability threshold to be reduced. In this case, flexibility is provided both by demand and CHP. Flexibility on CHP units is implemented through boilers and heat storage tanks installed by the ESCo at each customer site.
4. **Actors involved (companies, organizations and so on):** Customers, aggregator, TSO, power market, large gas supplier

Actor	*Role*
PPC TSO	TSO
PPC Retailer	Aggregator
PPC DSO	DSO
DEPA	Gas Supplier
Greece Market	Market
Customers	DER Owner

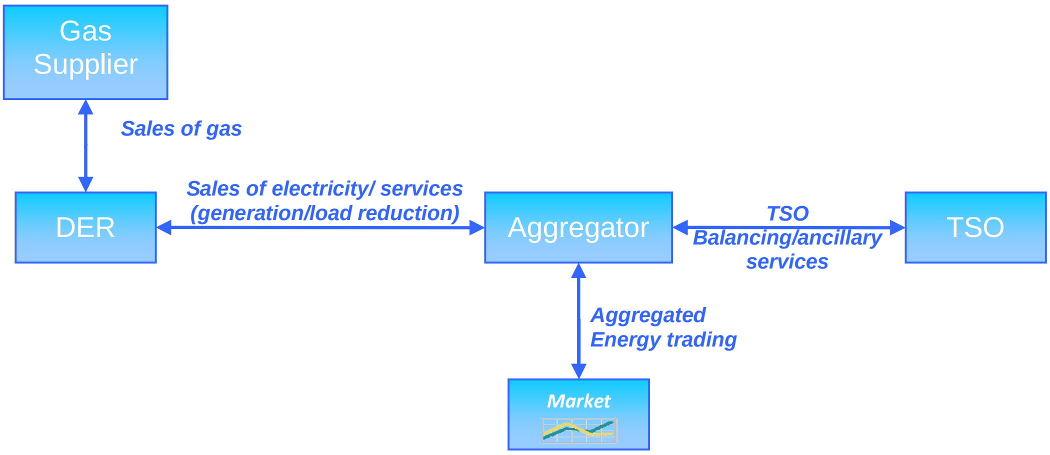
5. **Their (logical) Roles in the Business Case:** The aggregator use CHP units to produce heat and electricity for the customers, but he also trades part of that electricity and provide balancing services to the TSO. The aggregator enables a reduction in the energy bill for customers.

Role	***Description***
DER Owner	The DER owners of **flexible supply** (high efficiency generation CHP units and flexible load) connected to a distribution network, trade part of the

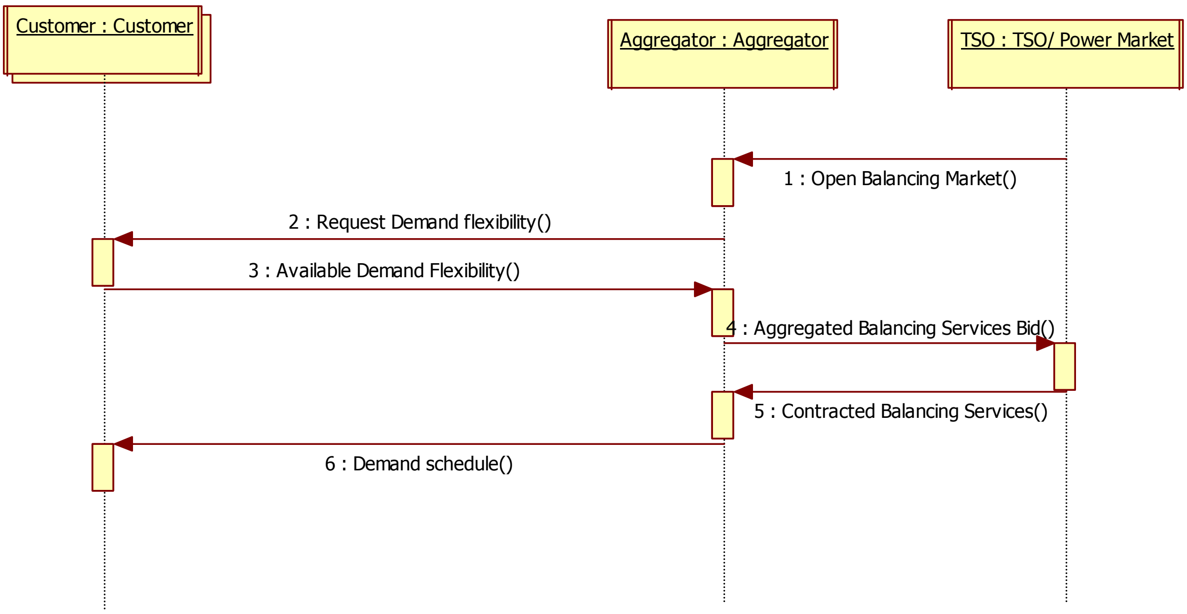
	electricity generated to the TSO. In this case the DER owner does not own the CHP, which belongs to the Aggregator.
Aggregator	The **Aggregator** is a competitive market actor that aggregates a DER portfolio (generation and load) not necessarily constrained by location and acts to generate the most favourable commercial value from the CVPP portfolio in the wholesale and balancing electricity markets. This approach allows the DER owners to experience economies of scale in market participation. The Aggregator also supplies energy to the DER owners.
Gas Supplier	The **Gas Supplier** acts as a gas retailer by selling gas to the DER owners (ESCo), so that they can generate heat and electricity for selling to consumers and for participating in the electricity market. The **Gas Supplier** could be at the same time the retailer of electricity
TSO	The Transmission System Operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators. It can act as single buyer of electricity and of balancing and additional ancillary services offered by DER.
DSO	The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers. In this Business Model the DSO it only performs the role of transporting the energy generated by DER owners.
Electricity Markets	There are different market in which the DER can be involved through the aggregator: • the wholesale market for energy commodities. This may comprise: o forward markets (based on custom-made bilateral trades); o OTC (over-the-counter) standardised bilateral trades, typically enabled by electronic bulletin boards; o day-ahead power exchanges (with a central counterparty); o intra-day adjustment power exchanges; o intra-day bilateral adjustment trades; • ancillary markets for the provision of flexibility and controllability services to system operators who are in charge of system security and system quality assurance; • real-time balancing market, that is a one-sided uniform-price market with the TSO as central counter-party who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power;

6. **Product / Services and related Transactions:** The aggregator supplies customers with heat and electricity either from CHP production or by buying electricity in the market. The use of heat storage tanks allows a flexible operation of CHP units, so that the aggregator can trade such flexibility in the market.

Product/Service	***Definition***
Energy/ancillary services sales	The DER (generation and load) offers power and ancillary services, such as balancing services to the Market, through the Aggregator
DER Capacity Aggregation	The Aggregator aggregates capacity from DER units
Aggregated electricity trading	The Aggregator trades the electricity in the market and arranges the provision of ancillary services.



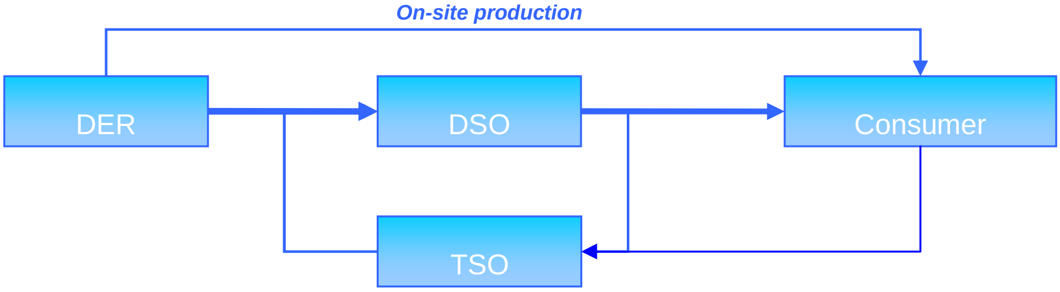
7. **Information exchanged between the actors**: The aggregator monitors the level of the heat storage, in case some changes are required in the CHP unit operation.



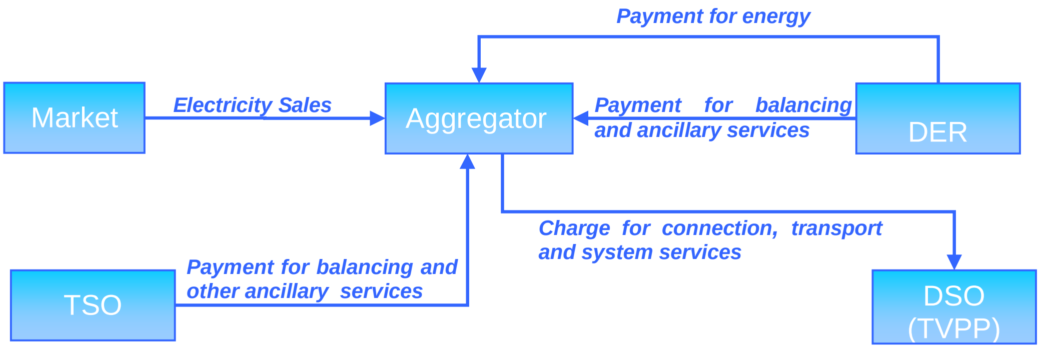
8. **Energy flows between the actors**: The electricity produced by DER units is directly delivered to the distribution network. Most of this electricity is, then, distributed to the consumers by the DSOs. If the supply exceeds demand, the surplus of electricity is delivered to the transport grid and the TSO transports it to another distribution network.

   A last significant part of this electricity goes in direct consumption: it is the electricity produced on-site by the ESCo for supplying consumers.

   All the heat produced is consumed by on-site consumers or stored for a later consumption.



9. **Economic flows between the actors**: Customers pay for electricity and heat to the aggregator. The aggregator trades electricity in the market to benefit from participating in day-ahead market prices, reduction of imbalance charges and provision of balancing services to the TSO.



10. **Mapping role towards ETSO/ebIX harmonized role model**

Role	***Corresponding ebIX roles***	***ebIX definition***	***Notes***
DER	Producer/Consumer	A party that produces and consumes electricity	
Aggregator	Balance Services Supplier	A party that participates in the balancing market by aggregating the energy capacity provided by several Customers**. This capacity is composed of generation and consumption**	*The aggregators aggregates many DER units and participates (in their place) in the market, in the TSO-organized balancing market (where it exists) and plays the part of DER systems in arranging the provision of certain ancillary services.*
DSO	Grid operator	A party that operates one or more grids.	
TSO	System operator	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The TSO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	

Part 2: Technologies needed / Investments required

11. **Enabling technologies (non-ICT and ICT)**:DER controller, Load Controller, BEMS, DER management system, electricity market price forecasting tools

Technology Type	***Description of functionality***	***Role by which it is***	***Tools used in Fenix***	***IPR-holders***	***Maturity level***

		used			
DER CONTROLLER	It is both software and hardware. It obtains: - Measurement of current (RMS), Voltage(RMS) and Frequency. - Communication via LAN. The controllers are scheduled to be connected via a Hub to a PC. The PC will be connected to the internet. - The controllers have the ability to control two (2) switches via PLC (power line communication).	DER	Inverter based equipment, stimulating real units measurements and accepting commands	ANCO,S.A.	Demonstration tool
Load Controller	It has the same functionality as the DER controller	DER		ANCO,S.A.	Demonstration tool
Aggregation server	Implements schedule and energy optimisation functions for DER units, so enabling the access of DER units to the market. - In details it is an agent based Decentralized Energy Management System)	Aggregator	Multi-Agent system	ANCO,S.A.	Demonstration tool

12. Other technologies needed

Technology name	***Description of functionality***	***Role which need it***
Market price forecasting software	Software used to forecast market prices in energy markets.	Aggregator
Smart meter	A fast implementation of smart meters will enable not only trading operations but also near real-time remote control by network operators and commercial third party, thus stimulating introduction of smart tariffs. This will lead to the adoption of smart output-based incentives and so, in an indirect way, promotion of efficient DER integration.	DSO

13. **Related technologies available in the market or from other research projects**

Technology name	***Description of functionality***	***Role by which it can be used***	***IPR-holders***	***Maturity level***
DEMS	It is Distributed Energy Management System	Aggregator	Siemens	Commercial tool
	Protective relay extended to give the output of the small scale generation and to send control signals to the DER	DER	ZIV	Demonstration tool, based of an extension of a commercial one.
Power Matcher	It is a distributed energy system architecture and communication protocol. Takes offers and bids from remote “agents”.	CVPP	ECN	On the market

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.)**: Operation signals are sent every time optimal operation is calculated (day-ahead, intraday in case it is needed), but continuous communication is not required. Confidentiality must be ensured.
15. **Communication protocols and mediums used**: FIPA protocol and Multi-Agent Systems mediation.
16. **Data format/standards**: The communications between the actors have to based on agreed formats.

Part 3: Benefits and Obstacles

17. **Benefits to participants (economical and not; operational savings, for each actor):**

    The DER owner benefits because it can participate in the market for offering energy (generation, consumption reduction or both) in different markets and in this specific test in the Balancing market. This participation results in an economic benefit for him. Customers can have a reduction of 2-6% in their energy bill.

    The aggregators can take advantage of this services by participating in the balancing and other markers, using the flexibility of DER for balancing his own deviations an finally to get a higher economic benefit.

    The aggregator’s benefits can be increased by 1.5-2 percentage points, while reducing imbalance exposure risk.

18. **Benefits to society (emissions, efficiency enhancement, etc.)**:

    The society benefits because less expensive and less pollutant plants are used for balancing the deviations.

19. **Operational costs**:

    They are increased by the need to have a heat storage tank, ICT needs and because CHP’s O&M costs are higher than those of boilers.

20. **Other obstacles in its implementation**

    Appropriate commercial and regulatory framework.

    Standardized information and communication between VPP and relevant actors.

21. **Geographical limitations**: Quite high heat demands are required.
22. **Regulation related issues**: Flexible support schemes (such as bonuses or green certificates) are more appropriate for the business than feed-in tariffs.
23. **Lessons learnt**

Part 5: Bibliography

24. **Where to find more information?**

The reference Web site of the project (http://www.eu-deep.com/)

Business model 4a: Fenix business case 1

Part 1: case description

1. **Name of the Business Case:** Access to the Market through commercial aggregator, in ***absence*** of strong pressure to integrate DER.
2. **Location of the Business Case (nation / project that generated the BC):** FENIX Project
3. **Short description of the case and business rationale:** A *Commercial Virtual Power Plant* is a competitive market actor that aggregates DER units (not necessarily constrained by location) from the point of view of the access to the Market. This kind of aggregator helps the DER to access to the market with the optimal returns prospective and market visibility. It carries out the economical transactions between the market and the DER and so it looks to the market like an imaginary single physical plant.

