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Supporting Energy Efficiency in Smart Generation Grids Through ICT

Thematic Network

ICT PSP Programme

ICT FOR DATA MANAGEMENT AND INTER-STAKEHOLDERS SERVICE MONITORING IN SMART GRIDS

(Requirements, ICT solutions available and need for further developments)

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Executive summary

The focus of WP3 is identifying and assessing **ICT solutions** supporting **Monitoring in future Smart Grids** enabling increased **Energy Efficiency** and supporting user **empowerments**.

The following Figure 3.1 captures the expected transition from energy systems of today towards the Smart Grids of tomorrow incorporating vast amounts of **Distributed Energy Sources (DER)** and **Renewable Energy Sources (RES)**.

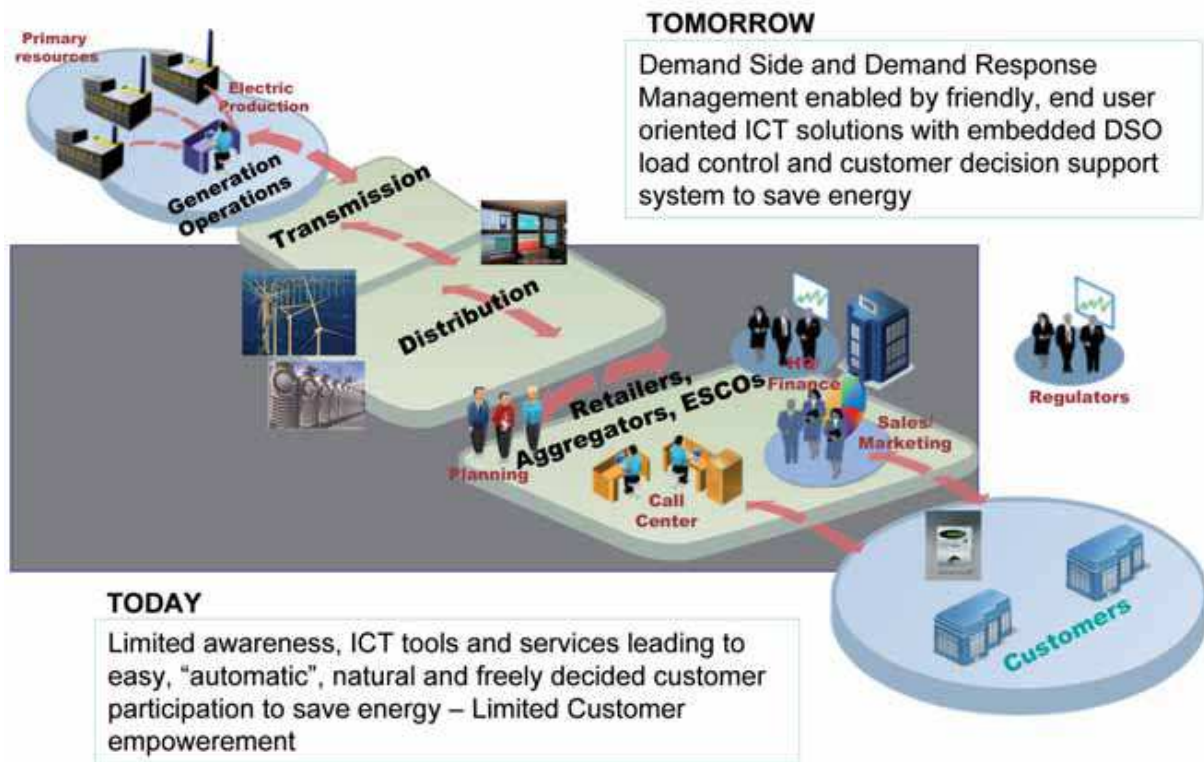


Figure 3.1: Main components and requirements enabling the transition from utilities of today towards the Smart Grids of tomorrow.

In Figure 3.1 the main stakeholders and roles are depicted as well as the path of transformation from Today to Tomorrow related to effects due to the **unbundling** of the energy market. The deregulations and **increased intelligence** in the Transmission and Distribution networks enabled by **smart programmable electronic components** and **smart ICT information management systems** are the two main drivers of this transition.

Figure 3.1 depicts the main architectural components related to the **energy flow** of the future smart grid. The following Figure 3.2 outlines the **information flows** between groups of



stakeholders to enable and support new business models as well as empowerment of the customers¹.

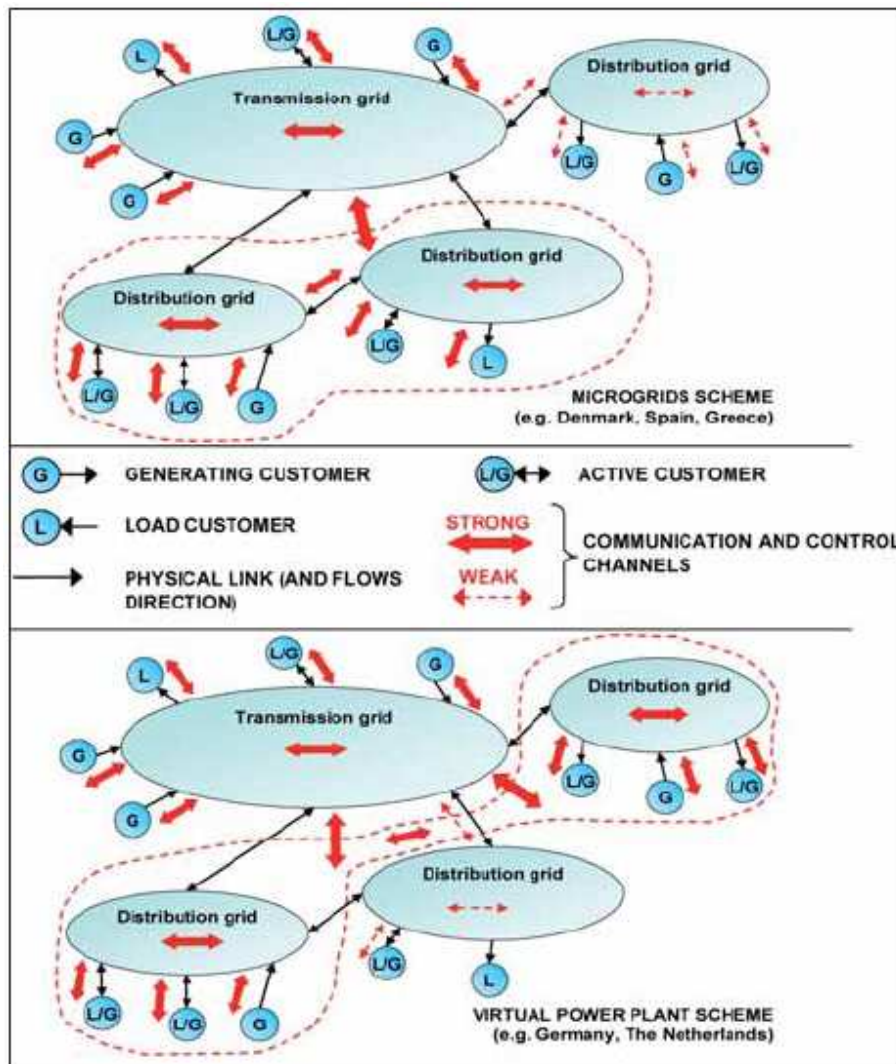


Figure 3.2 Information flows in future Smart Grids.

From Figure 3.1 and Figure 3.2 we deduce **firstly**, that new stakeholders, e.g., Aggregators and Retailers, will interact in Smart Grids between e.g., DSOs and Customers, and **secondly**, we will have **flexible configuration** of stakeholders, such as **Virtual Power Plants (VPP)**. **Finally**,

¹ From *ICT for a Low Carbon Economy. Smart Electricity Distribution Networks* (EC report 2009)



we will need communication networks that must support the energy flow (SCADA) as well as the customer-based business information flows. In short, present SCADA systems have to be supported by novel ICT based information systems to meet the requirements of future Smart Grids.

As a consequence, the **monitoring task** of present day energy systems has to be **re-assessed** and re-designed. To that end we propose to extend the monitoring task in two directions by introducing the concept of **Service Level Agreements (SLAs)** to:

- Allow flexible grouping of stakeholders
- Allow flexible empowerment of users

The remaining part of this deliverable is organized as follows. In **Section 1** we present the **Objectives of WP3: ICT for data management and inter-stakeholders service monitoring**. The section includes an assessment of current monitoring systems (SCADA) and some of their shortcomings to meet the requirements of future Smart Grids. The concept and purpose of SLAs is described.

Section 2 Regulatory aspects related to unbundling EU open market and introduction of Metering Operations is based on two recent reports addressing data management and smart metering.

Section 3 Smart Grid functionalities and SLA monitoring introduces the purpose and means of SLA monitoring as well as an example of monitoring metrics. Issues related to data protection principles and tool based access control is also addressed. The section ends with a paragraph on related work on SLA.

Our approach of addressing challenges and promises of SLA-based monitoring is based on Use cases. The present set of those is presented in **Section 4 Use Cases**. The illustrative example given is on Monitoring voltage control and customer empowerment related to inclusion of massive amounts of DER. Business models and use cases as drivers of future Smart Grids are discussed and exemplified.

Section 5 ICT solutions supporting SLA Monitoring gives a state-of-the-art overview of the topic. Specifically addressing protection from interference of different business processes supported by the same underlying technical infrastructure.

Section 6 Available ICT solutions supporting monitoring, gives a short overview of existing technologies. The Final **Section 7 Future R&D development supporting data management and inter-stakeholders service monitoring** identifies some barriers and possibilities in the form of Platform-as-a-Service (a variant of Cloud Computing) supporting future Smart Grids. The report ends with **Section 8 References**.



1 Objectives of WP3: ICT for data management and inter-stakeholders service monitoring

The **Context** of WP3 is ICT supported and supporting monitoring of two main flows addressing different views of energy-based business processes (Figure 3.1 and Figure 3.2).

- *Energy flux* connects Energy sources (DER, RES) from DSOs, via Aggregators, with end users, enabling *Energy Efficiency*
- *Business flux* integrate Market communication with Customer communication, mediated by Aggregators, enabling added *Customer Value*

Stakeholders

Mainly; Customers, Aggregators, Regulators, TSOs, and DSOs

The **Objectives** identified in WP3 is to support increased **Energy Efficiency** by exploration of Business Cases (Section 4) relevant to:

- Management of the Network (coordinated with WP2)
 - Examples: SmartGrid reconfiguration, Energy management and Adaptive protection
- Demand Side Integration (coordinated with WP4 and WP5)
 - Examples: Support for active user profiling and selling or buying DER resources
- CO₂ emissions (Coordinated with WP 6)
 - Examples: Supporting incentives for increasing Energy Efficiency

In the service-oriented context, a **Service Level Management** (SLM) will provide the paradigm for the implementation of the ICT information based monitoring systems (Section 3).

The SLM is comprised of two essential components:

- **Service Level Agreements** (SLAs), which define the expected service, as is agreed upon among the relevant stakeholders, and the conditions for the assessment of the service itself.
- **Sub-contractors agreements**, which are commitments made by external vendors and suppliers that provide components or support services that are relied upon in meeting SLAs, for example guaranteeing uptime for frame relay connections.

Clearly, the SLM will demand new models and architectures of ICT based monitoring systems to enable and assure the performance and the quality of services.

For instance, classical SCADA (or similar Process Control Systems, PCS) will be increasingly integrated with business management ICT systems via Internet based on interoperability



technologies. This integration will pose new challenges related to performance, data handling, security, reliability, interoperability, and scalability of the new integrated ICT systems².

Figure 3.1 and Figure 3.2 illustrate the focus of WP3 on monitoring SLAs in different configuration of stakeholders (DSOs, Retailers, Aggregators, ESCOs and Customers) and at different ICT layers.

The objective of WP3 is to explore the requirements, state-of-the-art, adequacy and actual gaps of these ICT systems supporting identified crucial Monitoring tasks and to provide recommendations to their development and deployment.

Based on the figures above our aim with SLAs is to set up and monitor business and energy related services between: Customers and DSOs, Retailers, Aggregators, ESCOS, and Metering operators.

In Figure 3.1 the underlying electricity network (Transmission and Distribution Networks and corresponding SCADA systems) is depicted. However, inclusion of RES and DER as well as the necessary ICT systems supporting the system of Tomorrow and its Business processes are explicitly included in Figure 3.2.

This Deliverable D3.2 takes into account inputs from partners of WP3 on earlier drafts. The main objectives of WP3 are stated and concrete use cases exemplifies the main ideas supporting introduction of **Service Level Agreements** (SLAs) as a mean to coordinate and monitor value added energy processes involving different groups of stakeholders in SmartGrids.

Introduction of SLAs is motivated by the increased need of **controlled flexibility and information sharing** of future Smart Grids. Classical models of monitoring, exemplified by **SCADA systems**, are introduced and discussed including their shortcomings to meet the demands of future Smart Grids. SLAs are in fact a superset of **contractual infrastructures** proposed by EU projects such as FENIX and ADDRESS and US efforts such as SmartGRID (below).

1.1 SCADA systems

Traditional, **Supervisory Control and Data Acquisition (SCADA)** systems came as an evolutionary step to telemetry and telecomm and solutions. In the context of power management, they are used to monitor the generation, transmission and distribution of energy flows. Characteristics of SCADA systems are:

- Hierarchical
- Highly integrated
- Supporting simple data models (set points)

Furthermore, they were developed to be operating in a closed, controlled network environment. This is relevant in part due to the sensitive nature of the governed infrastructure, but also because the components that make out the system span a considerably larger period of time

² An overview of important differences between PCS and Administrative ICT systems is given in a report by NIST (http://csrc.nist.gov/publications/drafts/800-82/draft_sp800-82-fpd.pdf).



than other corporate ICT solutions, which implies that a larger span of attack techniques are viable and more likely to succeed than in a more dynamic open or semi-open network such as the internet or an intranet.

However, as the SCADA system is a key component in the retrieval of measurements on the current state of the governed infrastructure, information somehow need to move between the closed SCADA network to other parts of the corporate network. Thus, it is no longer feasible to assume or operate under the conditions of the SCADA network being closed of to the outside world.

As a matter of fact, without added communication systems, a transmission or distribution operator has **no way of determining whether customers are connected** or whether a problem has occurred somewhere in the field. The grid offers no intrinsic way of measuring from one location what is happening in another.

Furthermore, the tight coupling and integration of signals make it hard to “interpret”, “reuse” or “manage” data from a SCADA system. Of course, SCADA systems have also been supported by tools for data management (predictions, analysis) by system administrators. But, in summary, present SCADA systems have to be supplemented by other ICT systems supporting new energy based business processes (energy efficiency) and customer empowerment of future Smart Grids.

A requirement on those new ICT systems is that they have to be less tightly coupled to enable flexibility. The **decoupling** of systems is enabled by a **service oriented approach**, whereby applications are realized by configuration and coordination of services.

A decoupled (and hence more flexible) SCADA system could in fact be realized by a coordinated set of services. Those kinds of SCADA systems could then also be integrated with other (service oriented) ICT systems.

1.2 Service Level Agreements (SLAs)

Service Level Agreements (SLA) coordinates a bunch of services realizing a task. In a sense, the monitoring task related to a SCADA system could be realized as a SLA.

The main idea enabling controlled inclusion of massive DER while maintaining voltage control is to introduce **Aggregators as mediators** between Energy providers and Customers (Figure 3.1). This approach entails two sets of SLAs supporting management and maintenance of the energy balance of the energy systems and flexible customer driven business processes. One set of SLAs is regulating the energy based business processes between energy providers (including DER) and Mediators. The other set of SLAs regulates the Demand side Integration between Aggregators and empowerment of customers enabled by smart meters (Section 4).

In fact, Figure 3.1 allows an integration of relevant ideas and approaches from two EU funded project **FENIX**³ and **ADDRESS**⁴ that support and motivates our approach in this deliverable.

The FENIX concept can be conceptualised as a set of **commercial relationships** between a number of entities. These entities include among others Distributed Energy Sources (DER), Virtual Power Plants (VPP), wholesale energy markets, the Distribution System Operators (DSO) and the Transmission System Operator (TSO). In their interaction with each other, all the

³ FENIX homepage: <http://www.fenix-project.org/>

⁴ ADDRESS homepage: <http://www.addressfp7.org/>



FENIX parties will seek to maximise their revenue, minimize their cost, and manage their exposure to risk, while operating within legal and regulatory limits. In order to allow the FENIX concept to operate successfully, these commercial relationships will have to be underpinned by a robust set of contracts, defining the relationship between parties and their obligations to one another.

The FENIX contractual structure is based on an analysis of shortcomings of present, mostly unidirectional information flows, to meet the communication and coordination needs of future Smart Grids. The proposed **contractual structure** can be seen as a **backbone for our proposed SLAs**.

The ADDRESS project focus on supporting customer oriented **active demand** of future smart grids. The proposed conceptual architecture have the following components Aggregators, Retailers, BRPs, Traders, DG and RES, Markets and contracts, DSOs, and TSOs. The market consists of all kinds of **commercial agreements** between power system participants (such as bilateral contracts, forward markets, real-time markets, power exchange). The basis of interaction between the power system participants is the exchange of **real-time price signals and real-time volume signals**.

Clearly, our proposed **SLAs are supersets** of the proposed commercial relationships of FENIX and ADDRESS. Furthermore, we allow **richer data formats and monitoring mechanisms and rule sets**, including Key Performance Indicators (KPI).

In our Case study (Section 4) Individual DER is characterized by SLA parameters including capacities, voltages and geographic position. The Aggregators will have a global view of the voltages and energy contributions of the set of DER. Tools supporting predictions for demand supply of energy flows managed by the aggregators will enable:

- A controlled global energy balance during variations of inclusions of DER.
- Identified owners of data with assured access control by stakeholders and services (tasks).

Details and motivations of the suggested approach are given in Section 3 and Section 4.



2 Regulatory aspects related to unbundling EU open market and introduction of Metering Operators

The un-bundling of the EU market is in effect since July 1st 2007 and implied introduction of Metering Operators utilizing intensive data communication between the stakeholders (Directive 2003/54/EC⁵).

2.1 Reports

Demand Side Integration (DSI) will empower users by supporting active change of profiles and/or respond to incentives related to Energy Efficiency or price signals. Hence DSI has to take into account Regulatory Aspects and Requirements of Smart Metering. An input to WP3 on those issues is the following two reports:

- **Status Review on Regulatory Aspects of Smart Metering (Electricity and Gas) as of May 2009.** ERGEG (European Regulators Group for Electricity & GAS), Report REF E09-RMF-17-03, 19 October 2009.
- **D 1.2 Report on Regulatory Requirements.** EU FP7 Open Meter Consortium Report, Version 1.1, 2009.

The two reports give a background, from different perspectives, on the topics mentioned. That is; Meter Value Management, Roll-Out Policy, Access to Data and Privacy, Functional and Technical aspects (ERGEG) and European Regulations and National Regulations (Open Meter). Citations from the reports are given below.

Meter Value Management related to Electricity concerns the collection, treatment and use of the data provided by utility meters. The approach to the management is central to market functioning and is the subject of much debate, in particular as regards functional and technical aspects. As smart meters with additional functionalities and offering more data more frequently come online, the question of meter value management will become all the more important. Meter value management is an important part of all metering systems, but it is also relevant for normal metering systems.

Legal responsibilities

In general, who is responsible for the different kinds of operations related to metering services depends on the market system. These services can be divided into the following 5 main operations:

- Installation;
- Maintenance;
- Meter reading;

⁵ Home page: http://europa.eu/legislation_summaries/energy/european_energy_policy/l27005_en.htm



- Data validation; and
- Data management.

In 23 EU member states and observers, these operations are the **responsibility of the DSO**. However, there are also markets where the metering service are liberalised and the supplier or an independent metering company can be responsible.

In 23 countries the installations are managed by the DSO. In many countries the DSO is also responsible for the installation. In most European Member States maintenance of the electricity meters must be done by the DSO. Also most of the metering services are the responsibility of DSO. Hence, the DSO is also responsible for data quality of readings.

Changed responsibilities due to unbundling and new metering operators

To date, only Finland, following a smart meter roll-out, has made changes to the distribution of responsibilities and activities between the entities in charge of the metering operations.

Access to data and privacy

When it comes to discussions about smart metering, data privacy and access to data are important issues from the customer's point of view. General data privacy laws normally address data exchanges in any sector or industry. Smart meters, however offer the possibility to collect much more data (including personalised data) than before. These new functionalities have led to discussions on adapting existing laws to specifically cover meter values.

Irrespective of the presence of smart metering devices, in terms of access to data the Status Review notes that in nearly all cases the DSO has access to most types of data (consumption, historical load curve, quality supply, etc). For electricity, in some countries the current supplier and competing suppliers have access to the customer's data. Customers generally have access to their data, primary through their bills, although not for all types of data (e.g. instantaneous power),

Functional and technical aspects

The definition of minimum requirements for functions, interfaces and standards is a key element of a regulatory framework for an efficient and working smart metering system.

Minimal functional requirements

There are many different functions, standards and technologies which together can guarantee a functional smart metering system:

- Remote control;
- Ability to measure both production and consumption interval of metering;
- Types of communication (one- or two-way communication);
- Communication protocol and technology;
- Data security;
- Storage capability;
- Local communication interface;
- Capability to record different tariffs (price signals).

So far, at least 16 countries in Europe have regulated or discussed some kind of minimal requirements for smart meters. The differences in the countries of the requirements themselves for each standard illustrates that a discussion at EU-level is required to promote interoperability,



standardisation and an effective and efficient approach to smart metering, as this has an direct impact on marketing functioning and customer choice.”

In the Scenario of Figure 3.1 the introduction of Aggregators as mediators between energy providers and customers will enable solutions to some of the issues (DSO centric readings and data management) mentioned in the reports above. In this context we need to address Data Managements in a broader context.

2.2 Data Management

Data gathered from sensory solutions, *such as Smart Meters*, will be central in the actual delivery of services but will also act as basis for the decision-making processes that governs and operates the grid.

Therefore, it is a top priority to ensure the **Confidentiality, Integrity** and (*Trusted-, Actual-*) **Availability** of gathered data (*CIA model of information protection and sharing*) on both a technical and on an economical/political level in order to enable sustainable business cases. To that end, we have identified a set of key concerns that will need to be addressed in both the large-scale and on an actor-to-actor level.

- **Privacy** - The data gathered ultimately pose the risk of exposing habits and usage patterns of individual and/or clusters of actors that it samples, indirectly putting them at risk. Therefore, the data sampled need to be shielded from disclosure to unwanted parties.
- **Validity** - The metering solutions must be able to guarantee the validity of the data sampled, in the sense that it is representative of current, actual events.
- **Integrity** - As the data is likely to travel across the boundaries of several subsystems, some or many of which are susceptible to disturbances from foreign sources, it is vital that the integrity of data can be both ensured and determined at any step on the way.
- **Ownership** - Due to the either overlapping or possible conflicts of interest between parties, the ownership and rights of use in regards to both sampled and processed data will need to be clearly defined and governed.
- **Capacity** - Each solution imposes its respective limits of capacity on the data in terms of size and quantity and measures need to be taken in order to assure that the configuration of technologies combined with the data model(s) do not exceed its inherent capacity for data management.

Thus, the implementations that address these concerns need to cover the **entire chain of data processing**-- from the metering solution to the distribution, aggregation, processing, storage and presentation.



3 Smart Grid functionalities and SLA monitoring

The following definitions of Smart Grid functionalities and characteristics captures some of the challenges related to data management and monitoring we address in this deliverable.

US Department of Energy (DoE) identified the following functionalities in June 2008:

1. Optimize asset utilization and operating efficiency⁶
2. Accommodate all generation and storage options
3. Provide power quality for the range of needs in a digital economy
4. Anticipate and respond to system disturbances in a self-healing manner
5. Operate resiliently against physical and cyber attacks and failure disasters
6. Enable active participation by consumers
7. Enable new products, services, and markets

The vendor ABB has listed in a White paper 2009. A Smart Grid is:

- Adaptive, with less reliance on operators, particularly in responding rapidly to changing conditions
- Predictive, in terms of applying operational data to equipment maintenance practices and even identifying potential outages before they occur
- Integrated, in terms of real-time communications and control functions
- Interactive between customers and markets
- Optimized to maximize reliability, availability, efficiency and economic performance
- Secure from attack and naturally occurring disruptions

3.1 Monitoring processes

The traditional SCADA systems were designed to monitor **industrial processes** such as generation, transmission and distribution of energy (Section 1.1). Several shortcomings of those systems have been identified in regard to implement future Smart Grids. In effect, there is an international agreement that we have to complement the SCADA systems with advanced ICT solution integrating smart networks components (IEDs), adopting open communication standards such as IEC 61850 and supporting empowerment of customers by providing new kinds of energy based-services. But also taking into account massive Renewable Energy Sources (RES) in smart distribution systems. The challenge is not only to monitor advanced industry processes but also related **business processes**.

In many aspects we can compare the challenges of designing, implementing and maintaining the future deregulated energy market with the deregulated telecom market. In the latter case tariff-centric telephone services have been replaced with more flexible contracts between providers and users of advanced new (and old) services enabling (and being enabled) by new

⁶ Energy losses in the transmission and distribution system nearly doubled in the U.S from 5 percent in 1970 to 9,5 percent in 2001.



kinds of infrastructures. The need of flexible contracts has led to different types of **Service Level Agreements** (SLAs) and their monitoring.

Undoubtedly, the deregulation of the energy market and the realization of Smart Grids is today much less advanced than the efforts on the telecom market. An example is efforts by the **TM Forum**⁷, an industry consortium in communication service providers and network operators, exemplified by the **SLA Handbook**.

Today, the preparedness of stakeholders in the energy sector to adapt to a **service based energy market** is uncertain, not the least towards introduction of SLAs as critical enablers of new energy-based business processes. In short, the unprepared-ness to assess the potential of SLAs is at present a **barrier** of implementation of SmartGrids. Despite planned large investments worldwide in Smart Grids actual deployment still represents a major departure from current utility practices. For an industry with time honored focus on reliability and certainty in the application of new technologies, the shift to smart grid present a daunting challenge. However, an exception is the US effort NextGRID⁸ that have, for instance, issued **SLA Template Repository Use Cases**.

The reminder of Section 3 is organized as follows:

The Roles of stakeholders, scope of monitoring and Key Performance Indicators (KPI) are addressed in Section 3.2 **Service Level Agreements. Data models and data managements** are addressed in 3.3, while **Tools and access models** are described in Section 3.4.

3.2 Service Level Agreements

The area of **Service Level Agreements** (SLAs) as a mean to clearly state, coordinate, and monitor business processes has gain considerable interest both in R&D communities and industrial settings nationally and internationally in response to efforts on opportunities of future markets of services. The EU FP7 programme includes ICT efforts such as Software & Services Architecture and Infrastructures⁹ and projects such as RESERVOIR¹⁰ and SLA@SOI¹¹ and European Test Platforms such as NESSI¹² (Networked European Software & Services Initiative).

SLAs have a background in **tariff-based** agreements between customers and energy or, e.g., telecom providers. Increased complexities, such as quality of service, paved way for more or less flexible **Service Level Agreements** (contracts) between consumers and producers, specifically in the telecom sector. Future Business processes in future SmartGrid environment evidently will benefit from a SLA-based approach towards delivering and monitoring of value-added services to customers.

⁷ TM Forum Homepage: <http://www.tmforum.org/browse.aspx>

⁸ NextGRID homepage: <http://www.nextgrid.org/>

⁹ Home page: http://cordis.europa.eu/fp7/ict/ssai/home_en.html

¹⁰ Home page: <http://www.reservoir-fp7.eu/>

¹¹ Home page: <http://sla-at-soi.eu/>

¹² Home page: <http://www.nessi-europe.com/>



Present day SLA typically identifies bi-lateral agreements between producer-consumer of services with a fixed set of criteria, including time span of duration for the agreement.

The following template of SLAs aims at capturing the unifying features of SLAs addressed in WP3. Basically SLAs will coordinate and monitor a selected set of services, e.g., a **service bundle**.

Template: Dynamic Service Agreements

Supports and empower active users

- Identification of stake holders and their roles
- Identification of services belonging to a service bundle (task)
- Identify service description terms
- Guarantee Terms: defined as ranges or as functions (allows flexibility and changes)
- Service Level Objective: defined as ranges or functions (allows flexibility and changes)
- Key Performance Indicators (KPIs). Metrics
- Certificates for Providers and Consumers
- Data management criteria
- Privacy criteria
- Policies and actions in detection of SLA violations

The monitoring of SLA can be divided into three types of monitoring

- Predictive monitoring (Proactive)
- Live monitoring
- Post monitoring (audit/trial)

Predictive monitoring: The predictive monitoring provides the prejudgment by looking at the current system logs/information and based on historical data and probability try to predict the future loads and usage and will provides a safe measure for the operators to act before anything happens.

Live monitoring: it's the monitoring of the system in real time, if anything happens it will be notify immediately to the operator.

Post monitoring (audit/trial): Audit trial is the post checking of the logs and looking for any faults/quality metrics and recalculating of the quality factors based on daily/weekly/monthly logs. It is used mostly where the situation is not critical and the service provider and customer can have time to renegotiate and have settlement after the provisioning of service amicably.

Each monitoring type has its own pros and cons, but based on the situation one can easily select any one or any combination of the three monitoring aspects.

Monitoring SLAs comes down to three sub-asks:

- (i) **validation** of stakeholders and their roles and the conditions of the SLA, including monitoring the rules and policies of data management and privacy,
- (ii) **monitoring** the value set of parameters of Guarantee Terms and Service Level Objectives, e.g., **monitoring metrics** and
- (ii) taking **actions** in cases of violations of SLAs.



Sometimes we can judge the value of a service by monitoring a crucial metric in a SLA. However, we might also evaluate a composition of metrics and/or the other measures such as QoS (below). For instance when assessing **KPI of a SLA over time** or from other points of view.

The following Figure 3.3 Illustrate the **SLA compliance Quality of Service (QoS)**. QoS serves as a benchmark to differentiate between services. However, the autonomy of service providers implies that the provider may defect in the course of service delivery, and not accurately deliver the quality agreed upon within a Service Level Agreement (SLA).

It becomes necessary, therefore, to measure how “trustworthy” a provider has been in complying with the agreed levels in the SLA in the past. A Quality of Compliance (QoC) is proposed which provides a mechanism for assessing the level of compliance of the service provider to an SLA, and therefore gives an indication of the actual service quality delivered. The QoS metrics determine the service usability and utility, both of which influence the popularity of the service. It comprises of techniques that aim to bring a balance between the needs of the service consumer and those of the service provider – while being constrained by the limited network and server resources. Delivering QoS is a critical trust mechanism.

The use of credentials is to ensure the correct identities of stakeholders of the SLA and their access to information.

In computing QoC we might need some of the following calculus:

- For each QoS metric, the QoC service computes the difference between the predicted or suggested value, and the actual value delivered.
- We can therefore consider the SLA to be a vector: $SLA = \{m^1, \dots, m^k\}$ of metrics that need to be satisfied. The measurement service, below, establishes the actual values of the SLA vector.
- The projected value m^i is the value that the service consumer and provider have agreed upon, and is defined in the SLA.
- The actual value m_a^i is the value that the service provider delivers, and is measured by the monitoring service
- In the context of an SLA, therefore, we can determine the deviation $\Delta M^i = m^i - m_a^i$ for the i^{th} metric ($1 < i < k$) – leading to:

$$\text{normalized } \Delta M^i = \frac{\Delta M^i}{m_a^i}$$

- This normalized value allows us to ensure that we can fairly compare (within some limited bound) different metrics. A positive value occurs when the actual value is less than the projected value, and vice versa.