   The DER units, through this kind of aggregation, are enabled to participate not only in the wholesale market but also in the TSO-organised balancing market and in the guarantees of origin (GO) market,

   Note that, in this business model, the CVPP does not absorb the balancing risks but shifts them to his clients. Moreover it does not operate remote control of its clients generating facilities.

   So, in this scenario, there will be only a financial aggregation of DER units without an operational integration.

   In order to develop the FENIX Project business models, two policy scenarios were fixed.

   This business case is set in a ***baseline policy scenario***. It is a possible future policy scenario that assumes the absence of strong societal pressures to really integrate DER into the electrical grid. Under this conditions, the current "fit and forget" practices will endure in the European operational network management. So distributed generation will penetrate fast, but it will not change the passive network operating philosophy.

4. Actors involved (companies, organizations and so on) :

5. Their (logical) Roles in the Business Case:

Role	***Description***
DER Producer	The DER producers are owners of **flexible supply** (high efficiency generation units as CHP, Combined Heat and Power, or CHCP, Combined Heat, Cool and Power or renewable energies units, as PV or Wind Farm) or **demand entities** or **energy storage facilities** connected to a distribution network.
CVPP	the **Commercial VPP** (CVPP) is a competitive market actor that aggregates a DER portfolio not necessarily constrained by location and acts to generate the most favourable commercial value from the CVPP portfolio in the wholesale electricity markets. This approach reduces imbalance risk associated with lone operation in the market and provides the benefits of variety of resources and increased capacity achieved through aggregation. Moreover it allows the DER to experience economies of scale in market participation.
TSO	The Transmission System Operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators. It

	can act as single buyer of electricity and of balancing and additional ancillary services offered by DER.
DSO	The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers.
Electricity Markets	There are different market in which the DER can be involved by the VPP: • the wholesale market for energy commodities. This may comprise: o forward markets (based on custom-made bilateral trades); o OTC (over-the-counter) standardised bilateral trades, typically enabled by electronic bulletin boards; o day-ahead power exchanges (with a central counterparty); o intra-day adjustment power exchanges; o intra-day bilateral adjustment trades; • real-time balancing market, that is a one-sided uniform-price market with the TSO as central counter-party who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power; • Guarantees of Origin (GO) market: The main function of GOs is to attest the renewable origin of electricity produced. The electrical companies have to achieve target about the percentage of renewable energy supplied. Companies can trade guarantee of origin (GO) for target-accounting purposes.

- The DSO covers the role of **grid operator**.
- The electricity market receives the bids from the CVPP. So, its role is: **market operator**.

6. Product / Services and related Transaction and Contracts:

Product/Service	***Definition***
Energy services sales	The DER offers power to the Market, through the CVPP.
DER Capacity Aggregation	The CVPP aggregates capacity from DER units
Aggregated electricity trading	The CVPP trades the electricity in the market and arranges the provision of ancillary services.

Note about contracts: In order to guarantee concrete applications of this business case the commercial relationships between the actors have to be sustained by a robust set of contracts. Being this business case innovative, the development of new contract models will be required.

In particular the contractual relationship between the DER and the CVPP must define the details about:

- billing and payment;
- metering of the power flow from and to the DER;
- protocols that have to be used for the communication between them;
- real time dispatching of the DER by means of CVPP;
- bid submission from DER to CVPP.

At the same manner it is necessary to define, in the contract between the CVPP and the market, the agreements about:

- billing and payment;
- metering of the output of the CVPP;
- bid submission from CVPP to the market;
- real time dispatching of the CVPP by means of the central system.

Nevertheless the contracts have to specify who must pay the penalties in cases of failure to deliver the contracted services.

Figura 1. Contractual relationships

7. **Information exchanged between the actors:**

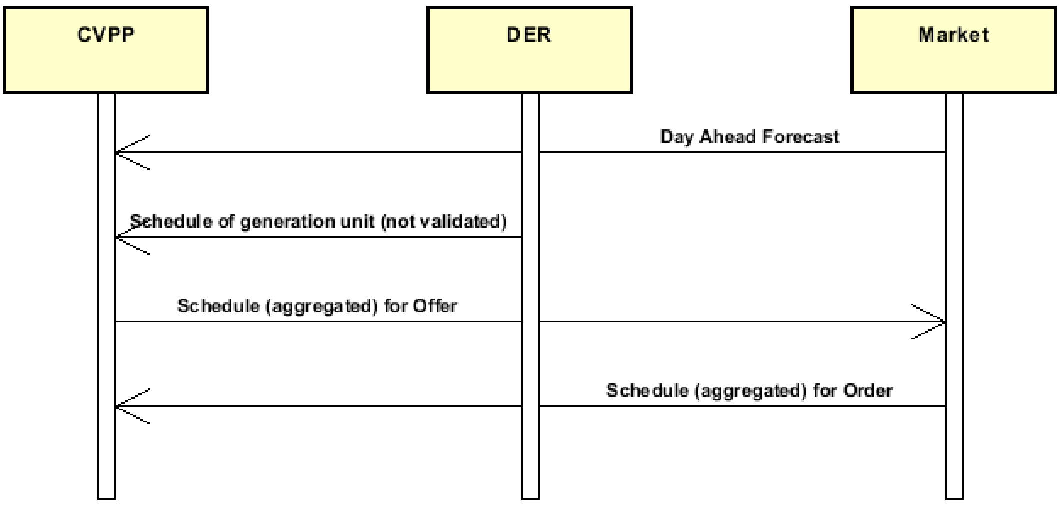


Figure 10. UML representation of flows between actors

The CVPP receives all the Day Ahead Forecast. Then it executes the optimization algorithms to define the energy blocks available for the day ahead and sends the supply/demands bids to the day ahead market and the offers for Balancing Mechanism. Then the CVPP notifies the DSO with DER generation schedules.

8. **Energy flows between the actors:** The electricity produced by DER units is directly delivered to the distribution network. Most of this electricity is then distributed to the consumers by the DSOs. If the supply exceeds demand, the surplus of electricity is delivered to the transport grid and the TSO transports it to other distribution network.

   A last significant part of this electricity goes in direct consumption. It is the auto-production of electricity made on-site by a consumer using DER units.

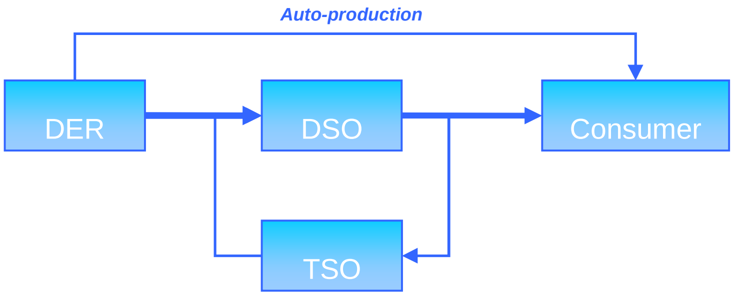


Figure 3. Energy flows between the actors

9. **Economic flows between the actors:** The CVPP receives the payment for electricity from the wholesale market, for balancing reserves and other ancillary service from the TSO and the payments for guarantees of origins sales from the GO market.

   DER operators receive the payments from the CVPP and pay it for intermediate. The DER operators pay also the DSO and the TSO for network service received.

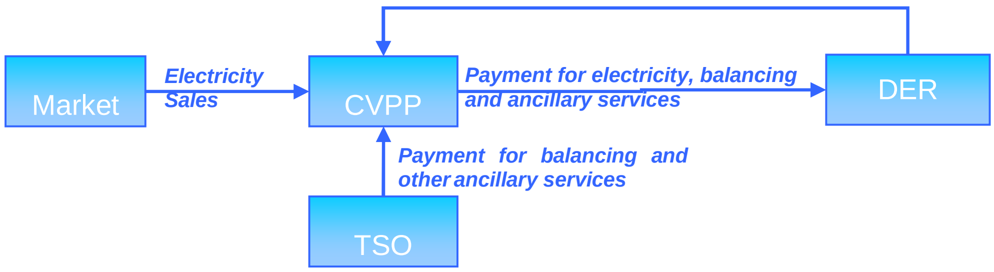


Figure 4. Economic flows between the actors

10. Mapping role towards *ETSO/ebIX harmonized role model*

Role	*Corresponding ebIX roles*	*ebIX definition*	*Notes*
DER	Producer	A party that produces electricity	

	Imbalance settlement responsible	A party that is responsible for settlement of the difference between the contracted quantities and the realised quantities of energy products for the balance responsible parties in a market balance area.	*The CVPP, in this business case, could shift on the DER the balance responsible: in this case it would cover also the role of imbalance settlement responsible*
Aggregator (CVPP)	Balance responsible party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. **This is the only role allowing a party to buy or sell energy on a wholesale level.**	*So the CVPP aggregates many DER units and participates (in their place) in the market. The CVPP also, participates in the TSO-organized balancing market, where it exists* *(NOTE: the offers of energy supplier in the balancing market will consist of demand response by they consumers).* *CVPP covers, the role of balance responsible party.*
DSO	Grid operator	A party that operates one or more grids.	
TSO	System operator	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The SO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	

Part 2: Technologies needed / Investments required

11. **Enabling technologies (non-ICT and ICT):** The following applications were developed in the FENIX project to enable the operations of such a decentralised electricity supply system:
    - **Fenix Box server**: it is an application that aggregates loads and generation and ensures their optimal use.
    - **CVPP server**: it implements schedule and energy optimisation functions for DER units.

    Details about these technologies are at the end of the second FENIC Business case
12. **Hardware needed for business case implementation (e.g. Smart Meter, Gateway, etc.):**

Technology name	*Description of functionality*	*Role which need it*
Reinforcing of Distribution Network	In this "fit and forget" scenario the distribution network will have to be reinforced to get a robust planning of network expansion. So obsolete components will be replaced by controllable components and more network monitoring sensors will be required.	DSO

13. **Related technologies available in the market or from other research projects**

    Details about these technologies are at the end of the second FENIC Business case

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.):** The design of the information exchanges between the actors is based on exchanging single values (real-time) and schedules (day ahead).

    The interactions concerning exchange of price and bid information requires schedules, while balancing market operation requires real time communications.

    Confidentiality and reliability must be ensured.

15. **Communication protocols and mediums used:** Each DER can communicate its situation to the Aggregator through a web page and the CVPP will aggregate all bids into a single one and places it in the Market.

    ICCP (Inter-Control Center Communications Protocol) is the protocol proposed, in FENIX, for real times communications between CVPP and DSO. Web Services can supply the infrastructure for exchanging of schedules.

16. **Data format/standards:** The communications between the actors have to based on agreed formats.

Part 3: Benefits and Obstacles

17. **Benefits to participants (economical and not; operational savings, for each actor):** This Business Model:
    - enables small DER units to access to the energy market, maximizing their revenues and minimizing the needed investments in trading ICT and market entree;
    - optimizes the utilization rate of DER units according to real time electricity demand and electricity market price signal;

18. **Benefits to society (emissions, efficiency enhancement, etc.):** The main benefit for the society of this business model is a partial stimulus in integration of renewable energy in the grid.

19. **Operational costs:** TSO and DSO incur expenditures for non-power materials inputs (including payment to network equipment vendors, outsourced maintenance and ICT providers).

20. **Other obstacles in its implementation:** Obstacle in implementation of the business model is the lacking of:
    - an appropriate commercial and regulatory framework;
    - standardized information and communication between VPP and relevant actors.

Part 5: Bibliography

21. **Where to find more information? (Web Site, Scientific Publications, etc.):** The reference site is http://www.fenix-project.org/ , where are also available many publications about FENIX.

Business model 4b: Fenix Business case 2

Part 1: case description

1. **Name of the Business Case:** Access to the Market through commercial aggregator, in ***presence*** of strong pressure to integrate DER.
2. **Location of the Business Case (nation / project that generated the business case):** FENIX Project (test in Spain and UK)
3. **Short description of the case and business rationale:** A *Commercial Virtual Power Plant* (CVPP) operates the commercial aggregation, while a *Technical Virtual Power Plant* (TVPP) operates the physical aggregation of the DER within a single geographical area.
   The CVPP composes a portfolio of DER units, not necessarily constrained by location, while a TVPP represents the network region at the point of connection with a transmission operator (TSO). It uses operating and cost parameters received from CVPPs and local network knowledge to manage the local DER systems.

   Within the FENIX project the TVPP role is implemented by the same actor, which plays the DSO role (typically a big DSO enterprise).

   In order to develop the FENIX Project business models, two policy scenarios were fixed.

   This business case is set in an ***advanced policy scenario*** (called FENIX scenario). It is a possible future scenario that assumes the presence of strong societal pressures to really integrate DER into the electrical grid. This stimulus will enable not only trading operations but also real time remote control of the meter interface at the doorstep of customers (with explicit customer approval and absence of privacy violations) by network operators and commercial third parties.

4. **Actors involved (companies, organizations and so on) :**

   The business case was implemented through two demo scenarios: Northern scenario and Southern scenario.