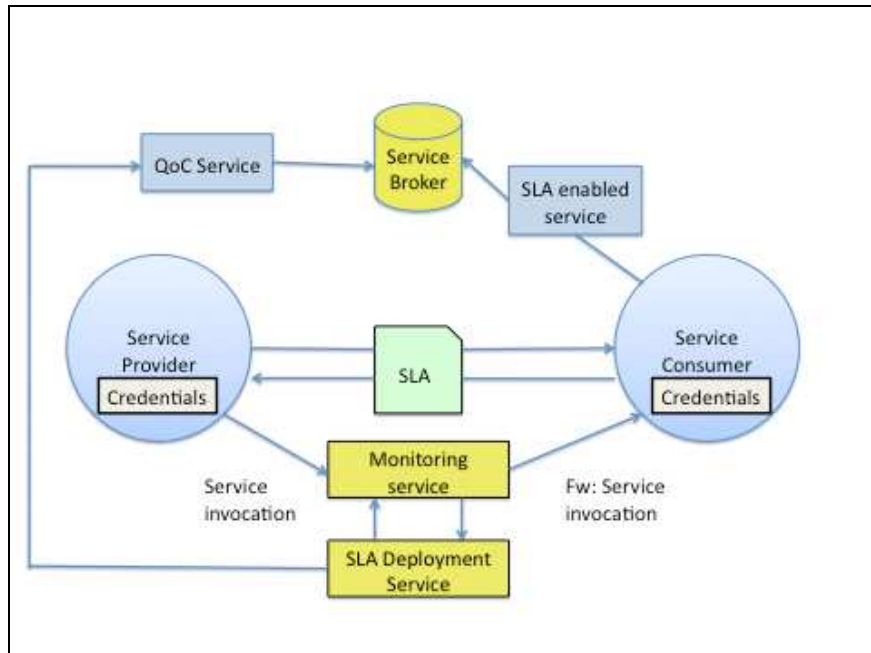


Figure 3.3 Measuring SLA Compliance

Monitoring services

The **Monitoring Service** of SLAs is responsible for monitoring service invocations, detecting any violation of service level objectives and sending action guarantees to responsible parties. The supporting services are:

- **Control service:** propagates the obligations between the Sub-services and control the interaction between them
- **Measurement service:** maintains run-time information on the metrics that are part of the SLA.
- **Evaluation Service:** compares measured SLA parameters against the thresholds defined in the SLA and notify the Action Service
- **Action service:** notifies the responsible parties.

In Section 4 **Use Cases** we exemplify the fill in slots of the SLA template given above.



3.3 Control loop and monitoring of SLAs

The monitoring processes of SLAs implements parts of the **four-stage autonomous control loop**¹³; Collect, Analyze, Decide and Act (Figure 3.4).

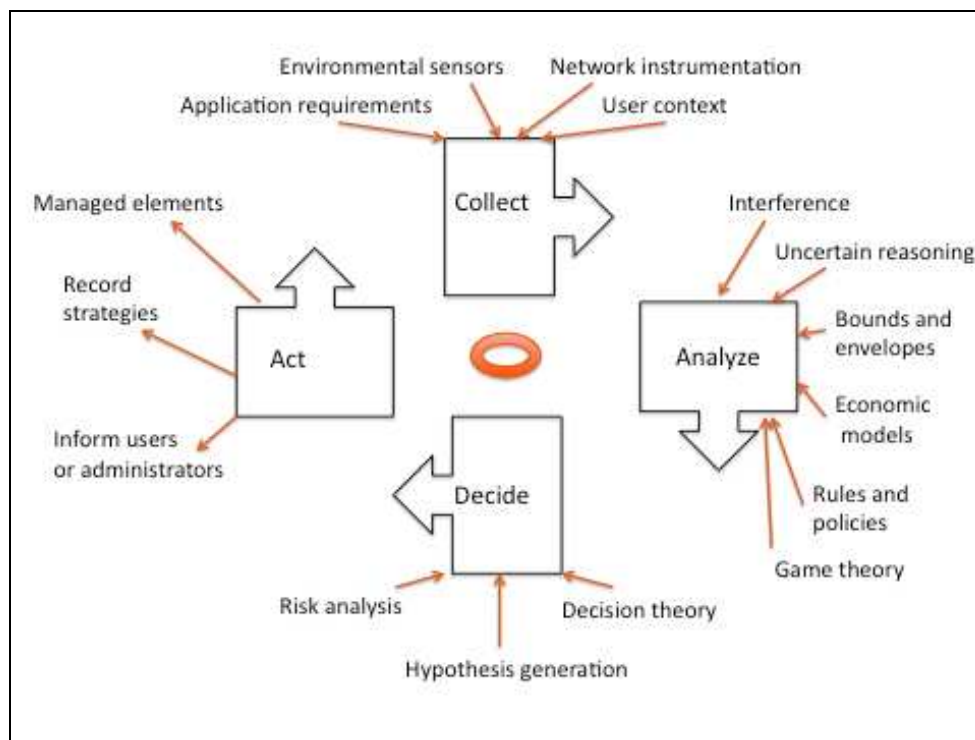


Figure 3.4 Technologies applied to the four stages of the autonomous control loop

The control loop of Figure 3.4 is inspired from Control theory. However, the structure encompasses symbolic and other techniques within the common framework of autonomous computing as well as aspects of both computing and communication. Moreover, the control loop itself is driven by the coordination mechanisms of the SLAs at hand and the relevant parameters, rules and policies.

3.4 Service level data and data models

The need and purpose of data models and data management was given in Section 1. Here we focus on data models and management related to setting up and monitoring SLAs.

¹³ Adopted from: Fulfilling the vision on Autonomic Computing. *IEEE Computer* January 2010, pp. 35-41



There is a trade-off between richness of data models and the complexity of their management. The needed expressiveness of SLAs is a key requirement.

3.5 Tool based access control

Access to data by actors or services/tasks has to be restricted and monitored. In many cases the access and processing of data can be facilitated by tools, e.g., Smart Meters, implementing proper access control mechanisms such as **Role-Based Access Control (RBAC)** or **Policy-Based Access Control (PBAC)**. Furthermore, the data processing and management by the tool could be monitored to ensure compliance with rules and procedures.

At present there are several ongoing international R&D efforts, not least within EU FP7 Programmes, focusing on implementing mechanisms ensuring **trustworthy ICT Services**.

In particular, new trustworthy tools for authentication of users are being developed by IBM and Microsoft. Those tools are based on **credentials** thus enabling authentication of users while providing protection of privacy,

The following Figure 3.5 captures the main aspects of tool based access control.

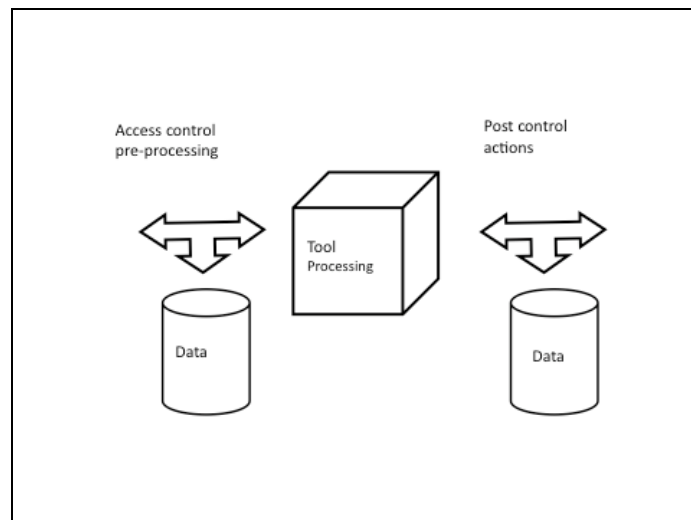


Figure 3.5 Principles of tool based access control

3.6 Related work

3.6.1 Ontology based approach for SLA obligations monitoring

In the paper [1] an ontology-based approach towards SLA monitoring is suggested. Challenges in service oriented computing require to monitor QoS contracts to detect and handle violation. Considering these challenges the author elaborated a complete, generic, and semantically richer ontology based model for SLA.



The main focus of this paper is modelling and monitoring of SLAs based on ontology's. The author has introduced complete model for monitoring the SLAs in SWRL (Semantic Web Rule Language). The rule based language will facilitates SLA monitoring and provide action triggering in case of violation. One of the advantage of SWRL is it generates semantic-enabled QoS obligation monitors.

End users want clear QoS agreements from service provider and also claims refined contracts, pricing, benefits and penalties in case of service violations. Interoperability between several services in different organizations leads to complex system which is difficult to evaluate, manage and maintained.

To handle such situations they designed ontology called SLAOnt based on OWL and SWRL. It provides an understandable language to both machines and humans. This method is a one of the well structured model for SLA monitoring and it also sends the message to signatory parties about the violation occurred.

3.6.2 SLA Monitoring and Management Framework for Telecommunication Services

In the paper [2] SLAs in telecommunication sector is addressed. The Service Level Agreement Management (SLAM) is the most demanding functionality for progress in QoS services and dynamic interactive control and monitoring of telecommunication resources. In this paper SLA Monitoring is described and implemented under SLA management framework for telecom service providers' Eureka project.

The most innovative part in this research concerns components for monitoring layer data transformation and their propagation to SLA management subsystem. The logical architecture of SLAM framework is composed of different levels containing Service Access Points (SAP). SLA Object representing SLA contract consists of set of common SLA parameters and SLA KPIs and it is instantiated according to SLA template. All parameters of services and SLAs are calculated continuously with configurable time period.

This computation approach has been identified as the most suitable for updating parameters of the SLA objects also known as service level objectives (SLO). Historical or outdated data coming from network infrastructure (events, KPIs) helps to improve the results of evaluation of parameters of service and SLAs. In the events and KPIs processing three main modes have been implemented to manage the SLA contracts to provide real time reporting with alarm, on demand reporting with reporting module and automatic schedule reporting with separate reporting module.

Sensitive point of the proposed solution is the SLA evaluation procedure. Splitting this procedure into 'near real time' and 'long-term' phases seems to be the only solution which could satisfy rather general needs. The future work can be done for the closed loop as the SLAM system here follows an open loop control model without feedback between observed SLA values and activities that should be taken on network infrastructure layer to achieve SLA objects.



3.6.3 Establishing and Monitoring SLAs in complex Service Based Systems

In the paper [3] the author described the process of establishment SLA framework, and then proposed architecture for monitoring of SLAs.

The link between SLA negotiations and monitoring of Service Based System (SBS) is discussed. It is stated as how during negotiation service providers require historical data from monitoring to evaluate SLA offers made by service customers. Composite Services (CS) and Atomic services (AS) are deployed on infrastructure services providing virtualization techniques, provisioning of CS to a customer regulated by SLA. From a CS provider perspective the provisioning of the SLA is based on a complex hierarchy of SLAs established with atomic and infrastructure services.

The proposed framework is generic in order to accommodate difference real-world scenarios, including both intra and inter-domain SLAs. Life cycle of SLA starts with its negotiation where service provider and customer exchanges messages. In negotiation phase both parties are using knowledge and assumptions for maximizing their profit and value of SLA at hand. SLA negotiation introduces two requirements for SLA monitoring, first one is monitoring should allow collection of SLA violations during the provisioning of a service under the terms of an SLA. Secondly, monitoring should be able to assess the monitor ability of the guarantee terms specified in a SLA offer made by an agreement initiator to an agreement responder.

The architecture of SLA monitoring framework relies on capturing runtime information during SLA provisioning at the difference services of the managed by suitable event handling and making it available to difference components of the monitoring framework. This relationship between negotiation and monitoring cannot be disregarded, especially in such complex hierarchies and how a SLA hierarchy reflects on monitoring hierarchy. Finally the complete theme of this paper focuses on mechanisms for SLA offer negotiation on the consumer side and on how consumer-generated monitoring data may be integrated in service provider SLA monitoring frame work.



4 Use Cases

Our identified use cases are:

- Service Monitoring between TSO & DSO focusing on Network (coordinated with WP2)
- Service Monitoring between DSO, Suppliers and Customers focusing on Demand services (coordinated with WP4 and WP5)
- CO₂ Emission

4.1 Management of the Network

The following tasks have been provided by WP2 to take into consideration for monitoring of SLAs:

- SmartGrid reconfiguration
- Energy Management
- Adaptive protection

In the area of Energy management **Voltage control** has been proposed. The importance of voltage control as a **key limiting factor for introducing DG** in 30 kV network has been identified.

“Without massive grid reinforcement, additional generators would frequently be switched off by over voltage protection. Keeping the voltage between the defined limits is becoming a major concern of DNOs (DSOs). Increasing level of DG penetration causes the voltage to rise above limits, presenting risks for customer equipment. Without local voltage control, systems with high penetration of distributed energy resources are likely to experience voltage and/or reactive power excursions and oscillations.

Keeping the voltage between the defined limits is becoming a primary concern of DNOs. Increasing level of DG penetration causes the voltage to rise above limits, presenting risks for customer equipment. As the present DNOs voltage control equipment is only able to handle limited amount of DG, the modification, replacement and new installation of different equipment is necessary to increase the DG penetration on distribution networks. Loads, the impedances, power exported by the DG and the distance of the DG from the primary substation are the most important factors causing the changes in the voltage profile.”

In a report from WP2 the architecture for a **Communication system for coordinated voltage control** is given.

Management of DG penetration is at present the responsibilities of DSOs (Section 2). However, **aggregated** effects of DER penetration and use could be monitored via SLAs connecting customers and Retailers, Aggregators, ESCOS and Metering operators as proposed in our **Integrated approach** (Figure 3.1 and Section 5.2). The introduction of a **third (trusted) party** between DER providers and DER consumers will enable a **separation of concerns related to DER monitoring** much in line with the proposed solutions of FENIX and ADDRESS (Section 4.2).

Our Integrated approach combines voltage control with empowerment of the user as a **service monitoring controlled integration and use of DER** (Section 5.2).



In the specifications of SLAs involving DER we, among other things, specify the **location** (geographically and/or network specific) of DER. This gives us options to resolve voltage and/or usage violations of relevant SLA by invoking **other** Network services such as SmartGrid reconfiguration and/or adaptive protection. In effect the service Voltage control might have links also to the services Network reconfiguration and/or Adaptive protection on the network side. The DER consumption on the other hand can be connected to user services related to, e.g., CO₂ emission or Energy Efficiency. In short, there are several new opportunities of new value-added services enabled by SLA bundling by different stakeholders in Figure 3.1. However, in this report we only address the typical service of **Monitoring voltage control and customer empowerment** (Section 5.2).

Adaptive protection is another task from WP2 that could itself partially have use of a SLA-based monitoring. Adaptive protection might, for instance, be supported by monitoring of SLAs involving sensor networks.

4.2 Demand Side Integration

Demand Side Integration aims at empowering the customer with tools that enable him/her to take an active part in energy efficiency activities and/or environment protections.

Smart Meters and smart metering is a key enabler for DSI (Section 2). An identified task related to DSI is setting and changing user profiles. We can identify a spectrum of tools, depending on SLAs, supporting an active user (Section 3.4). Inclusion of services managing and controlling home-based equipments could increase the incentives of customers to participate in Energy Saving or CO₂ reduction initiatives.

The corresponding SLAs could be gradually expanded from simple templates. It is here important to couple those SLAs to existing or planned roll-outs of Smart meters (Section 2).

4.3 CO₂ emissions

Information has to be provided by partners. In effect, there could be contributions to less emission by:

- Changes to higher penetration of RES
- Improved efficiency of power generation-transmission and distribution
- Empowering active customers

One use case is that the customer wants to utilize “Green Energy”, for that he/she might want to pay little more amounts as compared to what he/she is paying now. But in order to make sure about the source of energy, he/she want to make sure that he/she is getting what he/she paid for. But due to limited DER resources it might be problematic for the aggregator to accommodate customer more than a certain limit. The other solution is to priorities based on profile of the customer or provides a monthly/weekly/daily schedule for this type of resource management to all customers.

The above case present scenario more demand for DER integration and RES in energy sector. That will eventually leads to better CO₂ emission and empowering the customer by realizing the true potential of free/open market.



4.4 Voltage control and Customer empowerment

In Section 1.2 we suggested an integrated monitoring approach by introducing two sets of SLAs. One set is regulating the energy based business (voltage control) between energy producers and Aggregators. The other set of SLAs regulates the Demand side Integration between Aggregators and empowered customers supported by Smart Meters.

The corresponding SLAs are further described in Section 5.2.

4.5 An integrated approach of translation of use cases to SLAs

In this section we outline the process of translating use cases or business models into SLAs. The input to this section has been provided by VTT. In this section we give a short description of the provided to illustrate our translation process. A full description of the use cases are given in Appendix A.

In service oriented computing the modeling of SLA is presented in the Figure 3.6 below. Normally the SLAs are between two parties, one is the producer and the other is client. Publisher will act as a market, where producer and buyers meet and exchange values. In order to facilitate this negotiations/ transactions different parameters (SLOs) should be defined, measured and monitored for the effectiveness and efficiency of the smoothly delivery of service to the end customer. In our case we will extend the SLAs to typically involve more than two stake holders. Occasionally the stake holders can be grouped as classes of Clients or Providers.