   Northern scenario (that aim to demonstrate the value of **market** participation in CVPP):

Actor	*Role*
The UK TSO	TSO
EDF Energy	CVPP
EDF Energy Network	TVPP, DSO
Working Borough Council	DER Owner

Southern scenario (that aim to demonstrate the opportunities for distributed generation to deliver ancillary service to TSO and DSO):

Actor	*Role*
Iberdrola	DSO (TVPP)

Red Electrica	TSO
OMEL	Market
Several private companies out of consortium	DER units

5. Their (logical) Roles in the Business Case:

Role	*Description*
DER Producer	The DER producers are owners of **flexible supply** (high efficiency generation units as CHP, Combined Heat and Power, or CHCP, Combined Heat, Cool and Power or renewable energies units, as PV or Wind Farm) or **demand entities** or **energy storage facilities** connected to a distribution network.
CVPP	the **Commercial VPP** (CVPP) is a competitive market actor that aggregates a DER portfolio not necessarily constrained by location and acts to generate the most favourable commercial value from the CVPP portfolio in the wholesale electricity markets. This approach reduces imbalance risk associated with lone operation in the market and provides the benefits of variety of resources and increased capacity achieved through aggregation. Moreover it allows the DER to experience economies of scale in market participation.
TVPP	the **Technical VPP** (TVPP) represents the network region at the point of connection with transmission. It includes every DER in a distribution network region. The TVPP uses DER operating and cost parameters (received form CVPPS) and local network knowledge to manage the local system. Because of these requirements, TVPP is **monopoly role of DSO**. Note that DER can be part, at the same time, of both a CVPP and a TVPP.
TSO	The Transmission System Operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators. It can act as single buyer of electricity and of balancing and additional ancillary services offered by DER.
DSO	The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers. In this Business Model the DSOs use TVPP to remotely control DER units to integrate them in active management of their own distribution network and to provide DER aggregated profiles to the TSO.

<table>
<tr><td>Electricity Markets</td><td>There are different market in which the DER can be involved by the VPP:

the wholesale market for energy commodities. This may comprise:

forward markets (based on custom-made bilateral trades);
OTC (over-the-counter) standardised bilateral trades, typically enabled by electronic bulletin boards;
day-ahead power exchanges (with a central counterparty);
intra-day adjustment power exchanges;
intra-day bilateral adjustment trades;

ancillary markets for the provision of flexibility and controllability services to system operators who are in charge of system security and system quality assurance;
real-time balancing market, that is a one-sided uniform-price market with the TSO as central counter-party who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power;
Guarantees of Origin (GO) market: The main function of GOs is to attest the renewable origin of electricity produced. The electrical companies have to achieve target about the percentage of renewable energy supplied. Companies can trade guarantee of origin (GO) for target-accounting purposes.
</td></tr>
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6. Product / Services and related Transactions and Contracts:

Product/Service	***Definition***
Energy/ancillary services sales	The DER offers power and ancillary services, such as reserve, frequency response, reactive power, black start to the Market, through the CVPP..
DER Capacity Aggregation	The CVPP aggregates capacity from DER units
Aggregated electricity trading	The CVPP trades the electricity in the market and arranges the provision of ancillary services.
Validation of the schedules	The TVPP represents the single DERs at the point of connection with transmission and validates their schedules, according to network constraints.

Note about contracts: The relationship between CVPP and TVPP is central and a contract for this purpose will be needed. In it will be defined the details about: the communication of requirements and availabilities of delivery (both in advance and in real time) using a mutually agreed electronic system, the process for transferring supply of DER, payment to TVPP for use of system and so on.

Another area where this business case can create value is in allowing DER to offer ancillary services to the TSO. This offer has to be regulated by a contract between CVPP and TSO.

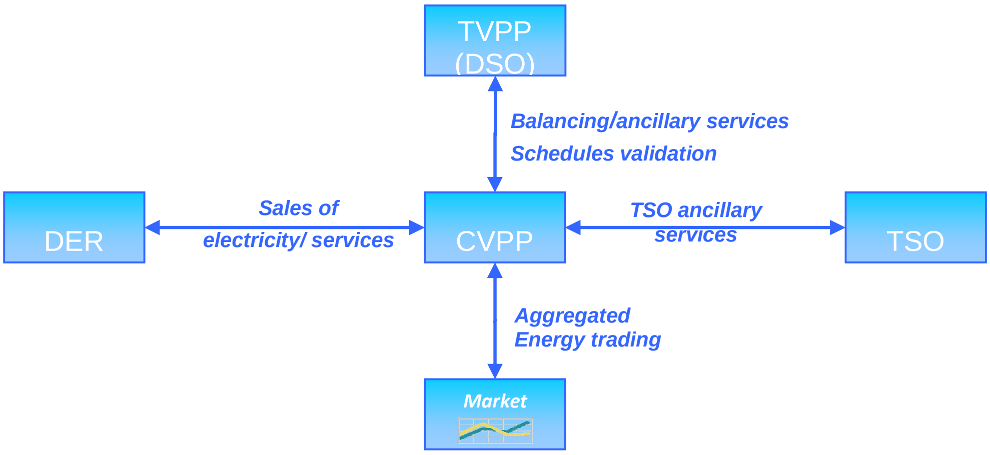

Figura 1. Contractual relationships

7. **Information exchanged between the actors:**

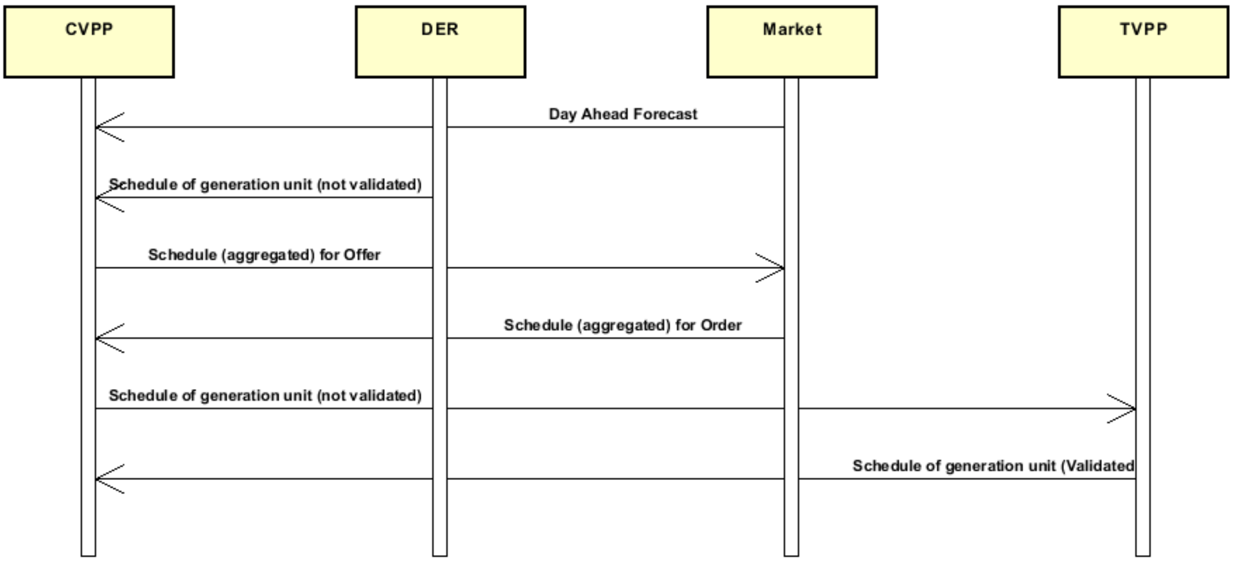

Figure 2. UML representation of the main information flows between actors

The CVPP receives offers from the DER and aggregates them for the market. It exchanges also information about requirements and availabilities of delivery, both in advance and in real time, with the TVPP.

The TVPP uses the generation schedules together with load forecast and work management plan as input and validates the feasibility of the schedules. If needed, the TVPP suggests an adapted generation schedule.

At the end of the process the DSO sends aggregated TVPPs results to the TSO.

8. **Energy flows between the actors:** The electricity produced by DER units is directly delivered to the distribution network. Most of this electricity is, then, distributed to the consumers by the DSOs. If the supply exceeds demand, the surplus of electricity is delivered to the transport grid and the TSO transports it to another distribution network.

   A last significant part of this electricity goes in direct consumption: it is the auto-production of electricity made on-site by a consumer using DER units.

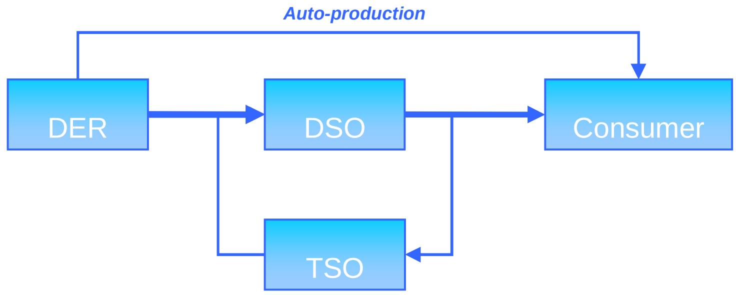

Figure 3. Energy flows between the actors

9. **Economic flows between the actors:** The CVPP receives the payment for electricity from the wholesale market, for balancing reserves and other ancillary service from the TSO and from DSO, for and for guarantees of origins sales from the GO market.

   DER operators receive the payment from the CVPP and pay it for intermediating.

   the DER receives payment also for the provision of ancillary services.

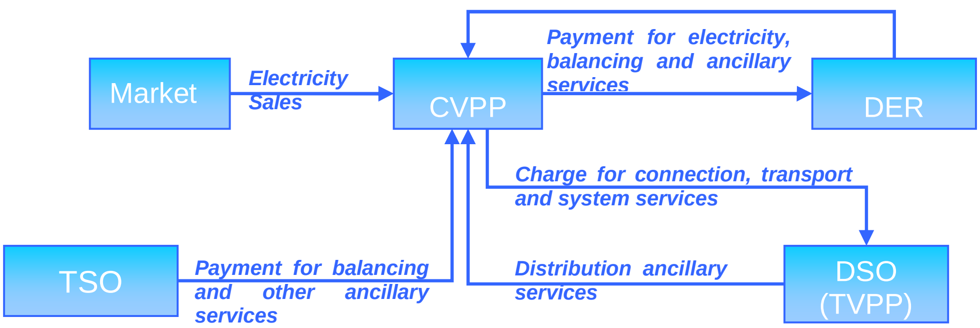

Figure 4. Economic flows between the actors

10. Mapping role towards *ETSO/ebIX harmonized role model*

Role	***Corresponding ebIX roles***	***ebIX definition***	***Notes***
DER	Producer	A party that produces electricity	
Aggregator (CVPP)	Balance responsible party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. **This is the only role allowing a party to buy or sell energy on a wholesale level.**	*The CVPP aggregates many DER units and participates (in their place) in the market, in the TSO-organized balancing market (where it exists) and plays the part of DER systems in arranging the provision of certain ancillary services.*
	Imbalance settlement responsible	A party that is responsible for settlement of the difference between the contracted quantities and the realised quantities of energy products for the balance responsible parties in a market balance area.	*In this business case CVPP can absorbs balance and trading risks of his client (or shares these risks with them) for extra fee.*
Aggregator (TVPP)	Control area operator	Responsible for : 1. The coordination of exchange programs between its related market balance areas and for the exchanges between its associated control areas. 2. The load frequency control for its own area. 3. The coordination of the correction of time deviations.	*The TVPP is a monopoly role of DSO. It manages all the DER units in its region and represents them at the point of connection with transmission and validates the feasibility of their generation schedules.*
DSO	Grid operator	A party that operates one or more grids.	
TSO	System operator	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The SO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	

Part 2: Technologies needed / Investments required

11. Technologies used:

Technology Type	***Description of functionality***	***Role by which it is used***	***Tools used in Fenix***	***IPR-holders***	***Maturity level***
FENIX Box Server	It is both software and hardware. It: - aggregates loads and generation and ensure their optimal use; - provide visibility of generation available and current demand	DER	Inverter based equipment, stimulating real units measurements and accepting commands	Imperial College London	Research prototype
	There are two types of FENIX Box: - the first is based on concentrator which read several advanced/smart meters, thus enabling high level protocol access and real time variation of the contracted power of the consumer; - the second is based on relay hardware which behaves like a gateway, translating high level protocol to local protocol.		*Linux Based FENIX Box:* Evaluation board with an embedded linux to serve the local intelligence	ECRO (Linux Based FENIX Box)	Demonstrating tool
			ZIV Fenix Box: Monitoring hardware used to measure the output of the small scale generation	ZIP	Demonstrating tool based on commercial one
CVPP server	Implements schedule and energy optimisation functions for DER units, so enabling the access of DER units to the market.	CVPP	e-TerraScada extended with CVPP functions,	Areva	Demonstrating tool based on commercial one
	In details it is a **DEMS** (Decentralized Energy Management System) configured as a CVPP and, in FENIX, it has been extended with functionalities about: - connectivity (interface to FENIX Box); - reactive power control; - integration (with DSO using ICCP and with energy market using Web Services)		Based on Siemens DEMS, it is a server that receives orders from selected customers with software to transmit electronic orders from selected Customers via the Internet using FTP. Some enhancement added to the commercial version were: aggregation/disaggregation, communication protocols, etc	Siemens	Demonstrating tool based on commercial one

TVPP application	TVPP is a general name for the set of functions that joins DER and electrical network. It is a part of the **SCADA/DMS** (Distribution Management System) of the network control system and validates generation schedules taking into account voltage and current violations. It have to: - validate the feasibility of scheduled generation of DER units; - if problems are detected, plan corrective measures (foe example, changing of scheduled generation of DER units); - optimize the voltage in the network. This functionality is calles Volt VAr Control (VVC)	DSO	e-TerraScada extended with TVPP functions,	Areva	Demonstrating tool based on commercial one
			OPF is a Module of the Siemens DMS (***Spectrum***), extended to include DER reactive power output as variable for Voltage Var Control	Siemens	Demonstrating tool based on commercial one
Real time link	Provide a simple huge access to all the DER. The technology used in FENIX demonstration is GPRS.	CVPP			

12. Other technologies needed:

Technology name	***Description of functionality***	***Role which need it***
Market price forecasting software	Software used to forecast market prices in energy markets.	CVPP
Smart meter	A fast implementation of smart meters will enable not only trading operations but also near real-time remote control by network operators and commercial third party, thus stimulating introduction of smart tariffs. This will lead to the adoption of smart output-based incentives and so, in an indirect way, promotion of efficient DER integration.	DSO

13. Related technologies available in the market or from other research projects

Technology name	*Description of functionality*	*Role by which it can be used*	*IPR-holders*	*Maturity level*
		DER	ECRO	Demonstration tool
	Monitoring hardware used to measure the output of the small scale generation	DER	ZIV	Demonstration tool, based of an extension of a commercial one.
Siemens DEMS	It is the Siemens Decentralized Energy Management System. It allows energy producers to optimize energy consumption in a particular area, based on pre-specified energy-related, economic and ecological criteria.	CVPP	Siemens	On the market
Power Matcher	It is a distributed energy system architecture and communication protocol. Takes offers and bids from remote "agents".	CVPP	ECN	On the market
***e-terra**scada*	**e-terra**scada is a suite of applications built on a common core technology, parte of an Energy Management System solution (**e-terra**platform)	CVPP TVPP	Areva T&D	On the market
Siemens Spectrum	It is the Siemens Distribution Management System. It provides tools for control of reserves, energy trading and minimization of production cost	TVPP	Siemens	On the market

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.):** The design of the information exchanges between the actors is based on exchanging single values (real-time) and schedules (day ahead).

    Particularly, the provision of ancillary services relies on real-time communication and control between the CVPP and DER. So DER units and CVPP must communicate about ancillary services, using real-time system.

    Moreover the CVPP and TVPP will be engaged in real-time communication, exchanging information about constraints on the network, requirements for ancillary services. CVPP and TVPP will exchange bids and offers from DER too.

    Confidentiality and reliability must be ensured.

15. **Communication protocols and mediums used:** GPRS and IEC-104 protocols can be used to enable this real time link for the communication between DER and CVPP (through the FENIX Box).

    Moreover each DER can communicate its situation to the Aggregator through a web page and the CVPP will aggregate all bids into a single one and places it in the Market.

ICCP (Inter-Control Center Communications Protocol) is the protocol proposed, in FENIX, for communications between CVPP and DSO.

Web Services can supply the infrastructure for exchanging of schedules.

16. **Data format/standards:** The communications between the actors have to based on agreed formats.

Part 3: Benefits and Obstacles

17. **Benefits to participants (economical and not; operational savings, for each actor):** This Business Model
    - enables small DER units to access to the energy market, maximizing their revenues and minimizing the needed investment in trading ICT and market entree;
    - optimizes the utilization rate of DER units, according to real time electricity demand and electricity market price signal;
    - helps the grid to overcome the obstacles that physical constraints of decentralization cause in energy transport;
    - provide to DER fast start-up capability in integrating in the grid.
18. **Benefits to society (emissions, efficiency enhancement, etc.) :** This Business Model
    - flats the intermittency of stochastic power generation and so stimulates the deployment of renewable energy;
    - increases the reliability of power system in consequence of the ancillary services offered by VPP, (e.g. regulating power, reserves, voltage control and so on);
    - reduces the emissions of the fossil fuel generators, stimulating the deployment of renewable energy;
    - contributes, through local distributed generation, to compensate for local line losses;
    - allows to postpone investment in network expansion of higher voltage distribution network.
19. **Operational costs**
    - TSO and DSO incur expenditures for non-power materials inputs (including payment to network equipment vendors, outsourced maintenance and ICT providers);
    - investments in network reinforcement in network sections where DER feeds;
20. **Other obstacles in its implementation** An obstacle in implementation of the business model is the lacking of
    - appropriate commercial and regulatory framework;
    - standardized information and communication between VPP and relevant actors.
21. *Regulation related issues*

Part 5: Bibliography

22. **Where to find more information? (Web Site, Scientific Publications, etc.**)

    The reference site is http://www.fenix-project.org/ , where are also available many publications about FENIX.

Business model 5: Ritiro dedicato

Part 1: case description

1. **Name of the Business Case:** Ritiro Dedicato
2. **Location of the Business Case (nation / project that generated the BC): Italy**
3. **Short description of the case and business rationale:** The Ritiro Dedicato is a real business case, that, in Italy, represents an alternative to direct sale to the market (bilateral contracts and wholesale market) for the DER units. It lies in simplified purchase arrangements between the GSE (Gestore dei Servizi Elettrici) and DER operators (with particular attention to Renewable Energy Sources). The DER producer who opts for Ritiro Dedicato assigns to the GSE the withdrawal (that is the purchase) of all the electricity it injects in the grid. This mechanism is thought to promote RES production by making easier the bureaucracy needed to sell energy.
4. **Actors involved (companies, organizations and so on) :**

Actor	*Role*	*Note*
GSE	Aggregator	GSE (Gestore del Sistema Elettrico) is a public owned company which promotes and supports renewable energy sources in Italy. GSE provides economic support to RES and promotes the awareness of environmentally-efficient energy use.
• Programmable RES plants with a nominal apparent power of less than 10 MVA • Not Programmable RES plants of any power (wind, solar, geothermal, etc.) • Non RES plants or Hybrid plants with a nominal apparent power of less than 10 MVA	DER Producers	This Role includes auto-production DER.
Terna (National Electrical Grid)	TSO	Terna is the Italian electricity transmission grid operator.
GME	Market	GME (Gestore del Mercato Elettrico S.p.A) is a company which organizes and manages transactions in Italian Electricity Market (IPEX).

5. Their (logical) Roles in the Business Case:

Role	***Description***
DER Producer	The DER producers are the owners of are the owners of the DER generation plants eligible for the service who opts for GSE indirect sale.
Aggregator	The aggregator, in this business case, is a monopoly role of the GSE. It collects, commercially, the electrical power produced by DER units and presents itself to the electrical system as the only interface, replacing the real producers for sale of energy but also for ancillary services. Moreover it assures the despatching of the energy.
TSO	The Transmission System Operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators. The TSO assigns the hourly schedules for energy injections.
DSO	The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers. It is responsible for measurement.
Electricity Markets	There are different market in the IPEX (Italian Power Exchange): • the Day-Ahead Market: in it producers, wholesalers and eligible final customers sell and purchase electricity for the next day; • the Intra-Day Market: in it producers, wholesaler and eligible final customers modify the injection/withdrawal schedules previously defined in the Day-Ahead Market; • the Ancillary Services Markets: in it Terna procures the despatching services needed for the complete managing of the power system.

6. Product / Services and related Transactions and Contracts:

Product/Service	***Definition***
Energy/ancillary services sales	The Ritiro Dedicato relationship between DER and GSE, replaces any other accomplishment related to the commercial transfer of the energy, but also to the despatching and transport services. The producer which makes use of Ritiro Dedicato is obliged to give to the GSE all the electricity injected in the grid. The GSE sells, on the market, the withdrawn energy.
Administrative managing	The GSE manages, in place of the DER producers, all the administrative steps for energy selling. In particular it settles the network access with DSO and TSO
Physical connection and energy measurement	The Ritiro Dedicato agreement includes all technical and commercial aspects except connection and energy measurement. These services are provided from local distribution operators.

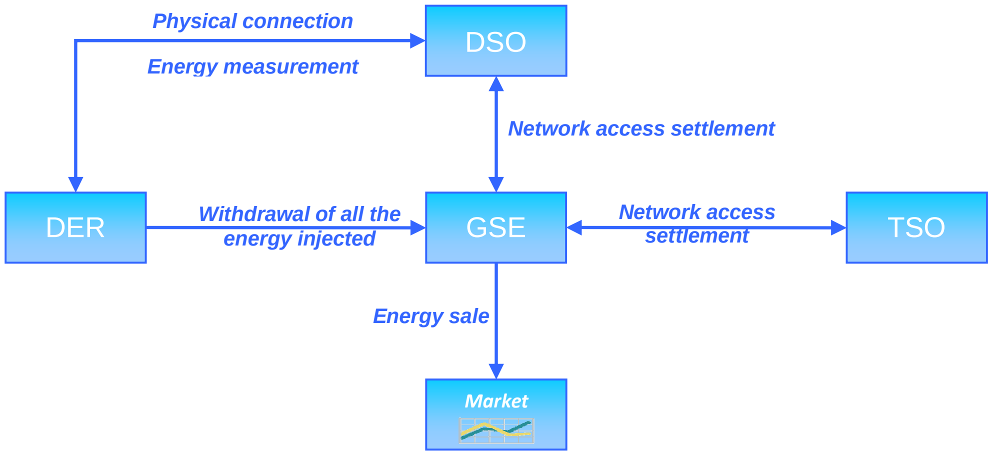

Figura 1. Contractual relationships

7. **Information exchanged between the actors:**

If the DER unit has a programmable production, the producer has to transmit the hourly scheduling of the electricity that it will inject in the grid. If the production in not programmable, the producer has to transmit historical data about the availability of the source and electricity injections.

The definition of procedures for electricity injection predictability improvement from Not Programmable Renewable Energy Sources is a GSE duty.

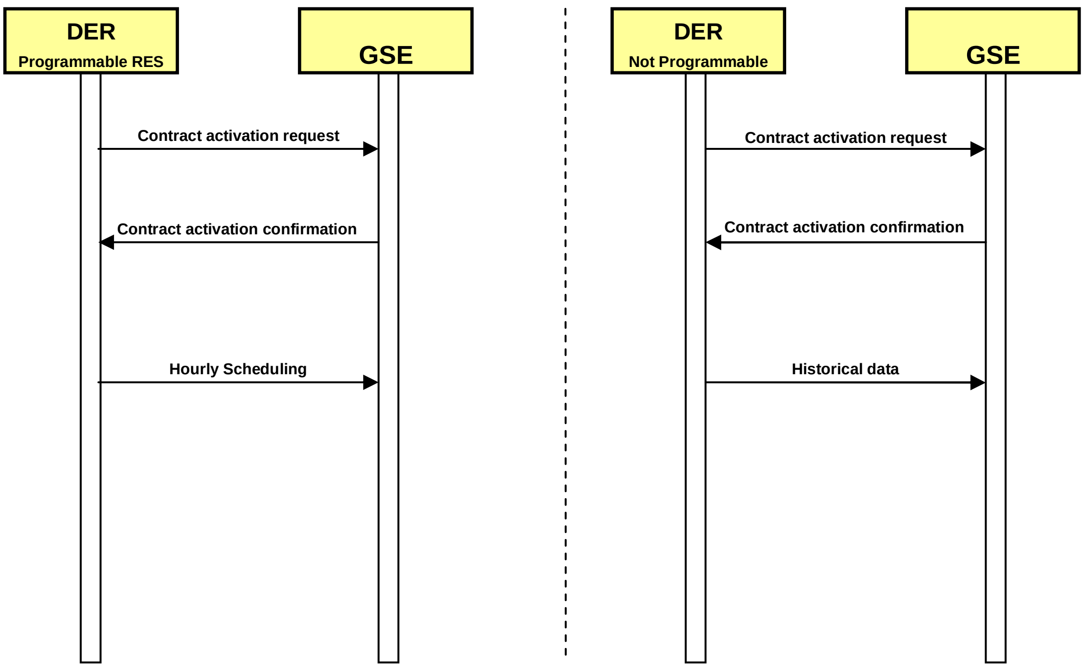

Figure 2. UML representation of the main information flows between actors

8. **Energy flows between the actors:**

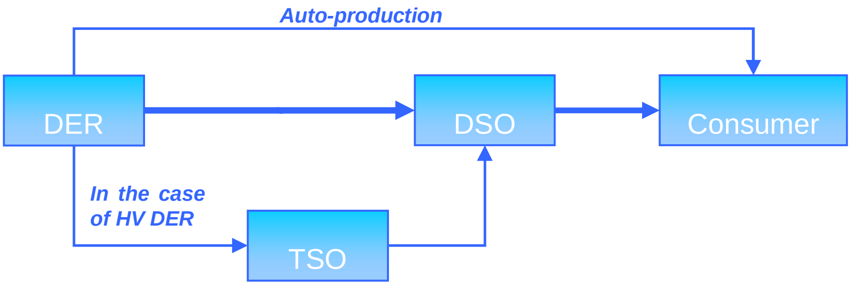

Figure 3. Energy flows between the actors

9. **Economic flows between the actors:**

Some important concepts:

- o The **unbalancing compensation** is the exploitation of the difference between the energy that a plant really puts in the grid, in the reference time unit and the energy that, according to the results, the plant has to produce.
- o If the energy injected in the grid is higher than the programmed one, the unbalancing is positive and the TSO remunerates the producer. Otherwise the producer has to remunerate the TSO.
- o The price of this exploitation depends on the sign of the total unbalancing of the zone. If the plant unbalancing has opposite sign with respect to the zone unbalancing, the plant contributes to unbalancing reduction. In this case the price is the same resulted in the day-ahead market and not penalizes the producer. Otherwise, the price is the marginal price of the despatching market and penalizes the producer.

In the Ritiro Dedicato the economic flows consists of:

- **Market Valorisation**: The GSE pay to the producer, for every hour, the **reference market price of the zone** where the plant stays.

  For Renewable Source Energy plant with a nominal active power of less than 1 MW (except the hybrid plants) the authority defines **guaranteed minimum prices** for the fist 2 million of kWh of electric energy introduced in the grid every year. If, at the end of the solar year, the energy valorisation at guaranteed minimum prices is less than its value at market prices, the GSE pays to the producers the related currency adjustment.
- **Unbalancing compensation**: Moreover the GSE shifts on the programmable plant owners the **unbalancing onerous amount** that is the difference between the **unbalancing compensation assigned** by the TSO and the value at market price of the **actual unbalancing reported** at the same time in the same point.
- **Administrative costs**: the producers pays to the GSE a compensation for the recovery of the administrative costs.
- **Measures aggregation**: if the plant has a nominal active power higher than 50 kW, the producer pays to the GSE an amount for measures aggregation service.

- **Transport Active compensation** : if the plant is connected to the grid in low or medium voltage point, the GSE pays to the producer plants a refund for not beard expenses, that is a Transport Active Compensation. It includes eventual network looses.
- **Transmission service**: it is an amount that the producer pays to GSE for the transmission service and GSE turns to TSO.