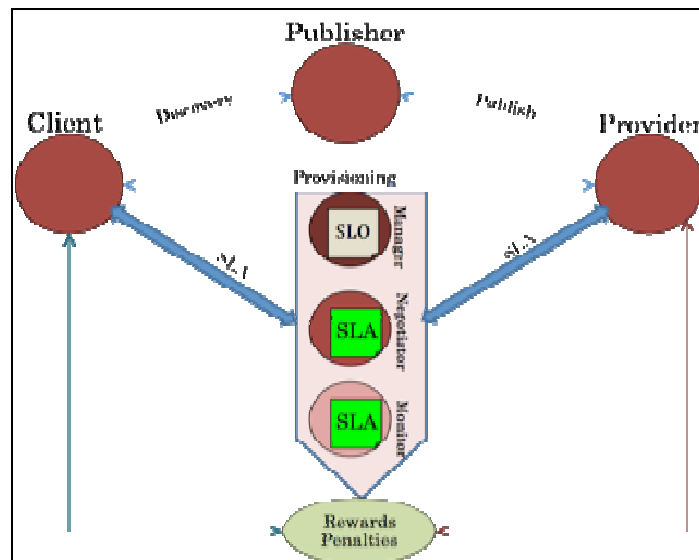


Figure 3.6 Main components of Service Level Agreements (SLAs)



A business use case is normally presented on a template identifying stakeholders, their roles and responsibilities, action points and the flow of information within the specified entities. The general business use case have of the following parameters.

- Describe the activities involved in this specific business process (Goals/Objectives)
- Who are the actors involved?
- What is their role and responsibility to achieve a particular goal?
- What are their relation and the constraint regarding those relations?

The SLAs also defines the types and value set of parameters to be monitored such as set points (allowed intervals) and Key Performance Indicators. Furthermore, rules of changing of the SLAs, rules when some SLA criteria is violated and rules to apply at break-downs could be included.

We have the following generic template for SLAs:

Service Name: Generic Name of Service

Service description: The following details should be listed, to define the boundaries of the service

- Service scope: Scope should contain parameters about general information about the agreements and the constraints in more general terms.
- Service requirements: What are the requirements for the provisioning of this service, any interaction or reliance with other agreements.
- Service function

Roles & Responsibilities: list the number of stakeholders and their roles and responsibilities accordingly

- Parties
 - Roles
 - Responsibilities

Service performance level: List of different parameters with specific units and frequency to monitor each individuals unit. These are also termed as Key Performance Indicators (KPI) and we can add threshold values in relation with the stakeholder, service breakdowns and penalties.

- Quality parameter (factors)
- Metrics, frequency
- Threshold values

Breakdowns: List of possible breakdowns with action for different stakeholder to repair the service in specific time duration.

- Response time/duration
- Primary responsibility
- Secondary responsibility

Penalty: Penalties having financial or technical aspects, related to service provision or rewards in points dependent on the agreement.

- Party
- Parameters
- Metrics



To determine the **service quality**, two main approaches will be used.

- Service assessment: The criteria are based on the functionality of the service, and are normally used after the utilization/provisioning of service.
- Run time Judgment: To make effective use of service, another approach is to look at runtime non functional agreements and provide quick feedback/actions based on some predefined agreements.

Our approach is to implement and measure those non functional requirements as **machine readable quality metrics**. Quality can be maintained by monitoring the threshold values of those factors. A grouping of such factors in the form of rules is known as Service Level Objectives (SLO). Each SLO must contain the specific, measurable and time bounded service parameters that can be easily monitored, aggregated and processed by the use of ICT. Each SLO has an impact on the stakeholders i.e. the relation between different entities involved in service agreements.

A good way to present relationship and dependency between stakeholders are in the form of logic. SLA can be defined using declarative specification with different rules set governing behaviours of each entity according to their roles and responsibilities. Now-a-days rule based systems are stable enough to handle such type of transactions in multi actors' dependent systems or complex system, where the action in local behaviour of small entities create a emergence at a global level. Multi-agent systems are best suited for simulating such environment to look at different aspects of emergent situation that is difficult to perceive because of feedback loops.

4.5.1 Aggregator based business models

In the following we briefly describe the aggregator business models that we have selected in our investigation. These business models (use cases) have been chosen from national and European projects that are familiar to the participants of SEESGEN –ICT.

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 A. We should note that **end users in those business models are mostly DSOs and not regular customers**. This fact might be due to present regulations (Section 2). The selected business models are:

1) Power re-profiling when called upon

Description of the service:

The aggregator agrees to provide demand reduction/DG increase in the specified transmission system or network area during the time intervals.

Attributes of the agreement:

- Demand reduction, x MW.
- Maximum duration of a single demand reduction
- Minimum recovery time between load reduction requests
- Time periods when the agreement is applied
- Maximum total duration of reductions within a year or a day



- Minimum lead time (how much before the service buyer must ask for the reduction)
- Transmission area (for BRP), transmission system nodes (for TSO) or area within a distribution network (DSO) where the demand reduction is applied

Verification of the response:

- Model based estimation of the responses from power measurements at the power grid (immediate verification)
- Measurements at the kWh-meters of individual customers or even individual appliances. (verification afterwards)

Penalties for failures to give response:

- Fixed fee per MWh of non-delivered response. (response delivered too late or not at all)
- Fee based on the prices of the balancing market.

Comments:

-It depends on the rules of the specific system to what extent DG increase can be treated similarly to demand reduction.

2) Fixed schedule power re-profiling

Description of the service:

The aggregator agrees to provide demand reduction/DG increase in the specified transmission system during the time intervals specified in the agreement with service buyer.

Attributes of the agreement:

- Demand reduction, x MW.
- Time periods when the load is reduced

Verification of the response:

- Model based estimation of the responses from power measurements at the power grid (immediate verification)
- Measurements at the kWh-meters of individual customers or even individual appliances. (verification afterwards)

Penalties for failures to give response:

- Fixed fee per MWh of non-delivered response. (response delivered too late or not at all)
- Fee based on the prices of the balancing market.

Comments:

-It depends on the rules of the specific system to what extent DG increase can be



treated similarly to demand reduction. E.g. can they be in the same balance or must they be in separate balances.

3) Selling and buying DER responses at the retail market, price control

Description of Service: *The customer and the aggregator/retailer agree on a price based mechanism*

Attributes:

- normal retail contract attributes
- reference price for the price based component
- price and volume for the fixed price component
- commission
- rules for price profile adjustments
- minimum lead times for the price signal

Verification:

- It must be verified that the aggregator/retailer uses the agreed price formulation and settlement mechanisms (= the prices are constructed using the agreed pricing mechanism such as spot-market price component + fixed price component + commission + adjustments of the prices in order to serve response needs)
- Interval measurement and settlement of the consumption (The customer pays according to the prices and consumption so failure to respond is mainly his loss. If very many customers fail to respond, then the balancing costs of the aggregator may increase, but this risk may be small.)

Penalties and incentives:

- Penalties for ad-hoc changes in prices (If the penalty is suitable, then the aggregator and the customer may both win in some situations.)
- Penalties for not providing the price signal too late or never (If the penalty is suitable, then the aggregator and the customer may both win in some situations.)

Comments:

Time resolution limited to the settlement time interval in the particular market

4) Selling indoor climate, comfort and functionality to the consumer/customer

Description of service: *The customer needs indoor climate, comfort and functionality of appliances, ICT and communication. Thus the aggregator/ESCO agrees to maintain indoor climate, comfort and functionality. Then minimising the energy costs is aggregator's opportunity.*

Attributes:



- Allowed range of indoor conditions and functionality

Verification:

- Measurements of the indoor climate etc.

Penalties:

- Penalties for failures to maintain the indoor climate etc.



5 ICT solutions supporting SLA Monitoring

5.1 Generic SLA Monitoring ICT Architecture

Our architectural approach is based on ongoing activities related to **Service Oriented Infrastructures (SOI)** and **Service Level Agreements** (Section 2) with considerations on **data management** and **privacy** (Section 1).

The Service Level Agreement, as above said, is a tool to manage, in the Service-oriented market, the interactions among the stakeholders, providing and consuming resources, by coordinating the activities of the service.

From a service perspective, the SLA requires:

- Identification of the service to be provided.
- Definition of needs and commitments of stake-holders and their respective roles.
- Identification of the indicators and respective thresholds to assess the service performances (qualitative and quantitative).
- Monitoring of the performances indicators (which are a function of the service), and assurance of performances (qualitative and quantitative) at an acceptable level.

The monitoring is the focus of WP3 and, more specifically, the ICT needed to support this activity. Digital control systems encompass the most important functions needed for SLA monitoring:

- **Data collection** (data storage, conversion and scaling, time stamping and feasibility assessment)
- **Supervising and Measurement** (status assessment, performance measurement and event and alarm management)
- **Control** (direct control, set point control and sequence control)
- **Planning and follow-up** (non-real-time–critical functionality, planning, logging and history and follow-up)
- **Maintenance and change** (putting in and removing from service, upgrading and management of development environments)

The service bundles enable **vertical integration** of data flows (traditional bottom-up aggregation from sensors to control centres or top-down control signal down to actuators) or **horizontal integration** and monitoring of services on the same level. For instance, using horizontal integration we can coordinate local Demand-side Integration to a global view addressing specific sets of **aggregators** by **flexible overlay architectures**, such as **peer-to-peer**, on top of the underlying distribution networks and ICT networks.

In future Smart Grids we must implement different trustworthy ICT solutions supported by partly the same physical infrastructure (Figures 3.1 and 3.2). This is likely to increase the overall brittleness of the larger system and adding to costs of implementation and further development as a larger number of combinations will need to be tested for both integration and regression, both in regards to the infrastructure and to other services this infrastructure supports. To lessen



these issues, solutions involved need to be separated and protected from unwanted interactions and be resilient against disturbances from all supporting layers.

Principally, this can be achieved through **virtualization**; the act of encapsulating a subsystem by forcibly establishing an intermediate, formal **border** between the solution and its supporting infrastructure (Figure 3.7). In principle, this works recursively.

For a solution to be considered virtualized, the following requirements need to be fulfilled:

- One or more defined interfaces for service exchange.
- Protocols governing service exchange across each defined interface.
- Solutions adapted to conform to the specifics of each protocol.

Each paired **interface** and **protocol** defines a tractable **border** between solutions. This border is enforced by the use of monitoring of service exchange to detect and prevent non-conforming exchange from cascading to other parts of the system.

In full, these regulations ensure that different ICT solutions are logically separated and protected against indirect, unintended, interactions between solutions (Figure 3.2).

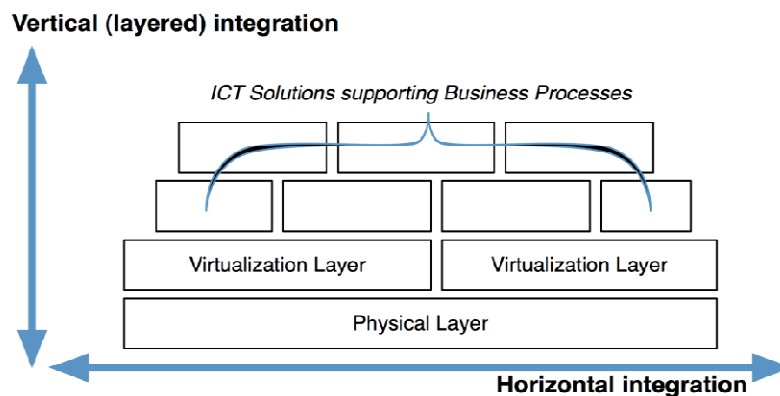


Figure 3.7 Layered separation using virtualization

5.2 Monitoring voltage control and customer empowerment

From Figure 3.1 we derive the need of two sets of SLAs coordinated by the Aggregators.

- **SLA_EPA**: Regulates the coordination between Energy providers and Aggregators.
- **SLA_AC**: Regulates the coordination between Aggregators and Customers

The primary role of the monitoring is two-fold:

- Monitoring that inclusion of DER is in compliance of the voltage control requirements
- Monitoring that customer change of DER inclusion is within the corresponding SLAs change space

The key parameter sets to be monitored are provided by the DER vectors:

$DER_i = (V_i, Cap_i, Pos_i)$, where V_i is the voltage at DER_i , Cap_i is the capacity of DER_i and Pos_i is the position of DER_i .



Furthermore, the following parameters will be considered to be included into the SLA agreement supporting empowerment of the customer and Demand Side Integration (DSI).

- **Amount and frequency** of DER-based planned energy that could be proposed for change by the customer at a given point in time and time interval.
- **KPIs** related to the SLA-based energy profile

The subset that will be part of the SLS_EP bundle will be developed in cooperation with WP2.



6 Available ICT solutions supporting monitoring

Given the drastic increase in both open-endedness and adaptively that comes with Smart Grid deployment; approaches in monitoring will undoubtedly need to be configured accordingly. To this end, we have identified several key groups in which monitoring will need to be addressed and re-enforced;

- **SLAs** - as covered by Section 5.1.
- **Communications network topology** - A comparatively mature and well-understood area of monitoring with open protocols (such as **SNMP**) in place and most large-scale vendors of network communication technology readily provide complementing solutions for monitoring of the communication network.
- **SCADA** – This may largely be the target of adapting existing systems from appropriate vendors, however ongoing open source efforts such as Mango¹⁴, openSCADA¹⁵ and freeSCADA¹⁶ may serve as a feasible starting point as their respective openness can be advantageous during both adaptation and security evaluation but also to combat some of the challenges and costs associated with development in general.
- **The monitoring solution itself**- Due in part to the larger task of data management that act as prerequisite for monitoring, the monitoring solution need to be able to be treated recursively, i.e. open for monitoring of itself in order to safeguard and verify both the data processing and the data presentation.

While each group pose unique requirements on monitoring solutions, there are additional concerns that span all the above-mentioned groups;

Hierarchical management - Suggested by the QoS metrics in Section 2, the different market roles warrant stakeholder dependent views (slices) of the monitored system where the role dictates the specificity of data and the level of aggregation. This means that monitoring will need to be able to cope with- and possibly coordinate- several levels of abstraction of the same monitored system based on the task at hand.

Appropriate representations - A critical part of each monitoring solution is the set of overlays that provide stakeholders with context in which the data presented can be understood and subsequently analyzed. Finding representations that combine support for the above-mentioned layered interpretation of data while accurately capturing dynamic, adaptive, activities within the Smart Grid will likely prove to be challenging.

These concerns stress the need of a strict and formal approach to Data Management (Section 2).

¹⁴ <http://mango.serotoninsoftware.com>

¹⁵ <http://www.oscada.org>

¹⁶ <http://www.free-scada.org>



7 Future ICT R&D development supporting data management and inter-stakeholders service monitoring

We need to customize monitoring tools to support different stakeholders. Section 3.4 Tool based access control gives an outline on needed requirements to that end.

Those issues will be addressed in the forthcoming deliverable D3.3. Important barriers identified in this deliverable are:

- Lack of regulatory frameworks for future Smart Grids
- Lack of implemented and assessed demonstrators of Smart Grids

7.1 What is it in the cloud?

Technological developments of software intensive systems following Grid computing and Service oriented systems include advancements in **Cloud Computing**¹⁷.

The concept of cloud computing is linked intimately with those of **laaS** (infrastructure as a Service); **PaaS** (Platform as a Service), **SaaS** (Software as a Service) all of which imply a service oriented architecture.

laaS are referred to as **Resource Clouds** provide (managed and scalable) resources as service to the user – in other words they basically provide enhanced virtualisation capabilities. Accordingly, different resources may be provided via a service interface. Examples: Amazon S3, SQ and Azure.

Compute clouds provide access to computational resources, i.e., CPUs. So far such low-level resources cannot really be exploited on their own, so they are typically exposed as part of a “virtualized environment” (not to be mixed with PaaS below), i.e., hypervisors. Compute Cloud Providers therefore typically offer the capability to provide computing resources (i.e., raw access to resources unlike PaaS that offer full software stacks to develop and build applications), typically virtualized, in which to execute cloudified services and applications. laaS offers additional capabilities over simple compute service. Examples: Amazon EC2, Zimory and Elastichosts.

PaaS provide computational resources via a **platform** upon which applications and services can be developed and hosted. PaaS typically makes use of dedicated APIs to control the behaviour of a server hosting engine which executes and replicates the execution according to user requests (e.g., access rate). As each provider exposed his/her own API according to the respective capabilities, applications developed for one specific cloud provider cannot be moved to another host – there are however attempts to extend generic programming models with cloud capabilities (such as MS Azure). Examples: Google Docs, Salesforce CRM and SAP Business by Design.

¹⁷ The Future of Cloud Computing. Opportunities for European Cloud Computing Beyond 2010. EC Expert Group Report, 2010.



Future Smart Grids might be supported by, e.g., suitable PaaS developed by industrial consortia.



8 References

- [1] K. Fakhfakh, T. Chaari, S. Tazi, K. Drira, and M. Jmaiel, "A Comprehensive Ontology-Based Approach for SLA Obligations Monitoring," *Proceedings of the 2008 The Second International Conference on Advanced Engineering Computing and Applications in Sciences-Volume 00*, 2008, pp. 217–222.
- [2] Kosinski, P. Nawrocki, D. Radziszowski, K. Zielinski, S. Zielinski, G. Przybylski, and P. Wnek, "SLA Monitoring and Management Framework for Telecommunication Services," *Proceedings of the Fourth International Conference on Networking and Services*, 2008, pp. 170–175.
- [3] M. Comuzzi, C. Kotsokalis, G. Spanoudakis, and R. Yahyapour, "Establishing and Monitoring SLAs in Complex Service Based Systems," *Proceedings of the 2009 IEEE International Conference on Web Services-Volume 00*, 2009, pp. 783–790.



Appendix A: BUSINESS CASES FORMS¹⁸

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
<i>Consumer</i>	The owners of flexible demand (e.g. air conditioners, chillers) connected

¹⁸ This Appendix has been prepared by WP5 of SEESGEN-ICT and has been extracted from the Deliverable D5-2



<p><i>Aggregator defined in eBIX</i> (not</p>	<p>to a distribution network, adjust their demand according to aggregator's request.</p>
<p><i>System operator</i></p>	<p>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.</p> <p>The System Operator (SO) is responsible for stable power system operation through a transmission grid. Operation of transmission includes management of energy flows, reliability of the system and availability of system services.</p> <p>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 counterparty who may accept or cancel regulating-up and regulating-down bids for the provision of balancing power. The TSO also operates power reserves market.</p>
<p>Imbalance Settlement Responsible</p>	<p>Subsidiary of SO, which calculates the power imbalance of each balance responsible party and charges them accordingly.</p>
<p>Market operator</p>	<p>Power exchange operates organized power markets with different lead times and mechanisms such as day-ahead market and intra-day power market.</p>

6. **Product / Services and related Transactions:** DR can be used for

- Planned balancing:
 - Reducing imbalance of the retailer-aggregators 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
<i>Commercial load management</i>	Selling energy released in load reductions to the spot market.
<i>Reduction of imbalance costs</i>	The Aggregator adjusts customers' loads to achieve smaller power imbalance.
<i>Triad management</i>	The Aggregator reduces transmission charges by reducing the annual peak consumption.
<i>Provision of frequency control services</i>	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 1.
8. **Energy flows between the actors (the economic path, not physical):** The aggregator as retailer provides 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.

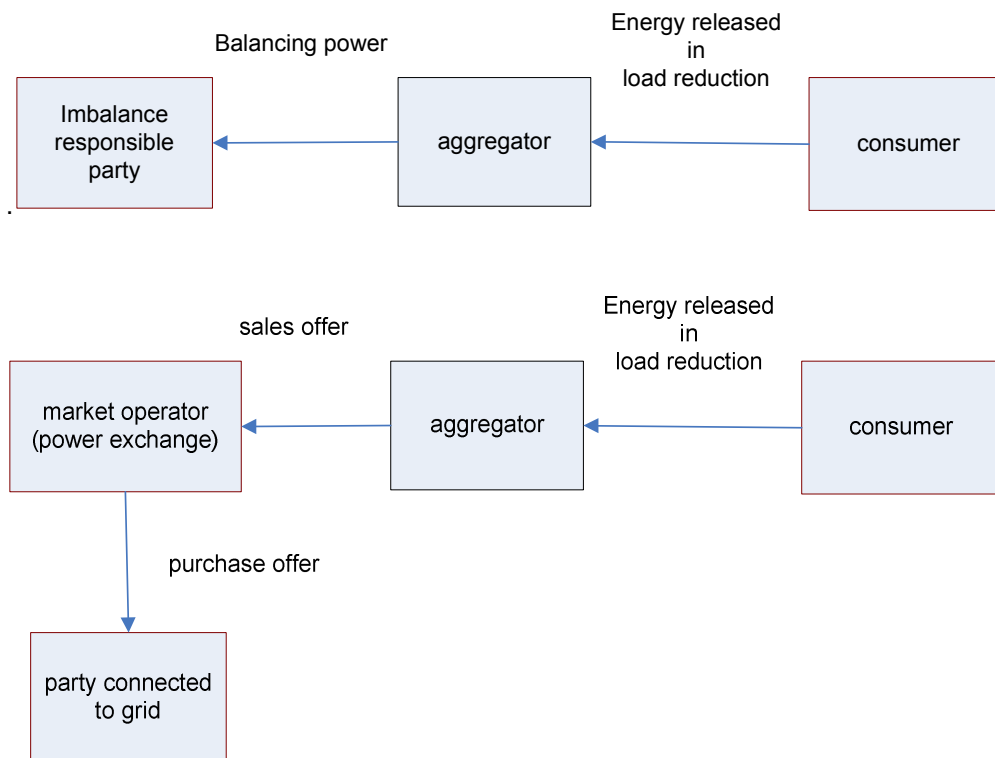


Figure 1: Some energy flows in different business models of the EU-DEEP task force 1.

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)

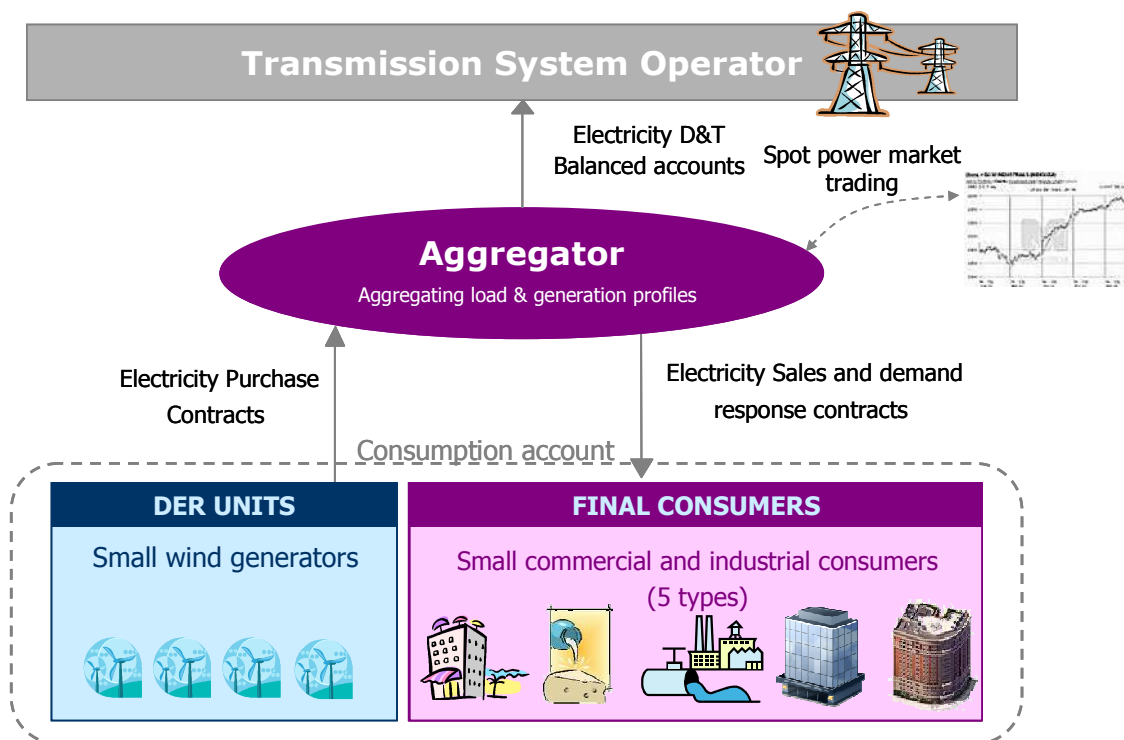


Figure 2 Simple representation of relationships between actors in EU-DEEP first business model. Consumption account refers to balance accounting, where DG and consumption is summed into one balance account and central generation into another.

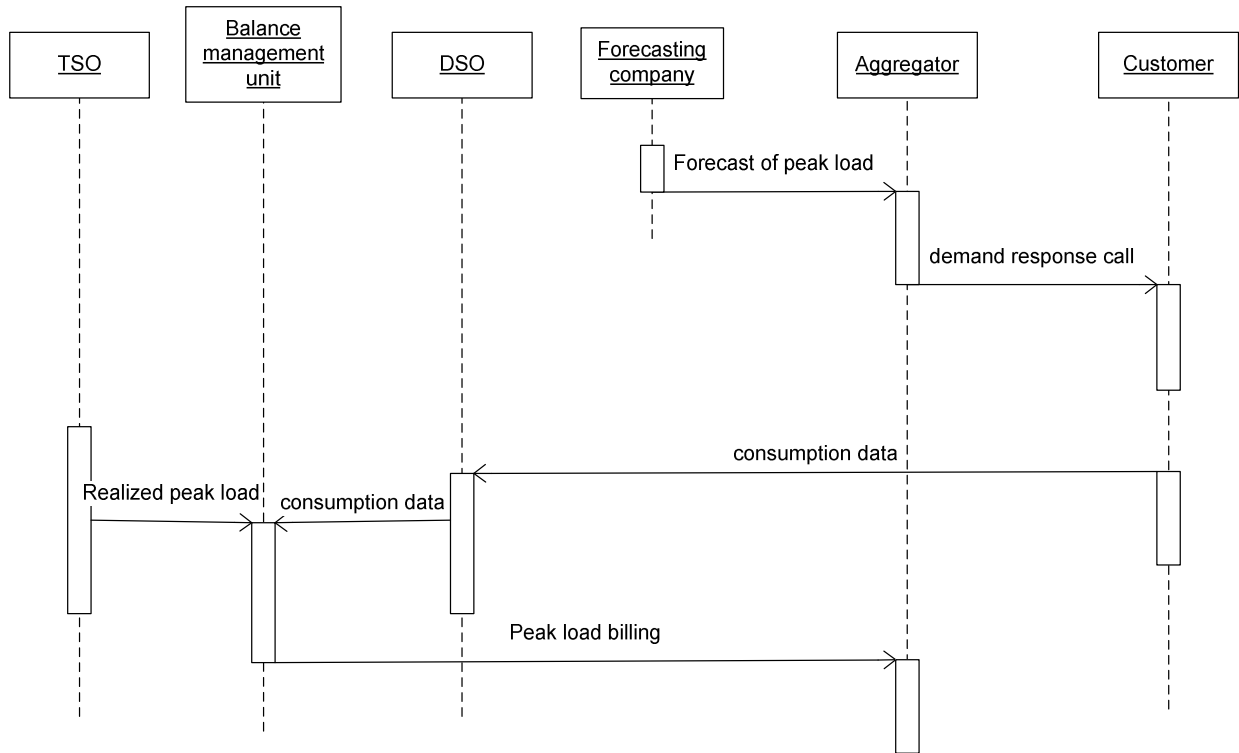


Figure 1 UML sequence diagram representation of reduction of distribution and transmission costs, in case where they depend on consumption during national peak load, by a retailer who also acts as aggregator.

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)

<i>Technology Type</i>	<i>Description of functionality</i>	<i>Role by which it is used</i>	<i>Tool used</i>	<i>IPR-holders</i>	<i>Maturity level</i>
<i>Scheduling software</i>	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



	<ul style="list-style-type: none"> - forecasts of market prices for electricity, - forecasts of load & generation imbalance for the aggregator. 				
<i>Simulation software</i>	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
<i>DR response forecasting software</i>	Simulates load behaviour based on physical models	Aggregator	Flexmod	UPV	Experimental tool
<i>Internet to GPRS gateway</i>	Provides the gateway from the Internet to GPRS communication.	Aggregator	External service provider	?	?
<i>GPRS modem</i>	Provides the communication link on the customer site	Customer			Commercial tool
<i>Programmable logic controller</i>	Provides run/interrupt signals to the customers appliances based on signals received by GPRS.	Customer		Siemens	Commercial tool

12. Other technologies needed

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

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

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



<i>software</i>	experimental control signals for DER such as load reduction requests and evaluates the income generated by DER by exploiting simulations of DER response.	engineering
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- 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, CO₂, 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**
Possible benefits from subsidies, minimum sizes for participating in market, etc.
- 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

<i>Actor</i>	<i>Role</i>
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
<i>DER Owner</i>	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.
<i>Aggregator</i>	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

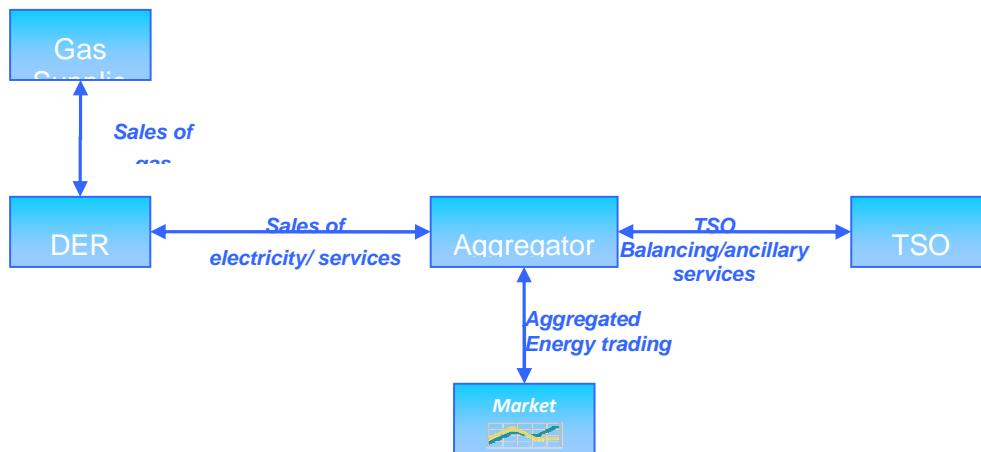


<p><i>Gas Supplier</i></p> <p><i>TSO</i></p> <p><i>DSO</i></p>	<p>wholesale and balancing electricity markets. This approach allows the DER owners to experience economies of scale in market participation. The Aggregator also supplies energy to the DER owners.</p> <p>The Gas Supplier acts as a gas retailer 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.</p> <p>The Gas Supplier could be at the same time the retailer of electricity</p> <p>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.</p> <p>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.</p>
<p>Electricity Markets</p>	<p>There are different market in which the DER can be involved through the aggregator:</p> <ul style="list-style-type: none"> • the wholesale market for energy commodities. This may comprise: <ul style="list-style-type: none"> ○ 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;