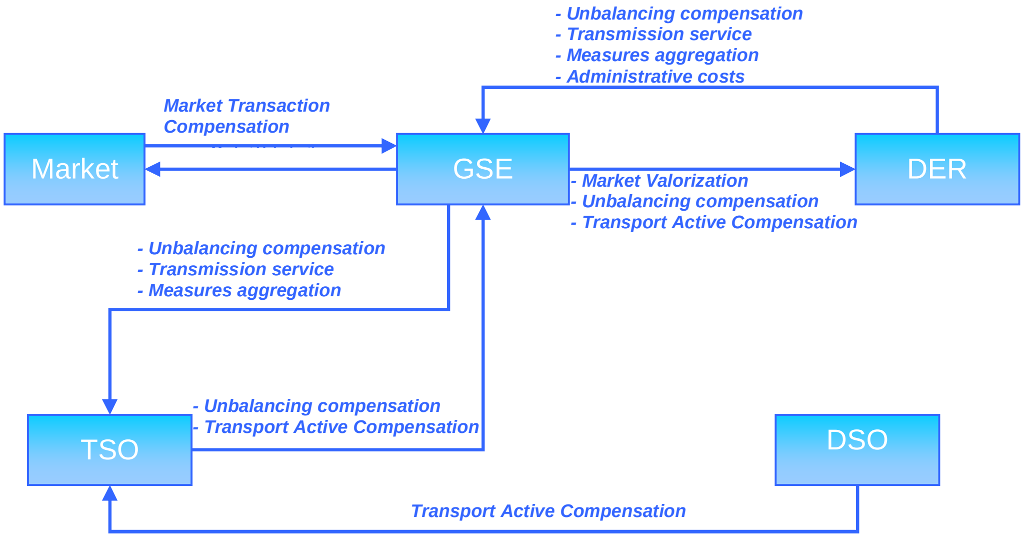

Figure 4. Economic flows between the actors

10. Mapping role towards *ETSO/ebIX harmonized role model*

Role	***Corresponding ebIX roles***	***ebIX definition***	***Notes***
DER	Producer	A party that produces electricity	
	Imbalance settlement responsible	A party that is responsible for settlement of the difference between the contracted quantities and the realised quantities of energy products for the balance responsible parties in a market balance area.	*The GSE shifts on the programmable plant owners the unbalancing onerous amount*
Aggregator (GSE)	???		
DSO	Grid operator	A party that operates one or more grids.	
TSO	System operator	A party that is responsible for a stable	

		power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The SO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	
	Balance responsible party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. This is the only role allowing a party to buy or sell energy on a wholesale level.	*In Italy it does not exist on the market an independent Balance responsible party. This role is always covered by the TSO*

Part 2: Technologies needed / Investments required

11. **Technologies used:**

Technology Type	***Description of functionality***	***Role by which it is used***	***Tools used in Ritiro dedicato***	***IPR-holders***	***Maturity level***
Internet Portal	It allows the managing of DER profiles, the request for Ritiro Dedicato subscription and the managing of data about energy injected and billing. Moreover it provides the energy injection schedules upload page. The schedules expected formats are XML and CVS. It allows also the managing of Distributors profiles, the upload of measures (XML or CVS formats), the access to the historical measure data.	GSE	GSE portal	GSE	In use
electronic meter	A device that measures how much electricity is injected in the grid. In absence of it, it is the TSO that has to	DER			This technology is available and different solutions are on the market. But it is not applied

	determine the hourly injection profile.	at large scale in the world.

12. Other technologies needed:

Technology name	*Description of functionality*	*Role which need it*

13. Related technologies available in the market or from other research projects

Technology name	*Description of functionality*	*Role by which it can be used*	*IPR-holders*	*Maturity level*

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.):** the data about scheduling and measurement are sensible data and requires an high level of confidentiality. The reliability has to be assured because these data are fundamental for the correct working of the grid.

15. **Communication protocols and mediums used:** the data are sent to the portal with the https protocol.

16. **Data format/standards:** XSD that defines the format of injection schedules (for the DER) and XSD that defines the format for hourly measures of the energy produced and injected (for the DSO) and the corresponding CVS formats are provided inside the official documentation. They are not available on the Web as XSD files. These are proprietary and not standard formats.

Part 3: Benefits and Obstacles

17. **Benefits to participants (economical and not; operational savings, for each actor):** This Business Model:
    - Avoids small DER units to deal continuously with DSO and TSO. It will be the GSE that mediates between producers and national electric system.
    - Replaces any other DER unit bureaucratic accomplishment and so makes easier DER integration in the grid;
    - Warrants to the DER an advantageous price for the energy injected.

18. **Benefits to society (emissions, efficiency enhancement, etc.) :** This Business Model
    - Promotes the integration of DER into the Italian electrical grid;

- Stimulates the integration especially of renewable energy sources plants and so promotes the reduction of emissions of the fossil fuel generators;

19. Operational costs

20. **Other obstacles in its implementation**

21. **Geographical limitations :** This is an Italian Business Case, different from the ones of other countries

22. Regulation related issues

23. Lessons learnt (if any)

Part 5: Bibliography

24. **Where to find more information? (Web Site, Scientific Publications, etc.**)

The main source is the GSE web site (http://www.gse.it)

Business model 6: Scambio sul posto (Italy)

Part 1: case description

1. **Name of the Business Case:** Scambio sul Posto (*onsite exchange service*)
2. **Location of the Business Case (nation / project that generated the BC):** Italy
3. **Short description of the case and business rationale:** 'Scambio sul Posto' is a real business case, that, in Italy, enables the DER producers (mainly RES, but also cogeneration plants) to inject in the grid the electricity they produce but do not use immediately and to withdraw it afterwards to satisfy their own consumption. Actually it is something like using the electrical grid as a storage.
4. **Actors involved (companies, organizations and so on) :**

Actor	*Role*	*Note*
GSE	Aggregator	GSE (Gestore del Sistema Elettrico) is a public owned company which promotes and supports renewable energy sources in Italy. GSE provides economic support to RES and promotes the awareness of environmentally-efficient energy use.
• RES plants with a nominal active power of less than 20 kW • RES plants with a nominal active power of less than 200 kW (if they started after 31th December 2007) • High efficiency cogeneration plant with nominal active power of less than 200 kW	DER Producers	
Grid Operators	TSO & DSO	Transmission and Distribution System Operator respectively
GME	Market	GME (Gestore del Mercato Elettrico S.p.A) is a company which organizes and manages transactions in Italian Electricity Market (IPEX).

5. **Their (logical) Roles in the Business Case:**

Role	***Description***
DER Producer	The DER producers are the owners of **flexible supply** who opts for Scambio sul Posto. They present the request to enter in the "scambio sul posto" agreement

Aggregator	The aggregator, in this business case, is a monopoly role of the GSE. It is the only which can put into practice this procedure. It is the intermediary among DER producers and the electrical power system. It corresponds to the DER producer the economical contribution for the energy exchange and receives from him the compensation for administrative costs
TSO	The Transmission System Operator (TSO) provides the economical valorisation for dispatching services
DSO	The Distribution System Operator (DSO) is responsible for the survey and the registration of injected electricity measurements. It sends monthly to the GSE data about plants, measures of energy injected and withdrawn in the previous month. It sends yearly (by the 3rd month of the year) the amount of energy injected and withdrawn in the previous year.
Retailer	The retailers are the counterparts of the supply contract, related to electricity withdrawn from the grid for the final user under onsite exchange service system. They send (monthly, at least quarterly) to the GSE data about user supply typology, billing of withdrawn energy and supply contract parameters.
Electricity Markets	There are different market in the IPEX (Italian Power Exchange): • the Day-Ahead Market: in it producers, wholesalers and eligible final customers sell and purchase electricity for the next day; • the Intra-Day Market: in it producers, wholesaler and eligible final customers modify the injection/withdrawal schedules previously defined in the Day-Ahead Market; • the Ancillary Services Markets: in it Terna procures the despatching services needed for the complete managing of the power system.

6. Product / Services and related Transactions and Contracts:

Product/Service	***Definition***
Energy Exchange service	The onsite exchange service achieves a virtual storage of the energy produced by the DER, allowing the DER producers to use the energy, produced when available (because of the not predictability of renewable source), when they actually need it.
Administrative managing	The GSE manages, in place of the DER producers, all the administrative steps for energy selling. In particular it settles the network access with DSO and TSO
Physical connection and energy measurement	These services are provided from local grid operator (DSO).

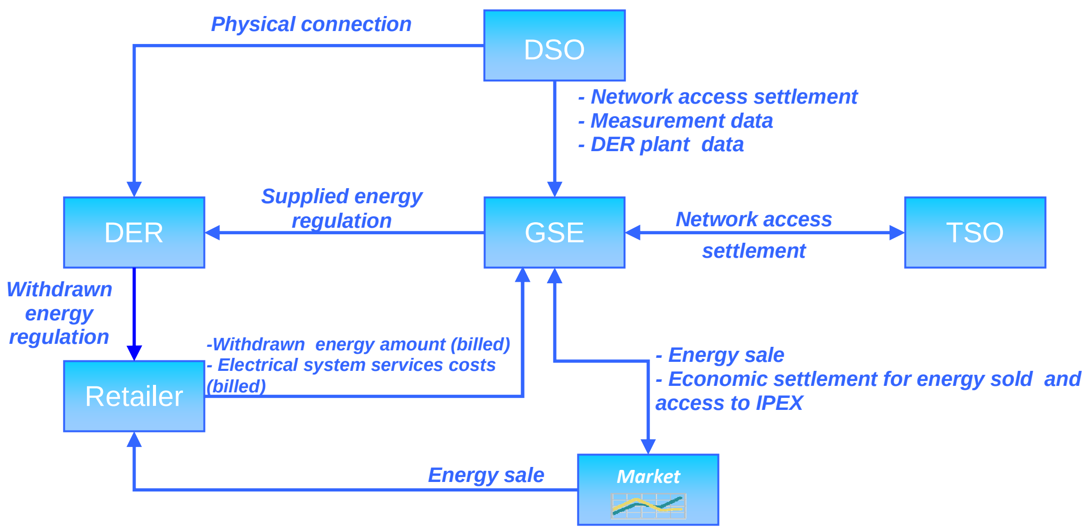

Figura 1. Contractual relationships

7. **Information exchanged between the actors:**

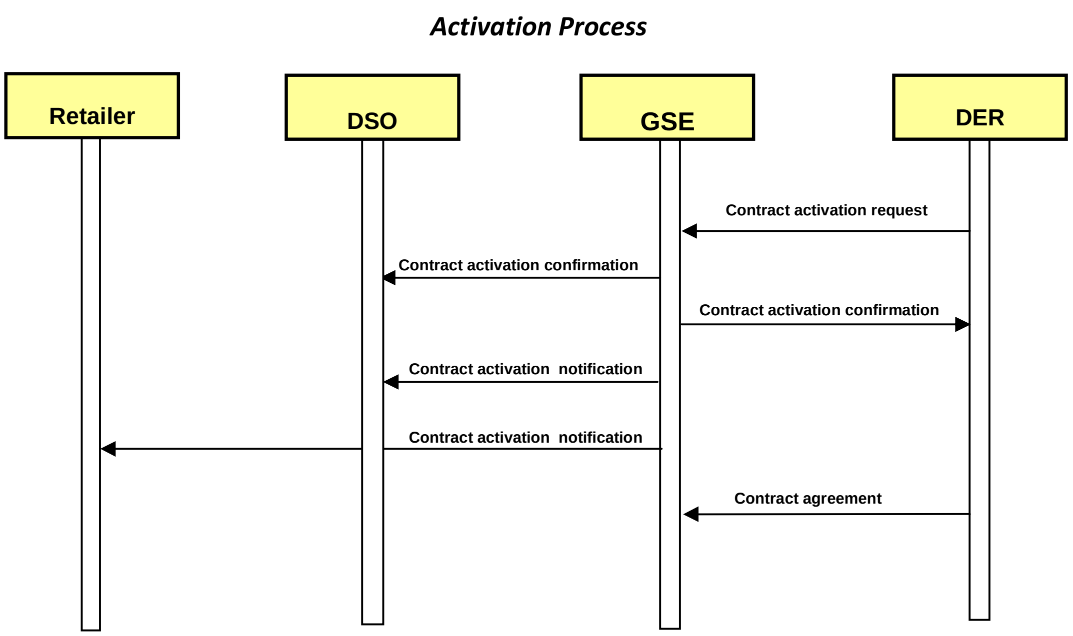

Figura 2. Activation of the onsite exchange service

The DER should send to DSO and to the retailer the contract activation notification. In order to simplify the procedures it will be the GSE itself to send this notification.

Current operation

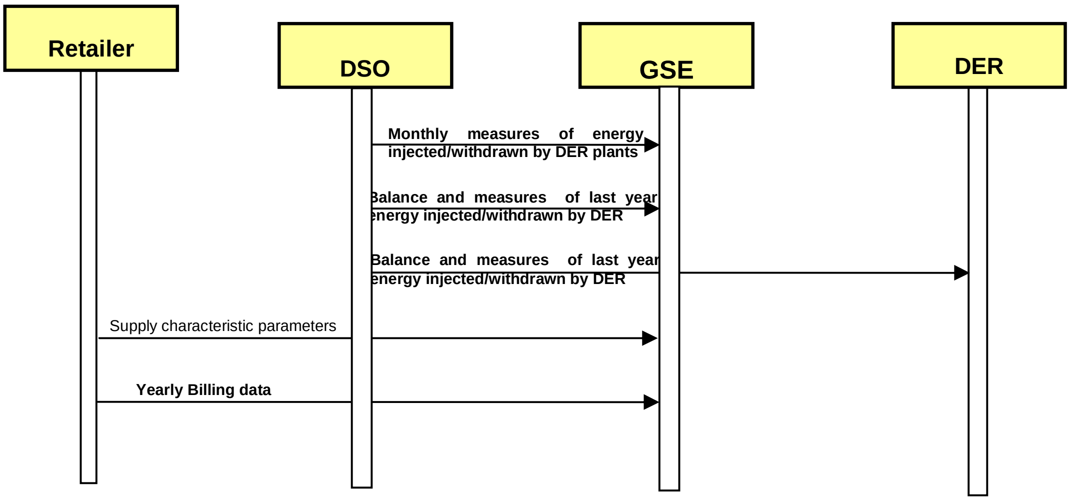

Figure 3. UML representation of the main information flows between actors during the normal operations

8. **Energy flows between the actors:**

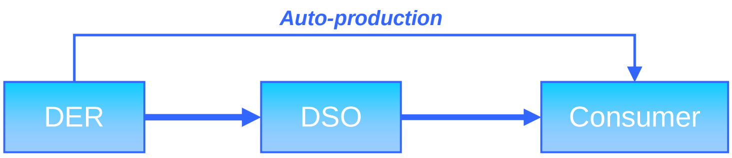

Figure 3. Energy flows between the actors

9. **Economic flows between the actors:**

The economic flows consists of:

- **Exchange Contribution:** The GSE pays to the producer an amount that warrants at least the equivalence between the DER producer expenses related to the withdrawn energy and the value of electricity it injected in the grid.
- **Administrative costs**: the producers pays to the GSE a compensation for the recovery of the administrative costs.
- **Dispatching contribution**: it is an amount that the producer pays to GSE for the dispatching service and GSE turns to TSO.

- **Measurement service**: the producer pays to the GSE an amount for measures aggregation service.

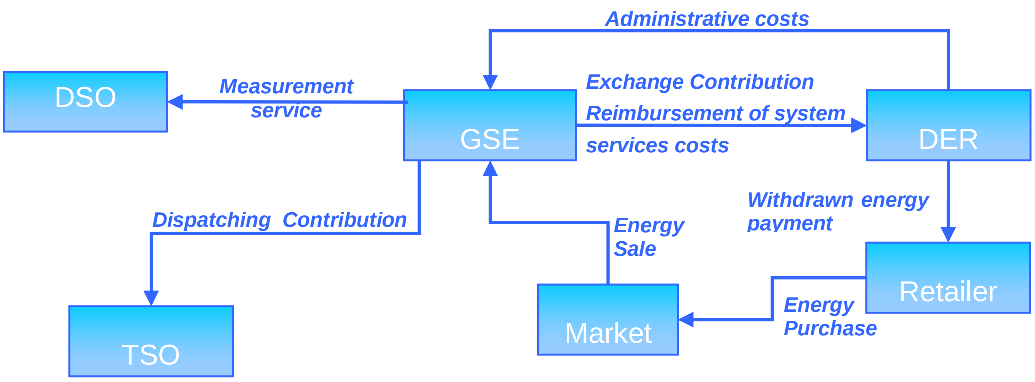

Figure 4. Economic flows between the actors

10. Mapping role towards *ETSO/ebIX harmonized role model*

Role	***Corresponding ebIX roles***	***ebIX definition***	***Notes***
DER	Producer	A party that produces electricity	
Aggregator (GSE)	???		
DSO	Grid operator	A party that operates one or more grids.	
TSO	System operator	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The SO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	
	Balance responsible party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. This is the only role allowing a party to buy or sell energy on a wholesale level.	*In Italy it does not exist on the market an independent Balance responsible party. This role is always covered by the TSO*

Part 2: Technologies needed / Investments required

11. Technologies used:

Technology Type	***Description of functionality***	***Role by which it is used***	***Tools used in Ritiro dedicato***	***IPR-holders***	***Maturity level***
Internet Portal	It allows the managing of DER profiles, the request for *Scambio sul Posto* subscription and the managing of data about subscriber plant. Moreover it provides the energy injection schedules upload page. The schedules expected formats are XML and CVS. It allows also the managing of DSO profiles, the upload of measures (XML or CVS formats), the access to the historical measure data and so on.	GSE	GSE portal	GSE	In use
Electronic meter	It allows hourly metering and telemetering	DER and DSO		DSO	Is use

12. Other technologies needed:

Technology name	***Description of functionality***	***Role which need it***

13. Related technologies available in the market or from other research projects

Technology name	***Description of functionality***	***Role by which it can be used***	***IPR-holders***	***Maturity level***

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.):** the needed data are sensible data and requires an high level of confidentiality. The reliability has to be assured because these data are fundamental for the correct working of the grid. There is no need for real time communication.

15. **Communication protocols and mediums used:** the data are sent to the portal with the https protocol. Telemetering is via PLC and GSM.

16. **Data format/standards:** XSD that defines the format of data needed by GSE and the corresponding CVS formats are provided inside the official documentation. They are not available on the Web as XSD files. These are proprietary and not standard formats.

Part 3: Benefits and Obstacles

17. **Benefits to participants (economical and not; operational savings, for each actor):**

This Business Model is advantageous for DER producers when the acknowledged value of the energy injected in the grid is at least equal to the cost of the energy withdrawn from the grid. If this is true the other benefits are:

- Avoids small DER units to deal continuously with DSO and TSO. It will be the GSE that mediates between producers and national electric system;
- DER producers receive an advantageous economical treatment will be reimbursed from the GSE of the costs of transportation, dispatching and for RES producers for general system costs as well.
- Transparency of the amounts of electricity injected and withdrawn

18. **Benefits to society (emissions, efficiency enhancement, etc.) :** This Business Model
    - Promotes the integration of DER into the Italian electrical grid;
    - Stimulates the integration especially of renewable energy sources plants and so promotes the reduction of emissions of the fossil fuel generators;

19. **Operational costs**

Administrative costs for GSE and compensation sent by the DER producers for those costs

20. **Other obstacles in its implementation**

21. ***Geographical limitations***

    This is an Italian Business Case, different from the ones of other countries

22. *Regulation related issues*

23. *Lessons learnt (if any)*

Part 5: Bibliography

24. **Where to find more information? (Web Site, Scientific Publications, etc.**)

    The main source is the GSE web site (http://www.gse.it)

Business model 7 – Network access and Power market interaction for local production

Part 1: case description

1. **Name of the Business Case:** Network access and Power market interaction for local production.
2. **Location of the Business Case (nation / project that generated the BC):** Norway / PLUG (EU FP 6 project)
3. **Short description of the case and business rationale:** The business case is based on a model developed in the EU project Power Generation during Loading & Unloading (PLUG) where production from ships carrying Liquefied Natural Gas (LNG) exchange power with the Nordic Power exchange in harbour. The model has many similarities with a aggregated portfolio of RES and DR operation against the organized markets: Day Ahead, Intraday and Balancing.
4. **Actors involved (companies, organizations and so on):** The Vessel (production and consumption), Aggregator (broker), Nord Pool Spot, TSO / Balancing Market, DSO, final customer
5. **Their (logical) Roles in the Business Case:** The aggregator sells electricity to Final Customers, purchases electricity from Generators and trades it on the Electricity Exchange (Nord Pool) and the Balancing Market. The DSO in deregulated electricity markets provides electricity transmission services to Final Customers and to Electricity Generators and is responsible for metering and billing. The TSO facilitates the Balancing Market.
6. **Product / Services and related Transactions:** The Vessel offers a price dependant bid curve (input or tap) of electricity referred to the connected node to the aggregator. The price curve from the vessel is included in the market bidding from aggregator. Detailed exchange program for the Vessel is established when the market prices are cleared. The network costs (DSO "point" tariff) is included in business case.
7. **Contractual relationships:** The aggregator (broker) operates on behalf of the Vessel (prosumer) according to contract.
8. **Information exchanged between the actors**: The aggregator receives bidding information from the Vessel and returns exchange program for the next 24 hours.
9. **Energy flows between the actors**: The energy flow is from production to consumption via the grid.
10. **Economic flows between the actors**: The aggregator will follow up the following flows: The spot market contract is settled with Nord Pool Spot and the profit/cost related to the exchange balance is settled with the TSO. The Network tariff cost is paid to the DSO directly.
11. **Graphical description of the case (UML if possible)**

    The business case is modelled by the e3value tool business model (http://www.e3value.com/) , which is shown in Figure 1. (The yellow and light yellow boxes in the Figure include the Legend.) The model shows for example, that DSO is a market segment, which has Electricity Transmission and Metering and Billing as its two value activities. DSO offers electricity transmission services to Final Customer (FC) and Vessel (V) as a value objects and receives transmission fees (distribution network tariffs and feeding tariffs) from the respectively Final Customer and Vessel. Value objects, are offered and requested via value ports, depicted by triangular arrows.

The arrow in a value port shows whether a particular actor requests or delivers an object of value to or from its environment. These ports are grouped into value interfaces, depicted by small rounded boxes surrounding two or more value ports. Such a value interface represents that objects are requested/offered only in combination and fulfils two modelling purposes:

- Value interface models economic reciprocity as, for example, transmission services in exchange for transmission fees (tariffs)
- Value interface may represent bundling of several products or services, saying that two or more value objects are offered (or requested) only in combination.

Additionally the model includes a scenario path (stippled line) that consists of one or more scenario segments, related by connection elements and start- and stop stimuli. Scenario path indicates via which value interfaces objects of value must be exchanged, as a result of a start stimulus, or as a result of exchanges via other value interfaces. A scenario path starts with a start stimulus, which represents a consumer's demand.

The scenario path includes connections and so-called forks (AND, OR), which are used to relate individual scenario segments. In our example the scenario starts simultaneously in two segments:

- FC demands for electricity AND transmission services, which are necessary in order to deliver the electricity on the customer's doorstep
- V demands electricity for its own consumption, which can be covered by own Electricity Generation OR by importing from the Aggregator (Electricity Broker (EB)). In this case the Vessel has also (AND) to purchase distribution network services from DSO and pay a network tariff for it.

The last segment(s) of a scenario path is connected to a stop stimulus. A stop stimulus indicates that the scenario path ends.

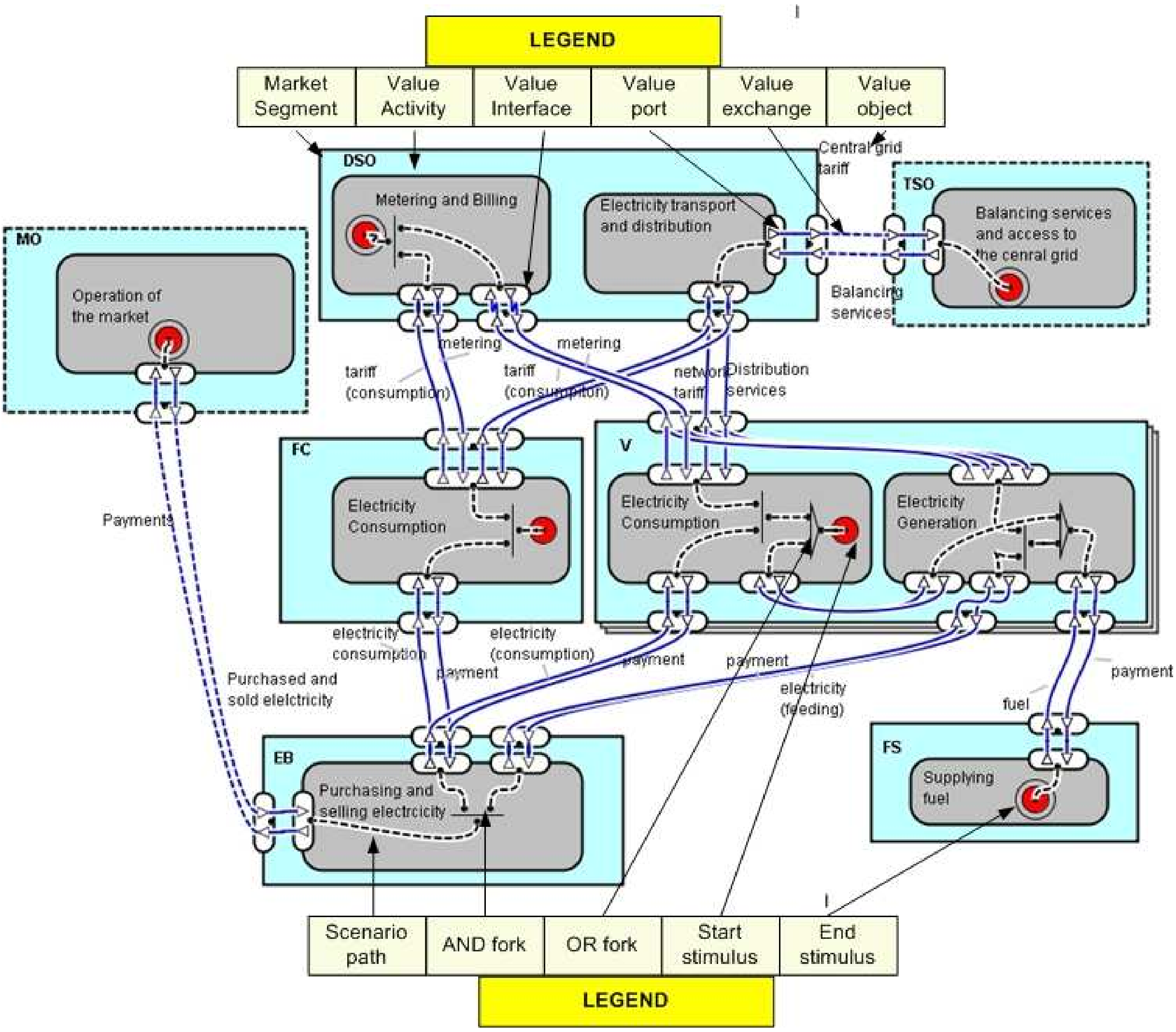

Figure 3 PLUG business nodel

Part 2: Technologies needed / Investments required

12. **Enabling technologies (non-ICT and ICT)**: A market simulator showing the bidding and resource allocation is developed
13. **Network parameters (HV, MV, LV..)**: LV
14. **Hardware needed for business case implementation (e.g. Smart Meter, Gateway, etc.)**: Metering in grid connection point is needed.

15. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.)**: Exchange of price and bid information via the web. Continuous communication is not required. Confidentiality must be ensured.
16. **Communication protocols and mediums used**
17. **Data format/standards**
18. **Specific software**:

Part 3: Maturity Level operational savings, CO_2, efficiency enhancement, etc.)

19. **What is the level of commercialization**: Research project
20. **If it is an existing practice, what about its success?** Not Applicable

Part 4: Benefits and Obstacles

21. Benefits to participants (economical and not; operational savings, for each actor)
22. Benefits to society (emissions, efficiency enhancement, etc.)

    Market based optimisation of production and flexible consumption will help rational exploitation of resources
23. Operational costs
24. Other obstacles in its implementation
25. Geographical limitations
26. Regulation related issues
27. Lessons learnt (if any)

Part 5: Bibliography

28. Where to find more information? (Web Site, Scientific Publications, etc.)

    « Assessment if a business model for power exchange between vessels and ashore electricity distribution network" Andrei Morch, Nicolai Feilberg, SINTEF, Norway, Damien Feger Snecma, France.

    NORDAC conference Bergen, Norway, 2008.