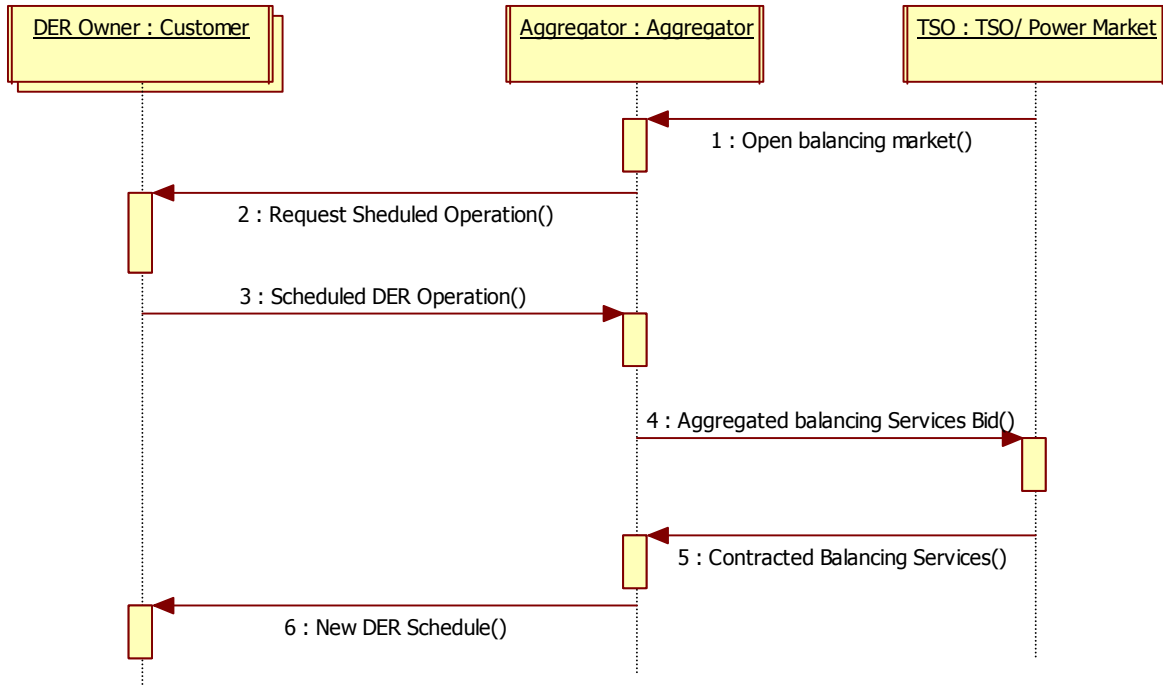
6. **Product / Services and related Transactions and contracts:** Micro-CHP owners provide electricity and flexibility to the aggregator, who trades them in the power market or with the TSO, respectively. On the other hand, the aggregator supplies micro-CHP owners with gas and with electricity when micro-CHP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



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



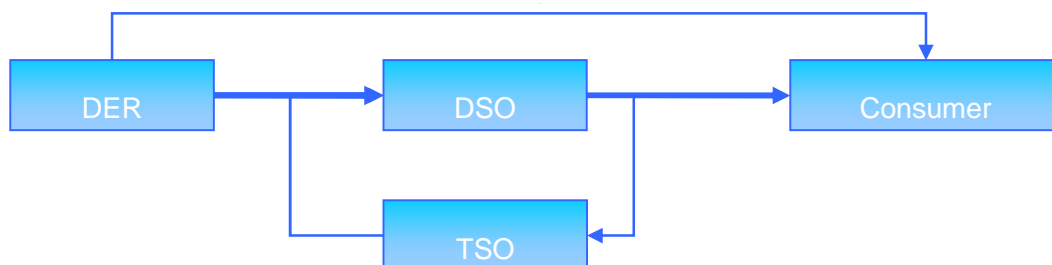
- Information exchanged between the actors:** The aggregator receives the opening of the balancing market and requests the schedule of operation of DER. It aggregates the available resources and contracts the balancing services with the TSO. Finally a new schedule is sent to each of the DER owners.



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.

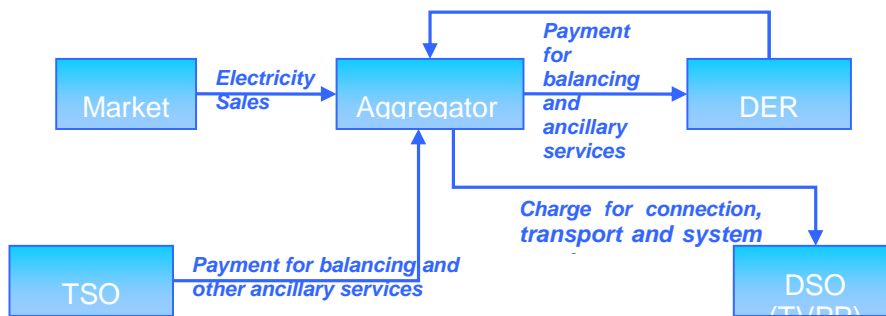
A last significant part of this electricity goes in direct consumption: it is the auto-production of electricity made on-site by a consumer using DER units.

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 Supplier Services	A party that participates in the balancing market by aggregating the energy capacity provided by several individual DER owners.	<i>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.</i>
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

<i>Technology Type</i>	<i>Description of functionality</i>	<i>Role by which it is used</i>	<i>Tools used in Fenix</i>	<i>IPR-holders</i>	<i>Maturity level</i>
<i>DER CONTROLLER</i>	<p>It is both software and hardware. It:</p> <ul style="list-style-type: none"> - It allows the DER to send a power request signal. - It collects several measurements: <ul style="list-style-type: none"> - water flow in the heat - 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
<i>Aggregation server</i>	<p>Implements schedule and energy optimisation functions for DER units, so enabling the access of DER units to the market.</p>	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
<i>Real time link</i>	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 MD730=3	Modem	Commercial

12. Other technologies needed

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which need it</i>
<i>Market price forecasting software</i>	Software used to forecast market prices in energy markets.	Aggregator
<i>Smart meter</i>	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

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which it can be used</i>	<i>IPR-holders</i>	<i>Maturity level</i>
	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



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

<i>Actor</i>	<i>Role</i>
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.

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

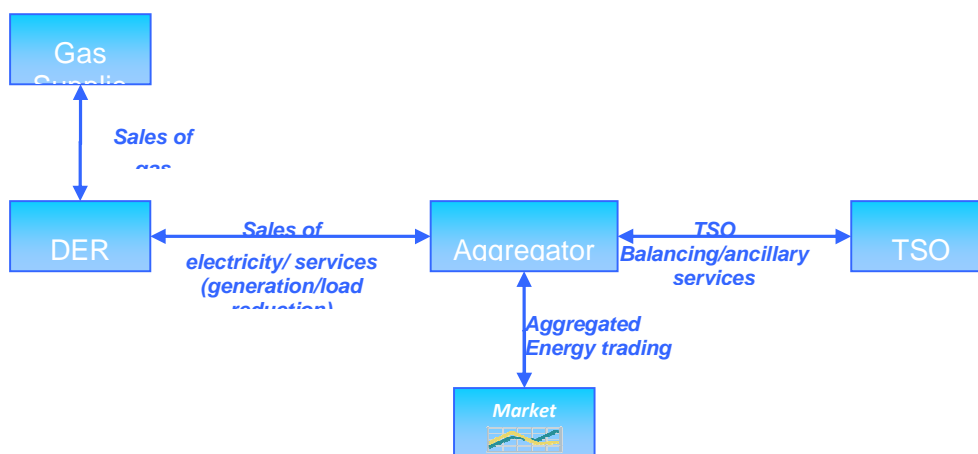


<p><i>Aggregator</i></p> <p><i>Gas Supplier</i></p> <p><i>TSO</i></p> <p><i>DSO</i></p>	<p>electricity generated to the TSO. In this case the DER owner does not own the CHP, which belongs to the Aggregator.</p> <p>The Aggregator is a competitive market actor that aggregates a DER portfolio (generation 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.</p> <p>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.</p> <p>The Gas Supplier could be at the same time the retailer of electricity</p> <p>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.</p> <p>The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers.</p> <p>In this Business Model the DSO it only performs the role of transporting the energy generated by DER owners.</p>
<p>Electricity Markets</p>	<p>There are different market in which the DER can be involved through the aggregator:</p> <ul style="list-style-type: none"> • the wholesale market for energy commodities. This may comprise: <ul style="list-style-type: none"> ○ 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;

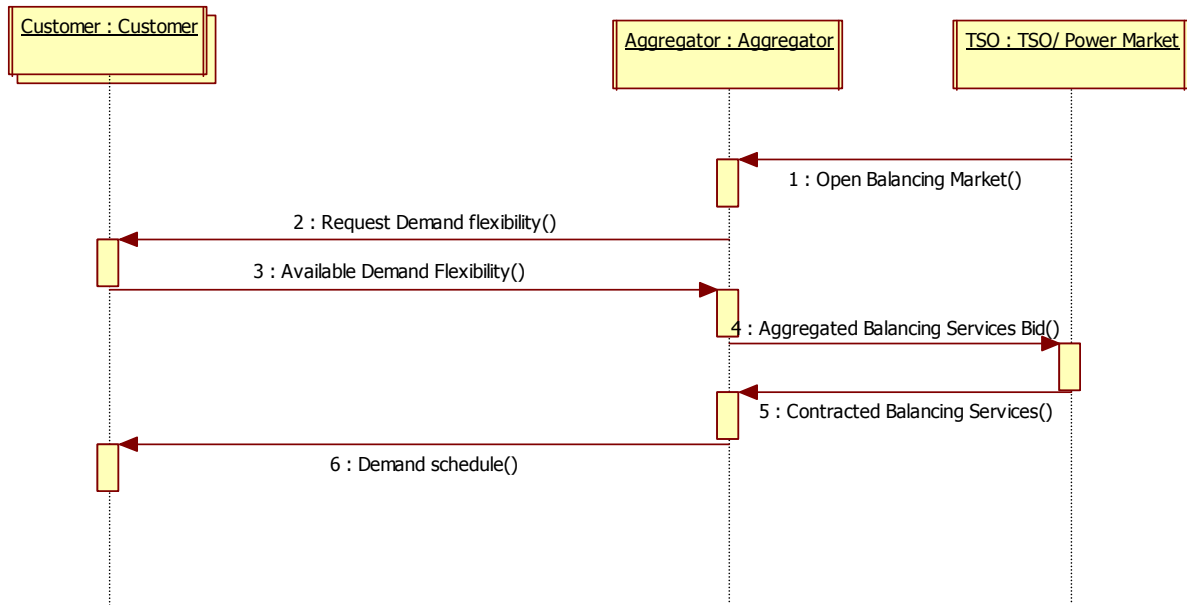


6. **Product / Services and related Transactions:** The aggregator supplies customers with heat and electricity either from CHP production or by buying electricity in the market. The use of heat storage tanks allows a flexible operation of CHP units, so that the aggregator can trade such flexibility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

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



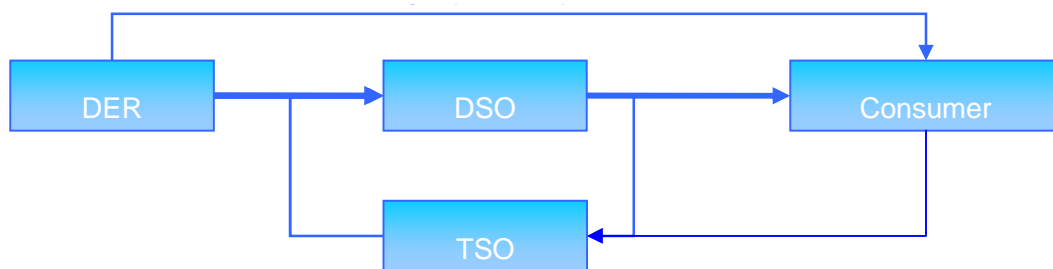
7. **Information exchanged between the actors:** The aggregator monitors the level of the heat storage, in case some changes are required in the CHP unit operation.



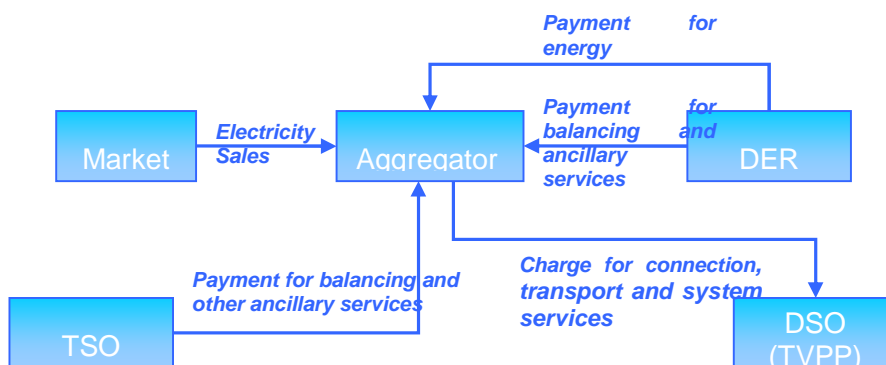
8. **Energy flows between the actors:** The electricity produced by DER units is directly delivered to the distribution network. Most of this electricity is, then, distributed to the consumers by the DSOs. If the supply exceeds demand, the surplus of electricity is delivered to the transport grid and 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 Supplier Services	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	<i>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.</i>
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
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		<i>used</i>			
<i>DER CONTROLLER</i>	<p>It is both software and hardware. It obtains:</p> <ul style="list-style-type: none"> - 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
<i>Load Controller</i>	It has the same functionality as the DER controller	DER		ANCO,S.A.	Demonstration tool
<i>Aggregation server</i>	<p>Implements schedule and energy optimisation functions for DER units, so enabling the access of DER units to the market.</p> <ul style="list-style-type: none"> - In details it is an agent based Decentralized Energy Management System) 	Aggregator	Multi-Agent system	ANCO,S.A.	Demonstration tool

12. Other technologies needed

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which need it</i>
<i>Market price forecasting software</i>	Software used to forecast market prices in energy markets.	Aggregator
<i>Smart meter</i>	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**

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which it can be used</i>	<i>by IPR-holders</i>	<i>Maturity level</i>
<i>DEMS</i>	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.
<i>Power Matcher</i>	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
<i>DER Producer</i>	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.
<i>CVPP</i>	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.
<i>TSO</i>	The Transmission System Operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators. It



<i>DSO</i>	<p>can act as single buyer of electricity and of balancing and additional ancillary services offered by DER.</p> <p>The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers.</p>
<i>Electricity Markets</i>	<p>There are different market in which the DER can be involved by the VPP:</p> <ul style="list-style-type: none"> • the wholesale market for energy commodities. This may comprise: <ul style="list-style-type: none"> ○ 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; • 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:

<i>Product/Service</i>	<i>Definition</i>
<i>Energy services sales</i>	The DER offers power to the Market, through the CVPP.
<i>DER Capacity Aggregation</i>	The CVPP aggregates capacity from DER units
<i>Aggregated electricity trading</i>	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:

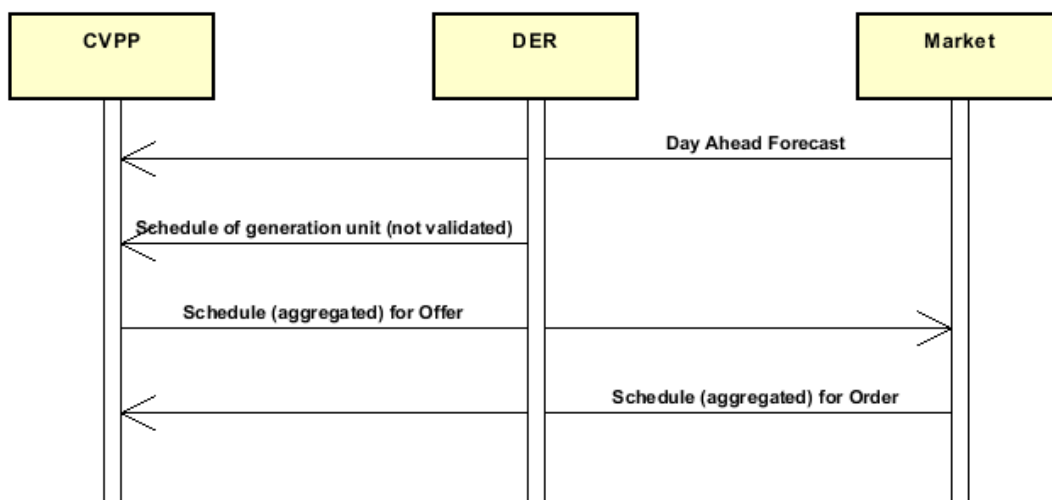


Figure 3. UML representation of flows between actors



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.

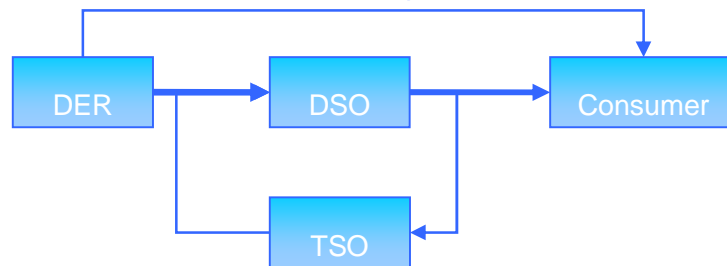


Figure 3. Energy flows between the actors

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.

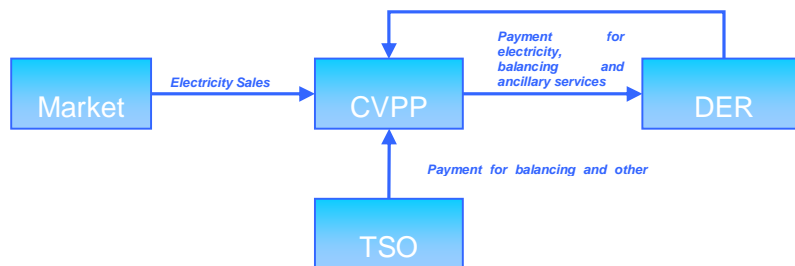


Figure 4. Economic flows between the actors

10. Mapping role towards ETSO/ebIX harmonized role model

(To be validated by Fritz)

Role	Corresponding roles	ebIX	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.	<i>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</i>
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.	<i>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.</i>
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 FENIX Business case
12. **Hardware needed for business case implementation (e.g. Smart Meter, Gateway, etc.):**

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which need it</i>
<i>Reinforcing of Distribution Network</i>	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):

<i>Actor</i>	<i>Role</i>
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):

<i>Actor</i>	<i>Role</i>
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
<i>DER Producer</i>	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.
<i>CVPP</i>	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.
<i>TVPP</i>	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 from 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.
<i>TSO</i>	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.
<i>DSO</i>	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.



Electricity Markets	<p>There are different market in which the DER can be involved by the VPP:</p> <ul style="list-style-type: none"> • the wholesale market for energy commodities. This may comprise: <ul style="list-style-type: none"> ○ 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.
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6. Product / Services and related Transactions and Contracts:

Product/Service	Definition
<i>Energy/ancillary services sales</i>	The DER offers power and ancillary services, such as reserve, frequency response, reactive power, black start to the Market, through the CVPP..
<i>DER Capacity Aggregation</i>	The CVPP aggregates capacity from DER units
<i>Aggregated electricity trading</i>	The CVPP trades the electricity in the market and arranges the provision of ancillary services.
<i>Validation of the schedules</i>	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.

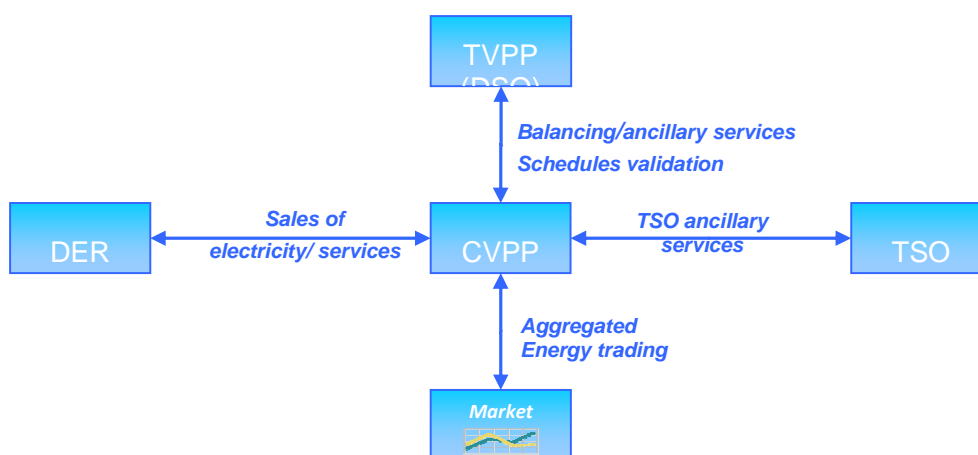


Figura 1. Contractual relationships

7. Information exchanged between the actors:

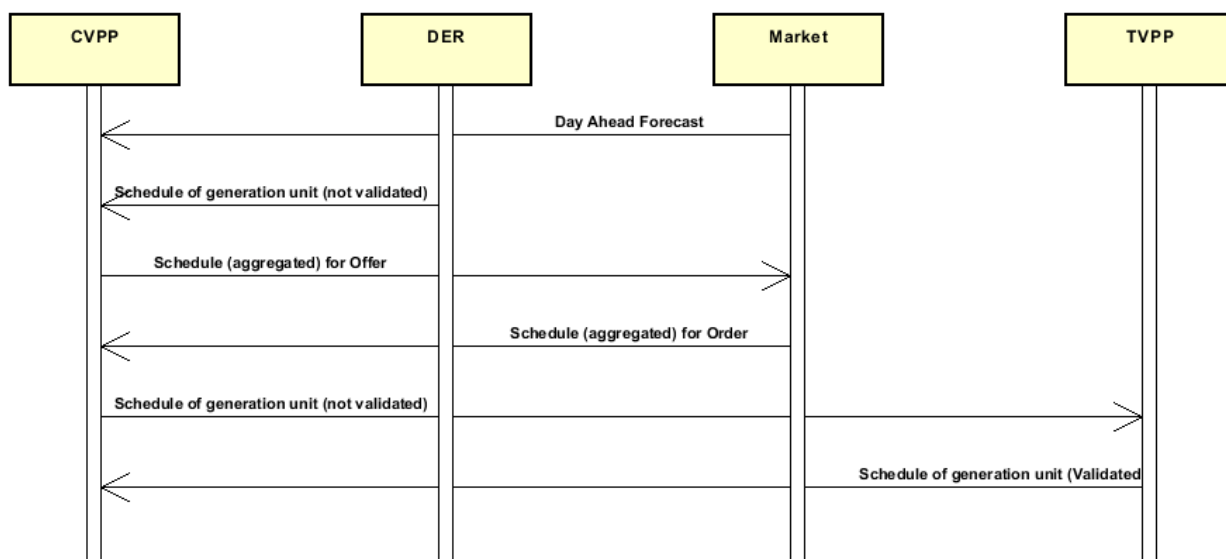


Figure 2. UML representation of the main information flows between actors



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.

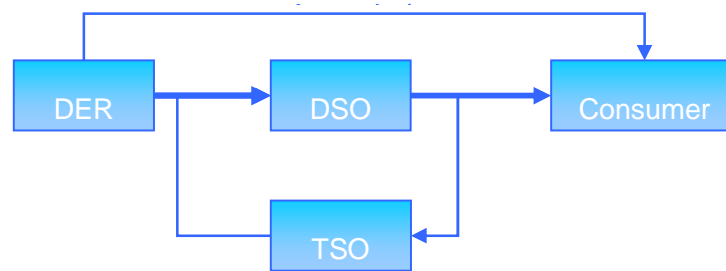


Figure 3. Energy flows between the actors

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.

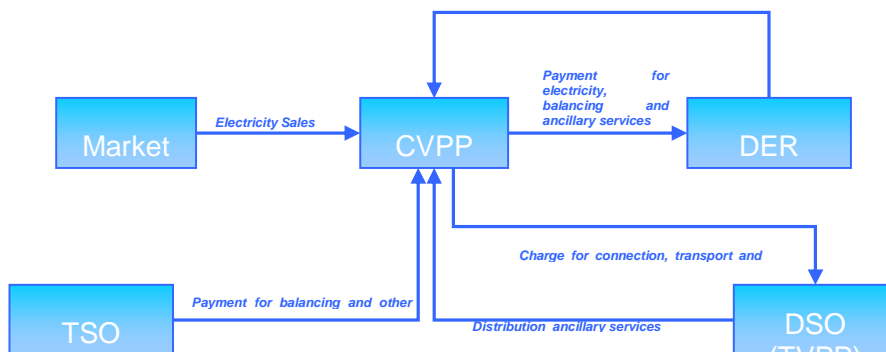


Figure 4. Economic flows between the actors



10. Mapping role towards ETSO/ebIX harmonized role model

(To be validated by Fritz)

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.	<i>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.</i>
	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.	<i>In this business case CVPP can absorb balance and trading risks of his client (or shares these risks with them) for extra fee.</i>
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.	<i>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.</i>
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:



<i>Technology Type</i>	<i>Description of functionality</i>	<i>Role by which it is used</i>	<i>Tools used in Fenix</i>	<i>IPR-holders</i>	<i>Maturity level</i>
<i>FENIX Box Server</i>	It is both software and hardware. It:	DER	Inverter based equipment, stimulating real units mesurementes and accepting commands	Imperial College London	Research prototype
	<ul style="list-style-type: none"> - aggregates loads and generation and ensure their optimal use; - provide visibility of generation available and current demand 				
	<p>There are two types of FENIX Box:</p> <ul style="list-style-type: none"> - 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. 				
<i>CVPP server</i>	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
	<p>In details it is a DEMS (Decentralized Energy Management System) configured as a CVPP and, in FENIX, it has been extended with functionalities about:</p> <ul style="list-style-type: none"> - connectivity (interface to FENIX Box); - reactive power control; - integration (with DSO using ICCP and with energy market using Web Services) 				
	<p>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.</p> <p>Some enanchement added to the commercial version were: aggregation/disaggregation, communication protocols, etc</p>				



<i>TVPP application</i>	<p>TVPP is a general name for the set of functions that joins DER and electrical network.</p> <p>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.</p> <p>It have to:</p> <ul style="list-style-type: none"> - validate the feasibility of scheduled generation of DER units; - if problems are detected, plan corrective measures (for example, changing of scheduled generation of DER units); - optimize the voltage in the network. This functionality is called Volt VAR Control (VVC) 	DSO	<p>e-TerraScada extended with TVPP functions,</p> <p>OPF is a Module of the Siemens DMS (Spectrum), extended to include DER reactive power output as variable for Voltage Var Control</p>	<p>Areva</p> <p>Siemens</p>	<p>Demonstrating tool based on commercial one</p> <p>Demonstrating tool based on commercial one</p>
<i>Real time link</i>	<p>Provide a simple huge access to all the DER. The technology used in FENIX demonstration is GPRS.</p>	CVPP			

12. Other technologies needed:

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which need it</i>
<i>Market price forecasting software</i>	Software used to forecast market prices in energy markets.	CVPP
<i>Smart meter</i>	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

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which it can be used</i>	<i>by IPR-holders</i>	<i>Maturity level</i>
		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.
<i>Siemens DEMS</i>	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
<i>Power Matcher</i>	It is a distributed energy system architecture and communication protocol. Takes offers and bids from remote "agents".	CVPP	ECN	On the market
<i>e-terrascada</i>	e-terrascada is a suite of applications built on a common core technology, parte of an Energy Management System solution (e-terrplatform)	CVPP TVPP	Areva T&D	On the market
<i>Siemens Specttum</i>	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*

Possible benefits from subsidies, minimum sizes for participating in market, etc.

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) :**

<i>Actor</i>	<i>Role</i>	<i>Note</i>
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.
<ul style="list-style-type: none"> • 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:**

<i>Role</i>	<i>Description</i>
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<i>DER Producer</i>	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.
<i>Aggregator</i>	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.
<i>TSO</i>	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.
<i>DSO</i>	The Distribution System Operator (DSO) transports energy from high-voltage transmission systems to end-use customers. It is responsible for measurement.
<i>Electricity Markets</i>	There are different market in the IPEX (Italian Power Exchange): <ul style="list-style-type: none"> • 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
<i>Energy/ancillary services sales</i>	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.
<i>Administrative managing</i>	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
<i>Physical connection and energy measurement</i>	The Ritiro Dedicato agreement includes all technical and commercial aspects except connection and energy measurement. These services are provided from local distribution operators.

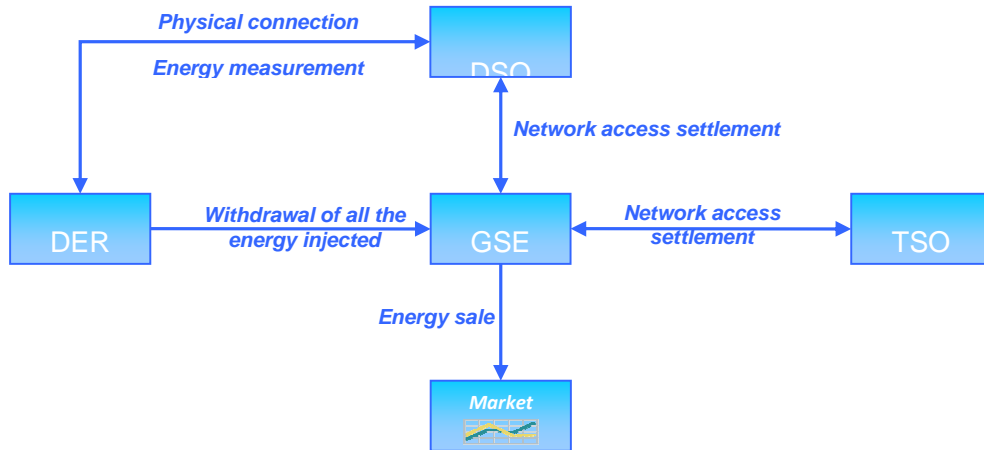


Figura 1. Contractual relationships

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 is 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.

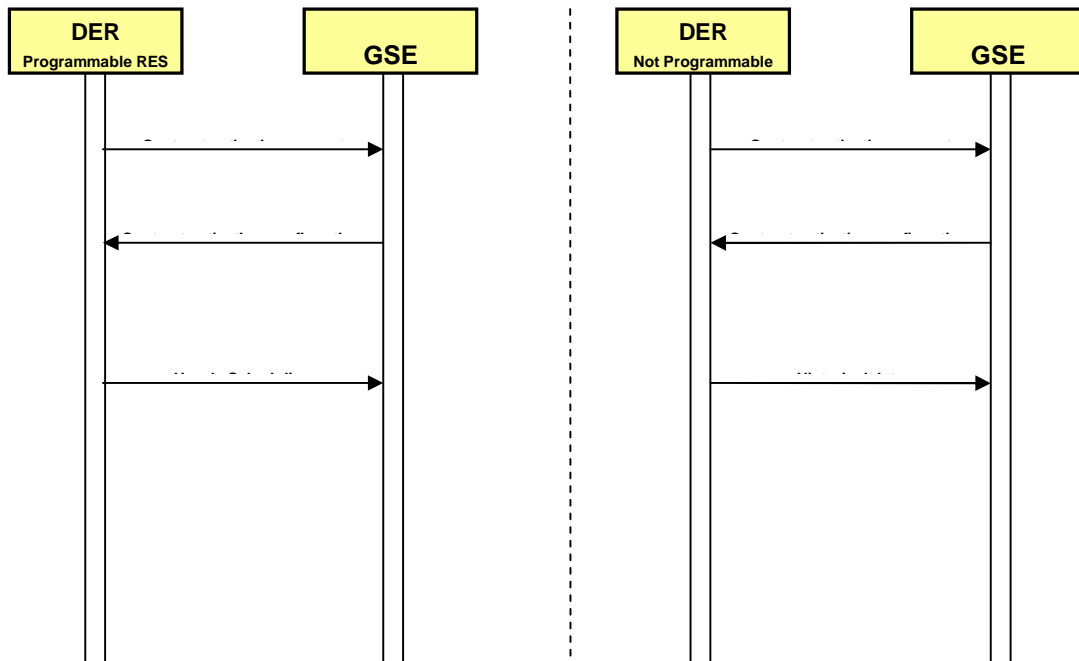


Figure 2. UML representation of the main information flows between actors



8. Energy flows between the actors:

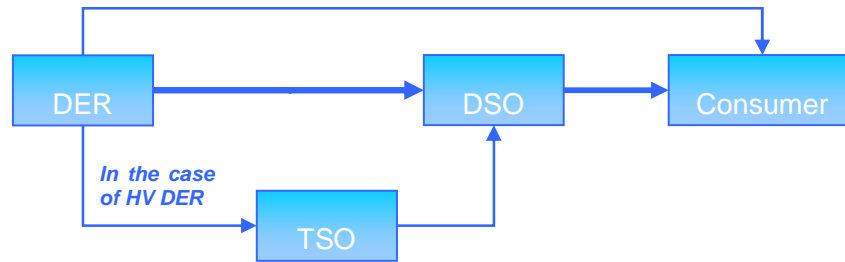


Figure 3. Energy flows between the actors

9. Economic flows between the actors:

Some important concepts:

- 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.
- 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.
- 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 Valorization:** 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 first 2 million of kWh of electric energy introduced in the grid every year. If, at the end of the solar year, the energy valorization 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 losses.
- **Transmission service**: it is an amount that the producer pays to GSE for the transmission service and GSE turns to TSO.