Business model 8 – Demand Response (DR) access to the Balancing Market through a commercial aggregator

Part 1: case description

1. **Name of the Business Case: Demand Response (DR) access to the Balancing Market through a commercial aggregator**
2. **Location of the Business Case (nation / project that generated the BC): Trondheim, Norway – a real business case**
3. **Short description of the case and business rationale:** The Norwegian power supplier TrondheimEnergi Kraftsalg is a commercial actor and operates in the power market on equal terms as other power suppliers – both in the financial and physical part. In this business case TrondheimEnergi Kraftsalg operates as an aggregator and makes bids both to the Balancing Option Market and the Balancing Market on behalf of several smaller end-users. The Balancing Option Market is established to secure a sufficient amount of power reserve in the Balancing Market – especially during the winter (October – April). The bids contain available power reserves aggregated from several end-users such as electrical boilers from the district heating station, stone crushers at a stone-crushing plant, ventilation plants and heating systems in buildings and reducible loads at a factory refining corn. The bids from TrondheimEnergi Kraftsalg to the Balancing Option Market include volume, price, period and potential restrictions with regard to duration of disconnection and the limited numbers of hours between disconnection periods. The Option contract is bilateral. In the bids from TrondheimEnergi Kraftsalg to the Balancing Market volume, price, maximum duration of disconnection and resting time between disconnections are specified. This bid will be included in the merit order list for the common Nordic Regulation Power Market. If the price in the Balancing Market exceeds the price specified in this bid, the Transmission System Operator (TSO) calls the system control centre at TrondheimEnergi and asks them to disconnect the loads. The response requirement is 15 minutes. The local control centre (DSO) performs remote load control (RLC)/signalling to the different end-users via the Automatic Meter Reading (AMR) system. The price in the Balancing Market is the marginal price in each hour.

   TrondheimEnergi Kraftsalg is a Balance responsible entity and the imbalance settlement is based on the contracted volume in the Nord Pool Elspot market (Day Ahead Market). TrondheimEnergi Kraftsalg can aggregate demand response from the whole Nord Pool price area where they operate, but they require that they shall be balance responsible and power supplier for all of the aggregated the customers
4. **Actors involved (companies, organizations and so on):** Customers with flexible demand, Aggregator (power supplier - TrondheimEnergi Kraftsalg), Distribution System Operator (DSO), Transmission System Operator (TSO).
5. **Their (logical) Roles in the Business Case:**

Role	*Description*
Customer	The owner of **flexible demand** connected to a distribution network.
Aggregator	The Aggregator is responsible for aggregating flexible loads into the bids to the Balancing Option Market and the Balancing Market. The aggregator needs an agreement with each customer with flexible loads.
TSO	The Transmission System Operator (TSO) transmits electrical power from

	generation plants to regional or local electricity distribution operators. The TSO is also responsible for operating the Balancing Option Market and the Balancing Market.
System control centre	The system control centre is responsible for the physical activation of the disconnection – when the price in the Balancing Market exceeds the price in the bids and the TSO ask them to activate the demand response. The system control centre is operated by the local DSO.
Balancing Option Market/ Balancing Market	The demand response can be involved in the following market: • Balancing Option Market - a market for standby reserves where the Aggregator bids the possible demand response, the price required and limitations regarding disconnection. • Balancing Market - a one-sided uniform-price market with the TSO as central counter-party who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power.

6. Product / Services and related Transaction and Contracts:

Product/Service	***Definition***
Demand response - aggregation and trading	The Aggregator aggregates demand response from several customers and bid them into both the Balancing Option Market and the Balancing Market.

The contractual relationship between the customers and the Aggregator must define the details about:

- Billing and payment; (specifying the required compensation to the customer.)
- Limitations regarding disconnection such as the hours when disconnection can be performed, maximum duration of a disconnection and minimum resting time between disconnections.
- Technology for remote load control (for example via the AMR-system)

The contract between the Aggregator and the market includes:

- billing and payment;
- Limitations regarding disconnection such as the hours when disconnection can be performed, maximum duration of a disconnection and minimum resting time between disconnections.
- bid submission from the Aggregator to the Balancing Option market and the Balancing market;

It is important that the contracts specify who must pay the penalties in cases of failure to deliver the contracted services.

Figure 1. Contractual relationships

7. **Information exchanged between the actors:**

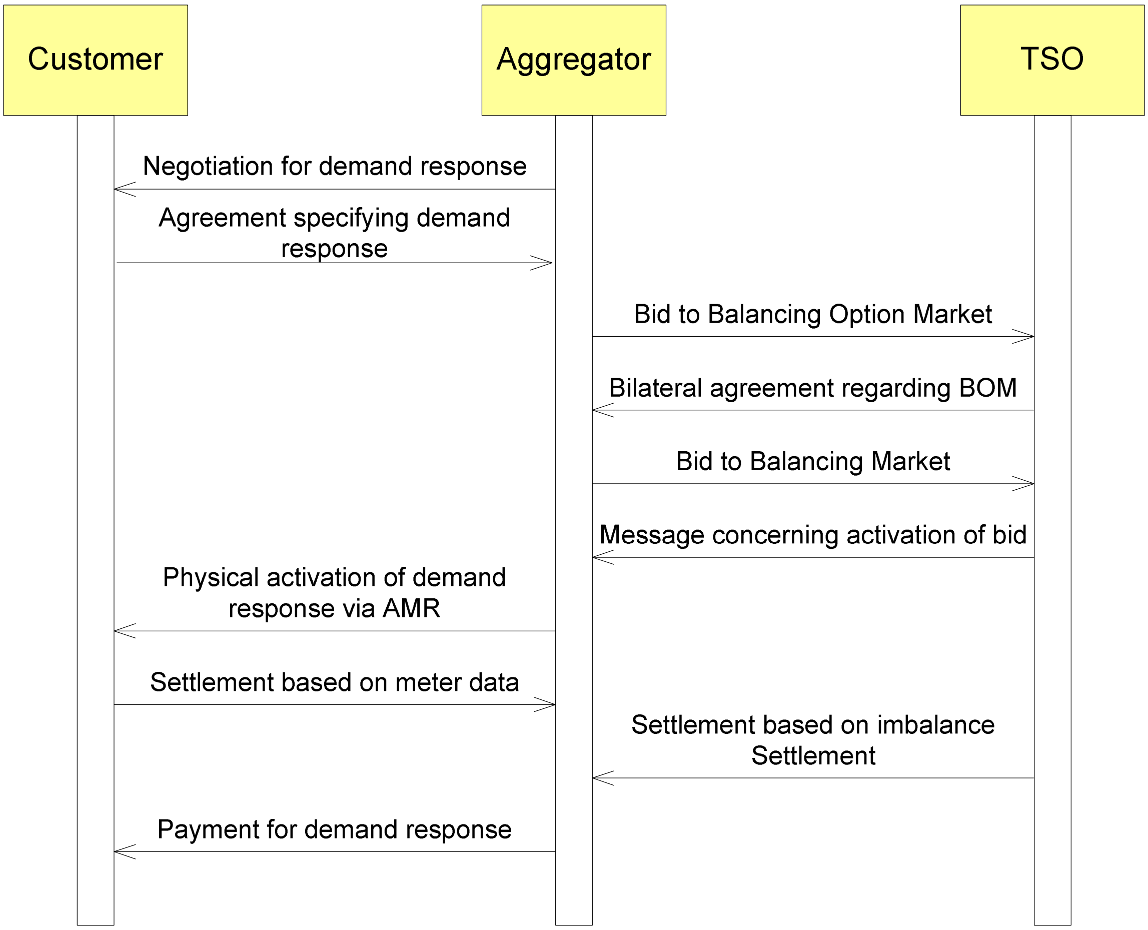

Figure 2. UML representation of flows between actors

8. **Energy flows between the actors:** The disconnection of the different loads at the customer site will contribute to a better balance between production and consumption of electricity in the power system. This does not result in an additional energy flows between involved actors – only reduced consumption is achieved.

   Only customers of TrondheimEnergi Kraftsalg provide disconnection of loads. This is to avoid interference with the power balance for other power suppliers,

Figure 3. Energy flows between the actors

9. **Economic flows between the actors:** From the TSO the Aggregator receives the payment resulted from the bids to both the Balancing Option Market and the Balancing Market. The amount of payment is based on the imbalance referred to the contract in the Day-Ahead market.

   The customers receive the payments from the Aggregator based on individual agreements. The largest customer regarding demand response gets paid based on actual contribution to the Balancing Market. This is because this customer is large enough to operate directly in the Elspot market. The payment to the rest of the customers is based on the payment from the Balancing Option Markets.

   In addition to this payment, the customers get a reduced network tariff for the amount of their consumption that can be reduced. This volume is calculated based on two test-disconnections every winter. (*Reducible load at a customers = Actual demand in "normal" operation – demand when disconnection is performed*)

Figure 4. Economic flows between the actors

10. Mapping role towards *ETSO/ebIX harmonized role model*

Role	***Corresponding ebIX roles***	***ebIX definition***	***Notes***
Customer	Consumption	A party that consumes electricity	
Aggregator	Balance responsible party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market.	*The Aggregator aggregates flexible loads from several customers and participates (in their place) in the Balancing Option market and the Balancing market. In this case the Aggregator is also the power supplier to the customers.*
DSO	Grid operator	A party that operates one or more grids.	*The DSO operates the system control centre.*
TSO	System operator	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The TSO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability.	*The TSO is responsible for operating both the Balancing Option Market and the Balancing Market.*

Part 2: Technologies needed / Investments required

11. **Enabling technologies (non-ICT and ICT):**

Disconnection of flexible loads

The disconnection is initiated by a telephone call from the TSO to the DSO's system control centre.

The technology used for disconnection of flexible loads differ between the customers;

- Electrical boiler in the district heating system is disconnected manually after a telephone call from the DSO's system control centre.
- The AMR technology is used to send a pulse to a signal lamp at the factory refining corn, so they can perform a controlled run-down of the production process.
- Smaller ventilation plants, electrical boilers and heating system are disconnected directly by signalling via the AMR system to the Building Energy Management System at the customer site.

Calculation of flexible demand

Meter data for each customer is exported from the DSO's Customer Information System (CIS) to a dedicated Excel-sheet, where the total flexible demand is aggregated and calculated.

12. **Hardware needed for business case implementation (e.g. Smart Meter, Gateway, etc.):**

Technology name	***Description of functionality***	***Role which need it***
Telephone	Telephone call from TSO to the DSO's system control centre for initiating the disconnection	TSO
Automatic Meter Reading-technology	Remote load control. Sending pulses to signal lamp and BEM-System to start disconnection of flexible loads.	DSO
Building Energy Management System	Performing disconnection of flexible loads	Customer
Customer Information System	Provide meter data for the customers participating with flexible loads.	DSO

13. **Related technologies available in the market or from other research projects**

n/a

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.):**

n/a

15. **Communication protocols and mediums used:**

n/a

16. **Data format/standards:**

n/a

Part 3: Benefits and Obstacles

17. **Benefits to participants (economical and not; operational savings, for each actor):**

    This business model enables small customer's access to the Balancing Option Market and Balancing Market.

    Both the Aggregator and the customers have got economical benefit from this business case. The reduced network tariff is the most important economical incentive the customers. The customers pay for necessary installation at their site and the power supplier pays for necessary changes within the AMR system. The benefits are based on the payment from the Balancing Option Market and divided between the customers and the power supplier after the installation costs are subtracted.

18. **Benefits to society (emissions, efficiency enhancement, etc.):** The main benefit for the society of this business case is increased volume of power reserves in the Balancing Market, which also imply increased security of supply.

19. **Operational costs:** This business case has low operational costs. The operational costs are mainly related to a small payment for the system control centre for activating the disconnection.

20. **Other obstacles in its implementation:** It is difficult to find flexible loads at customers and generally the customers do not want to have their loads disconnected. They concentrate their attention on their core business.

    The prices in the Balancing Option Market have gone downwards since the business case started. Reduction in the option premium and refusal to disconnection among the customers have made this business case less attractive for the Aggregator – but it is still in operation.

21. *Geographical limitations*

    Flexible loads to be included in the bids can only be located within the price area where TrondheimEnergi Kraftsalg operates as balancing responsible.

22. *Regulation related issues*

23. *Lessons learnt (if any)*

    Do it simple!

Business model 9: Conceptual business model for modernisation and developing of CHP and Energy Cogeneration with using of NG (NG-CHP producer contributing to spot and balancing power markets)

Some notes about Polish energy market

Polish Energy Market is still upon modernization being partially competitive The central body of state administration called Energy Regulatory Office was established in 1997 according to Polish Energy Law to control an Energy Market in Poland. It is also responsible among the other for: “granting and withdrawing licenses and approving and controlling of tariff applications for gaseous fuels, electricity and heat, including analyzing and verifying costs adapted by the energy enterprises (DSOs) as justified to calculate prices fees in their tariffs”2.

In Poland: big consumers3 (e.g. industry) and also small consumers (from 2007) can use the TPA (Third Party Access rule) looking for the reseller who deliver electrical energy with distribution (or transmission network) belonging to local monopolist. It means that the Energy Market in Poland is under constant transformation process to be completely competitive and liberalized Energy Market (EM). Fig.1 presents basic relationships in the Polish Energy Market.

Short description of electricity market (Fig1)

Main actors	Role and functional description
Delivers/Generation - All Electricity Producers (with DER)	Each kind of electricity producers (also DER) connected to the system network. Produces energy and sells it to the Global or Local Wholesale Turnover Energy Enterprises on competitive energy market
TSO	Responsible for electrical energy transmission, delivering it to regulated market, as well as for the balancing- and the day ahead markets.)
DSO	Responsible for energy distribution and is part of a regulated market.
GWE and LWE -Wholesale Turnover Enterprises (global and local)	Both Enterprises are Wholesale Turnover Enterprises global – and local and they are responsible for energy distribution (according to source of energy) to the end consumer: for that reason they can be considered as the Aggregators (the term “aggregator” it has not well defined meaning in Poland).
Technical operators and Brokers	Responsible for technical and commercial clearing of accounts and participate in the balancing market; dispatching generator units in the grid..
FC_TPA Customers (using TPA)	Full-rights TPA participant energy market elegible for agreements separate for transmission-, distribution and power

[2] http://www.ure.gov.pl/portal/en/4/22/Presidents_duties.html

[3] Difference between big- and small- consumers are not sharp; big consumer is fed from HV grid whereas small consumer – from LV distribution grid.

FC (Small Customers)	Small Customers fed with regulated (G-tariff); part of the regulated market.

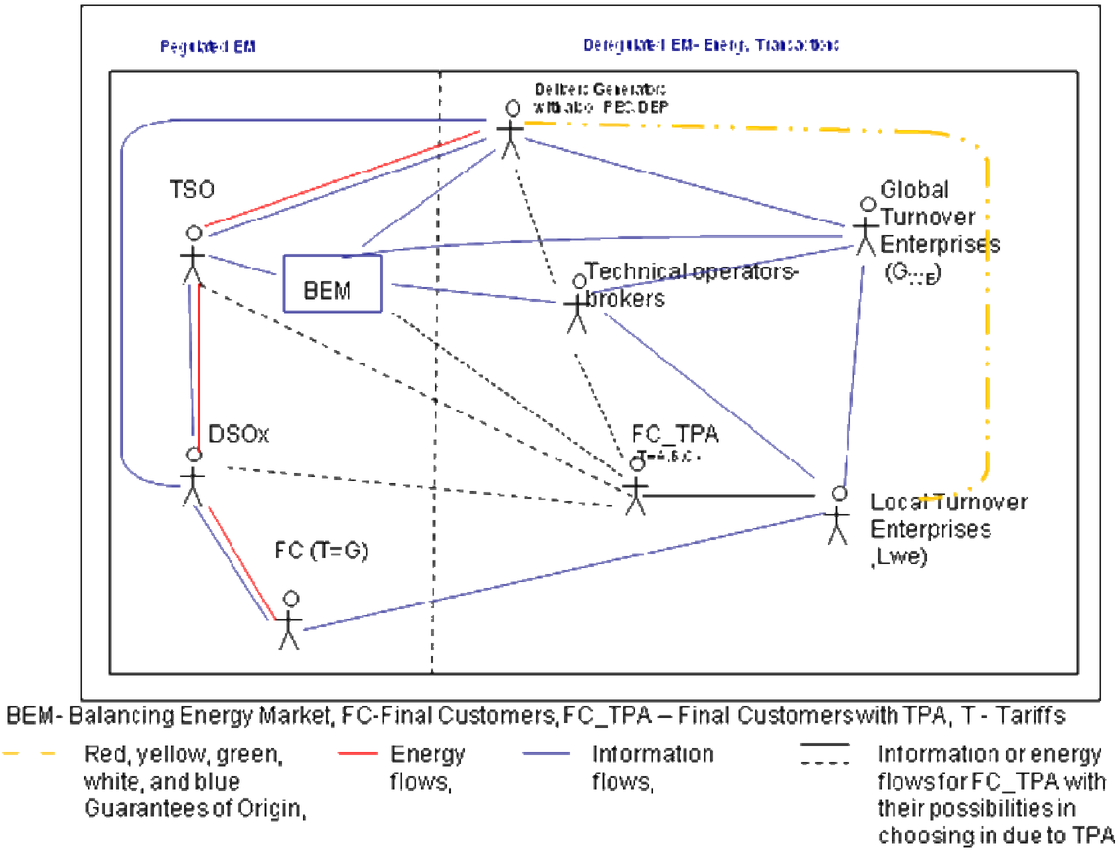

Fig.1. Energy Market Model in PL – relationship

Abbreviations: Gwe- Global Wholesale Turnover Energy Enterprise, Lwe-Local Wholesale Turnover Energy Enterprise, Tariffs=A, B, C or G – energy tariffs in PL according of different kind and users capacities.

Part 1: case description

1. **Location of the Business Case (nation / project that generated the BC):** The Business Case refers to a medium, coal fired CHP in Poland which can not deliver more hot water and electrical energy to growing number of consumers. If a source of Natural Gas (NG) exists near the CHP a gas turbine enabling to produce in cogeneration electricity and hot water could be installed. It is also

possibly to buy NG from big delivers by building linking pipe to the NG grid or to build biomass, collectors (or other RES).

2. **Short description of the case and business rationale:**

   Parallel collaboration of the steam turbine and gas turbine assures:

   - growth of the electrical energy as well as heat production for consumers,
   - cost of modernization is moderate,
   - shorter period of modernization.

   Note: If total capacity of energy produced by steam- and gas- turbine will not exceed 100 MW, the CHP may be considered as DER and to be one of the sources in future microgrid.

3. **Actors involved (companies, organizations and so on):**

   CHP,

   TSO for NG[4], local DSO for NG, (where NG- Natural Gas Market)

   TSO for EM, DSO for EM, (where EM-Energy Market)

   Broker

   Coal Delivers,

   Gas Delivers (and /or RES),

   Retailers for energy (GWE,LWE),

   Utility

   Local Consumers of heating.

4. **Their (logical) Roles in the Business Case:**

   CHP – electrical- and heat- producer ,

   TSO for NG, local DSO for NG,

   Utility – distribution network owners.

5. **Product / Services and related Transactions:**

   - Products: electric energy and heat;
   - Services: The CHP established broker managing relations with retailers and another transactions (e.g. buying/selling cogeneration certificates, energy) buying fuel (Coal, NG) etc.

     The broker operates on behalf of the CHP (CHP would be also as a prosumer) according to contracts. The broker negotiates a contract also with other GWE or LWE[5] on EM, with RES of Gas Delivers and with final heat consumers.

6. **Information exchanged between the actors**:

   Particular functionalities have been presented in Fig.2 and 3 and explained in paragraph 9.

7. **Energy flows between the actors**:

   The electrical energy and heat flows from CHP to receivers.

8. **Economic flows between the actors**:

[4] TSO for NG- it means Transmission System Operator for NG system grid

[5] i.e. Gwe, Lwe technical operators for BEM and others

9. Agreements and settlements between: NG Delivers,(and/or biomass delivers), TSO and DSO for NG market.
   - Inner agreement between CHP and Broker
   - Broker's settlements between[6] TSO,DSO, retailers , heat customer (also PPEX).
   - Bids and settlements on BEM (as an active participant of BEM-it could be),
   - Necessity for standardization of unified energy unit price combining all of natural basic sources for energy production (needed).

10. **Graphical description of the case**

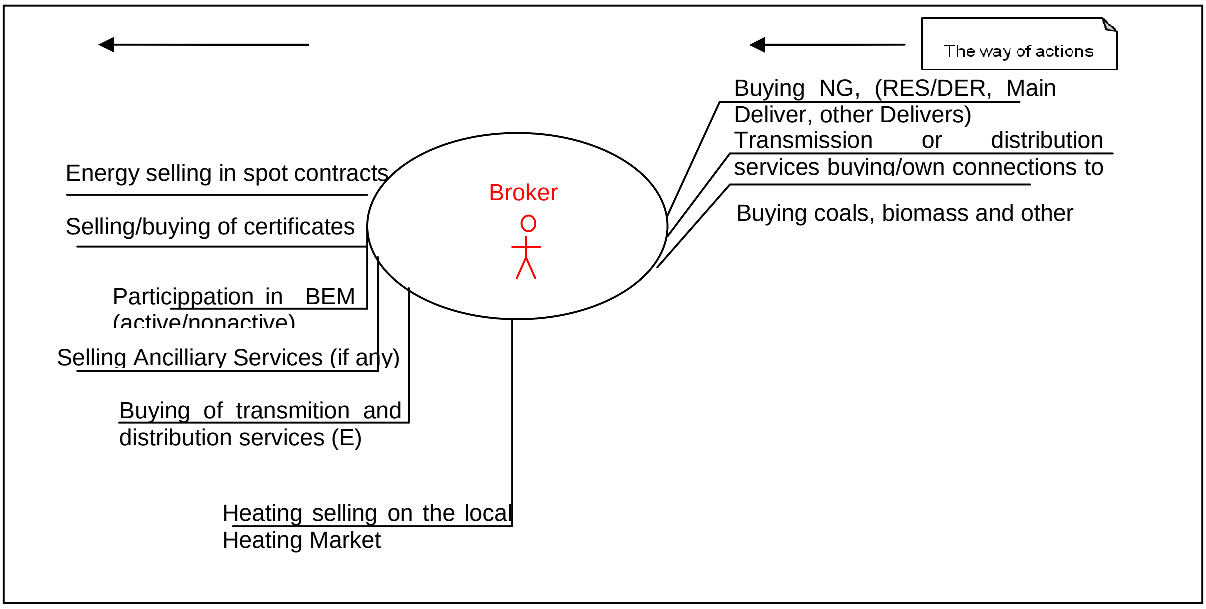

Fig 2.Graphical description of broker's functionality.

[6] According to agreements for transmission- and distribution grid services

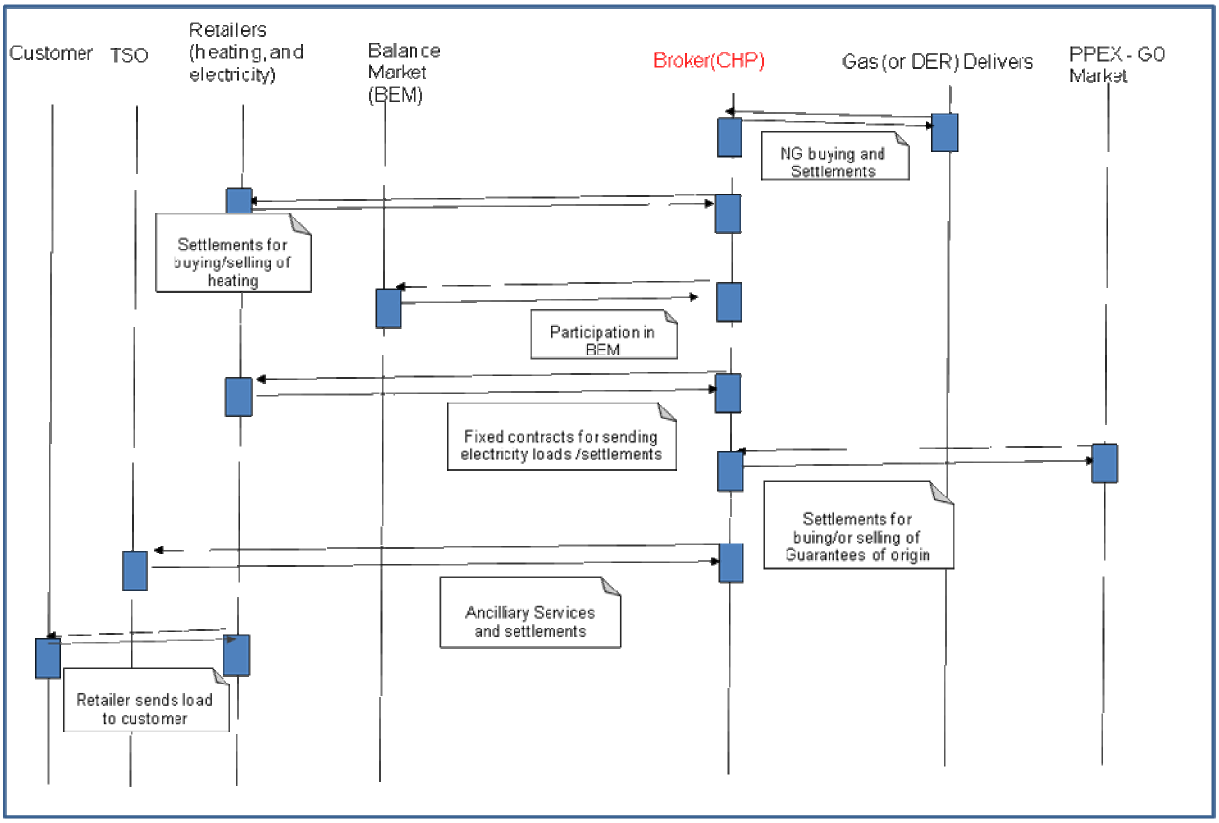

Fig. 3 Proposed Business Model - sequence diagram

Comment to Figs. 2&3

Broker – the CHP controlled company called to manage and control new Business Model for GEM (an unified Energy and Gas Market)

Part 2: Technologies needed / Investments required

11. **Enabling technologies (non-ICT and ICT)**:

    Infrastructure for natural gas and modernisation of CHP as well as ICT technologies like an intelligent metering for energy volume and payments systems, double way communications ICT tools for market and brokers there are needed.

12. **Network parameters (HV, MV, LV..)**

    Parameters as well as a voltage level can be determined when the rated power of the CHP will be defined.

13. **Hardware needed for business case implementation (e.g. Smart Meter, Gateway, etc.)**: Smart Meters and intelligent sensors in each node of the grid are needed.

14. **Communication requirements (reliability, confidentiality, bandwidth, delay time, etc.)**: Exchange of price and bid information via the internet and a dedicated system in real time. Confidentiality must be ensured.

15. **Communication protocols and mediums used**

    Will be defined depending on the CHP parameters.

16. **Data format/standards**

    Will be defined depending on the CHP parameters

17. **Specific software**:

    Will be defined depending on the CHP parameters

Part 3: Maturity Level operational savings, CO_2, efficiency enhancement, etc.)

18. **What is the level of commercialization**:

    Research project

19. **If it is an existing practice, what about its success?**

    The main goal for this project is to set the profitability effects for integrated Market (Natural Gas and Energy) with using NG, DER, modernization and development for CHP by setting new gas/or biomass blocs (third option), growing energy- and high-duty heating generation in cogeneration with NG.

Part 4: Benefits and Obstacles

20. Benefits for participants (economical and not economical; operational savings, for each actor)

- Cogeneration resulting lower price of an electrical- and heat energy.
- Income from selling green-, yellow-, red- and white- certificates (GO Market).
- Limiting CO2.
- Stable delivery of the electrical energy and heat.
- Contract guaranteed level of energy.
- Options for development of NG sources.

21. Benefits for society (emissions, efficiency enhancement, etc.)

- Market based optimisation of production and flexible consumption will help rational exploitation of resources.
- Energy from NG cogeneration, increasing of Energy Efficiency.
- Peak energy delivered to grid and base energy or local consumer.
- Heat production for local market.

22. Operational costs

Depends on the CHP parameters.

23. Other obstacles in its implementation

- Absence of strategy and regulations in energy- and gas market (e.g. gas monopoly).
- High costs of an old CHP modernization.

24. Geographical limitations

Success depends on geographical localization; CHP would be settled near to NG source (as a DER) and/or near to the NG system grid node.

25. Regulation related issues

Depends on the CHP parameters.

26. **Lessons learnt**

Part 5: Bibliography

27. Where to find more information? (Web Site, Scientific Publications, etc.)

Project under development wrapped in strict commerce confidence in economical details.