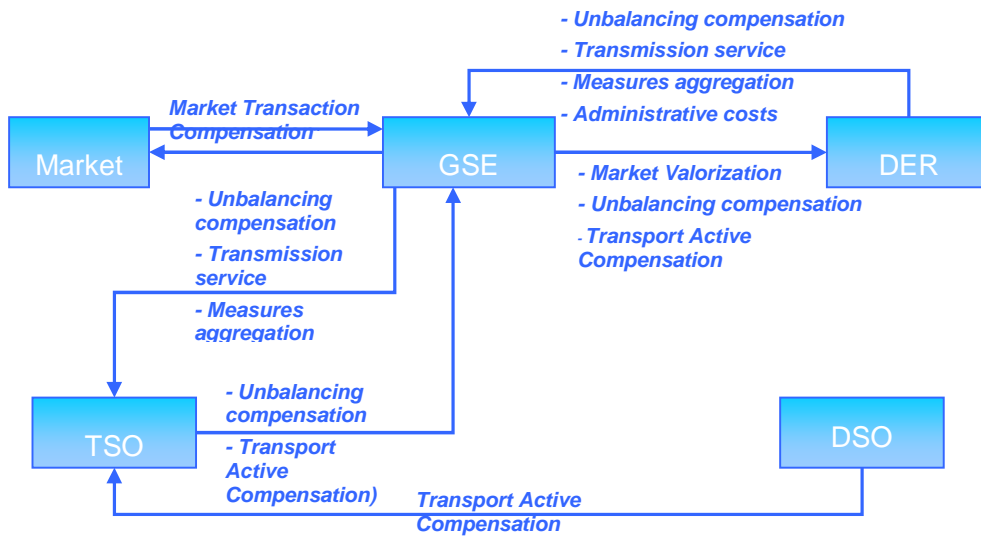


Figure 4. Economic flows between the actors

10. Mapping role towards ETSO/ebIX harmonized role model

(To be validated by Fritz)

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.	<i>The GSE shifts on the programmable plant owners the unbalancing onerous amount</i>
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.	<i>In Italy it does not exist on the market an independent Balance responsible party. This role is always covered by the TSO</i>

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
<i>Internet Portal</i>	<p>It allows the managing of DER profiles, the request for Ritiro Dedicato subscription and the managing of data about energy injected and billing.</p> <p>Moreover it provides the energy injection schedules upload page. The schedules expected formats are XML and CVS.</p> <p>It allows also the managing of Distributors profiles, the upload of measures (XML or CVS formats), the access to the historical measure data.</p>	GSE	GSE portal	GSE	In use



<i>electronic meter</i>	A device that measures how much electricity is injected in the grid. In absence of it, it is the TSO that has to determine the hourly injection profile.	DER	This technology is available and different solutions are on the market. But it is not applied at large scale in the world.
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12. Other technologies needed:

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which need it</i>

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

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role by IPR-holders which it can be used</i>	<i>Maturity level</i>

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) :**

<i>Actor</i>	<i>Role</i>	<i>Note</i>
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.
<ul style="list-style-type: none"> • 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
<i>DER Producer</i>	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



<i>Aggregator</i>	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
<i>TSO</i>	The Transmission System Operator (TSO) provides the economical valorisation for dispatching services
<i>DSO</i>	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 3 rd month of the year) the amount of energy injected and withdrawn in the previous year.
<i>Retailer</i>	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.
<i>Electricity Markets</i>	There are different market in the IPEX (Italian Power Exchange): <ul style="list-style-type: none"> • 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:

<i>Product/Service</i>	<i>Definition</i>
<i>Energy Exchange service</i>	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.
<i>Administrative managing</i>	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
<i>Physical connection and energy measurement</i>	These services are provided from local grid operator (DSO).

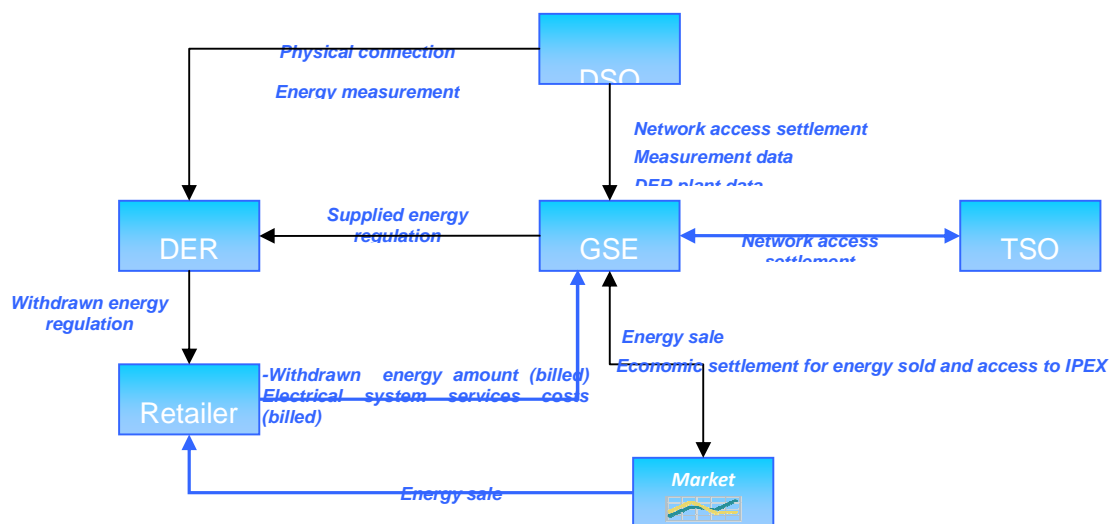


Figura 1. Contractual relationships

7. Information exchanged between the actors:

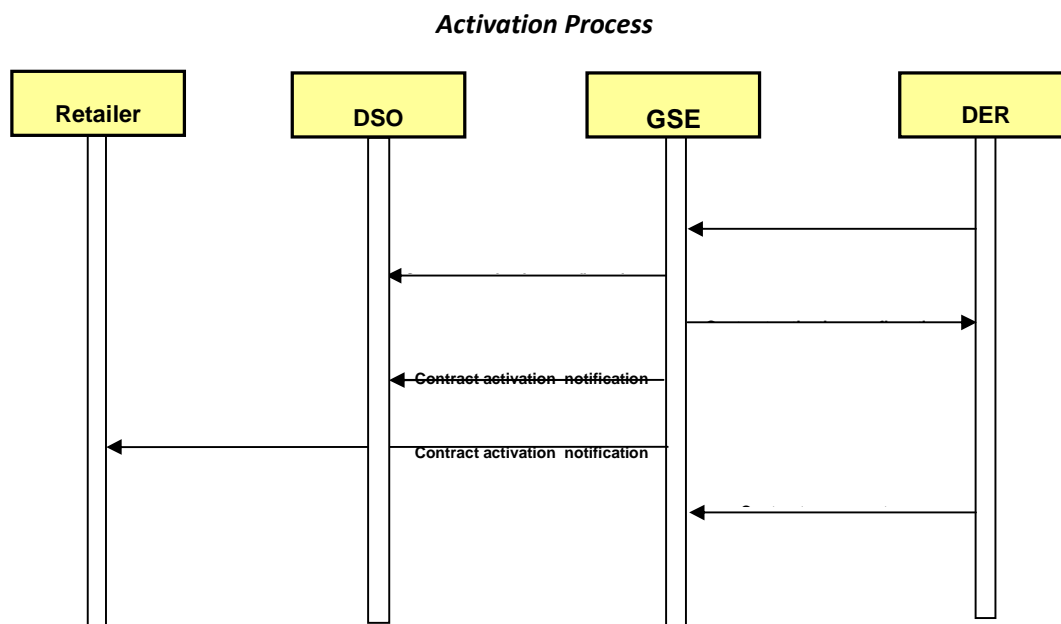


Figura 2. Activation of the onsite exchange service



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

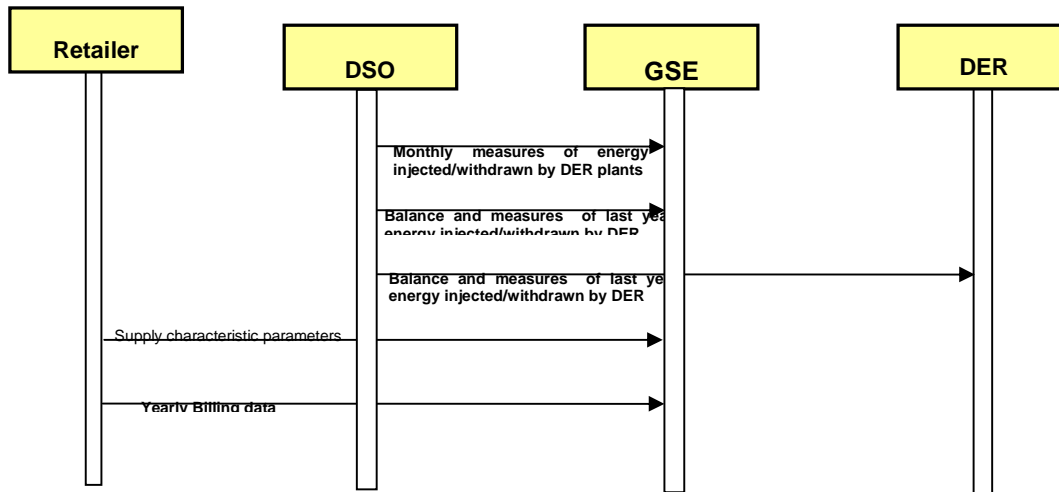


Figure 3. UML representation of the main information flows between actors during the normal operations

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.

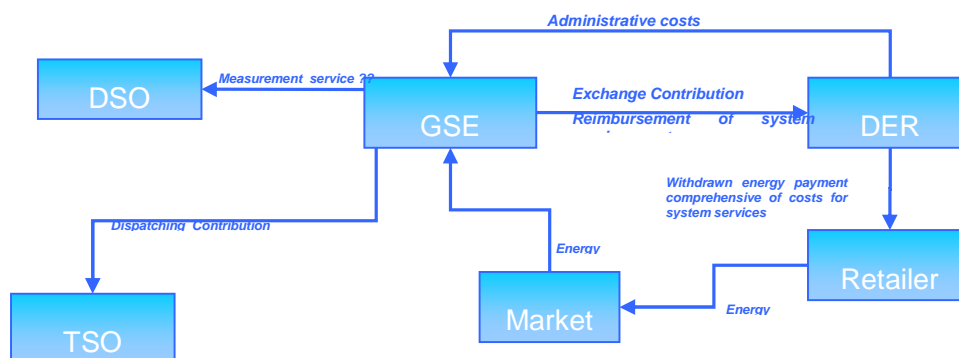


Figure 4. Economic flows between the actors

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

(To be validated by Fritz)

Role	Corresponding 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.	<i>In Italy it does not exist on the market an independent Balance responsible party. This role is always covered by the TSO</i>



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
<i>Internet Portal</i>	<p>It allows the managing of DER profiles, the request for <i>Scambio sul Posto</i> subscription and the managing of data about subscriber plant.</p> <p>Moreover it provides the energy injection schedules upload page. The schedules expected formats are XML and CVS.</p> <p>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.</p>	GSE	GSE portal	GSE	In use
<i>Electronic meter</i>	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. Telemetry 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.

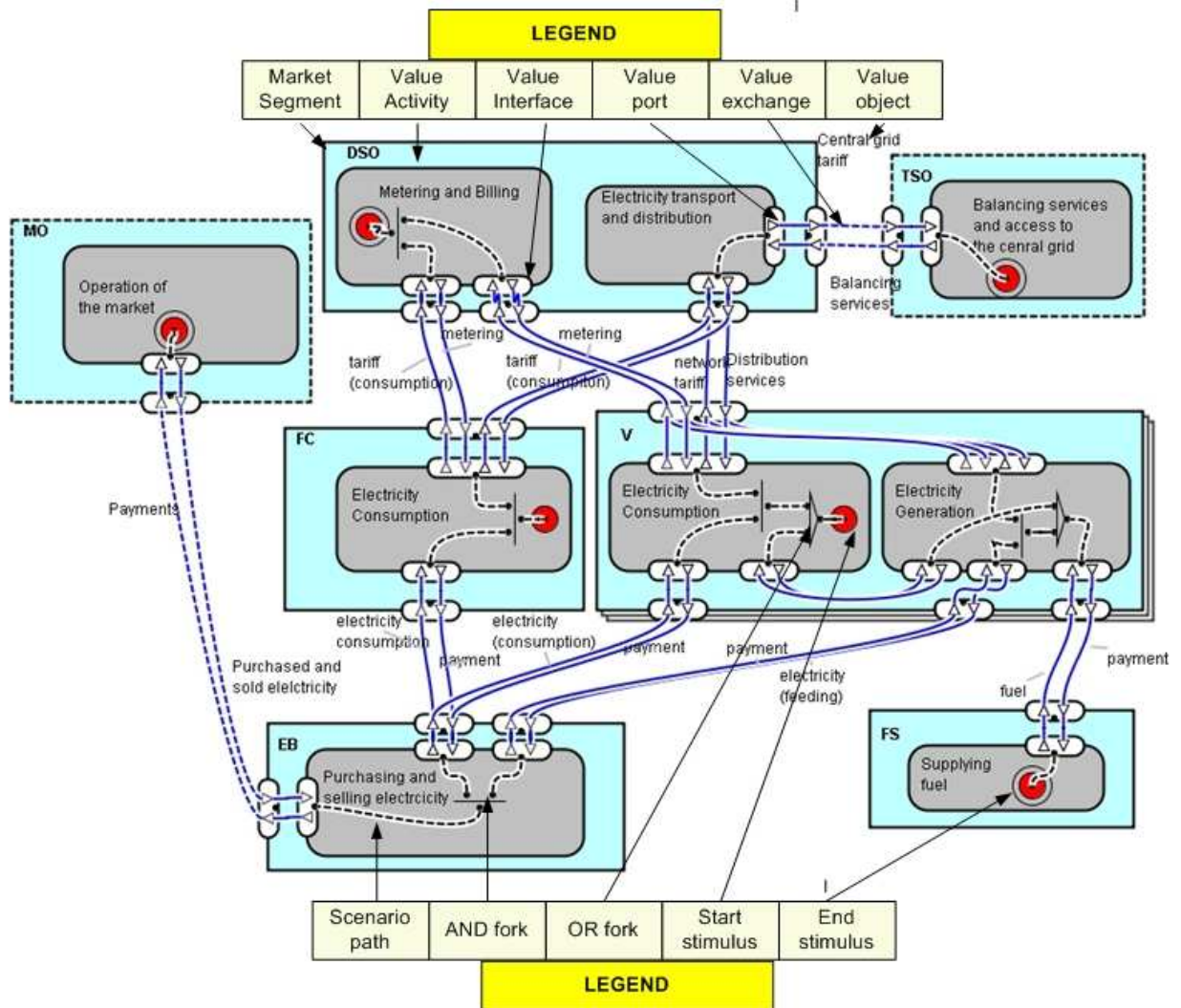


Figure 3 PLUG business model

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, CO₂, 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)
give quantitatively if possible
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
what gives rise to them, office space, personnel, maintenance, software...
24. Other obstacles in its implementation
including current regulations, attitude of regulated participants,
25. Geographical limitations
26. Regulation related issues
Possible benefits from subsidies, minimum sizes for participating in market, etc.
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, Nocolai 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
<i>Customer</i>	The owner of flexible demand connected to a distribution network.
<i>Aggregator</i>	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.
<i>TSO</i>	The Transmission System Operator (TSO) transmits electrical power from



<i>System control centre</i>	<p>generation plants to regional or local electricity distribution operators. The TSO is also responsible for operating the Balancing Option Market and the Balancing Market.</p> <p>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.</p>
<i>Balancing Market/ Option Balancing Market</i>	<p>The demand response can be involved in the following market:</p> <ul style="list-style-type: none"> • 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:

<i>Product/Service</i>	<i>Definition</i>
<i>Demand response - aggregation and trading</i>	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:

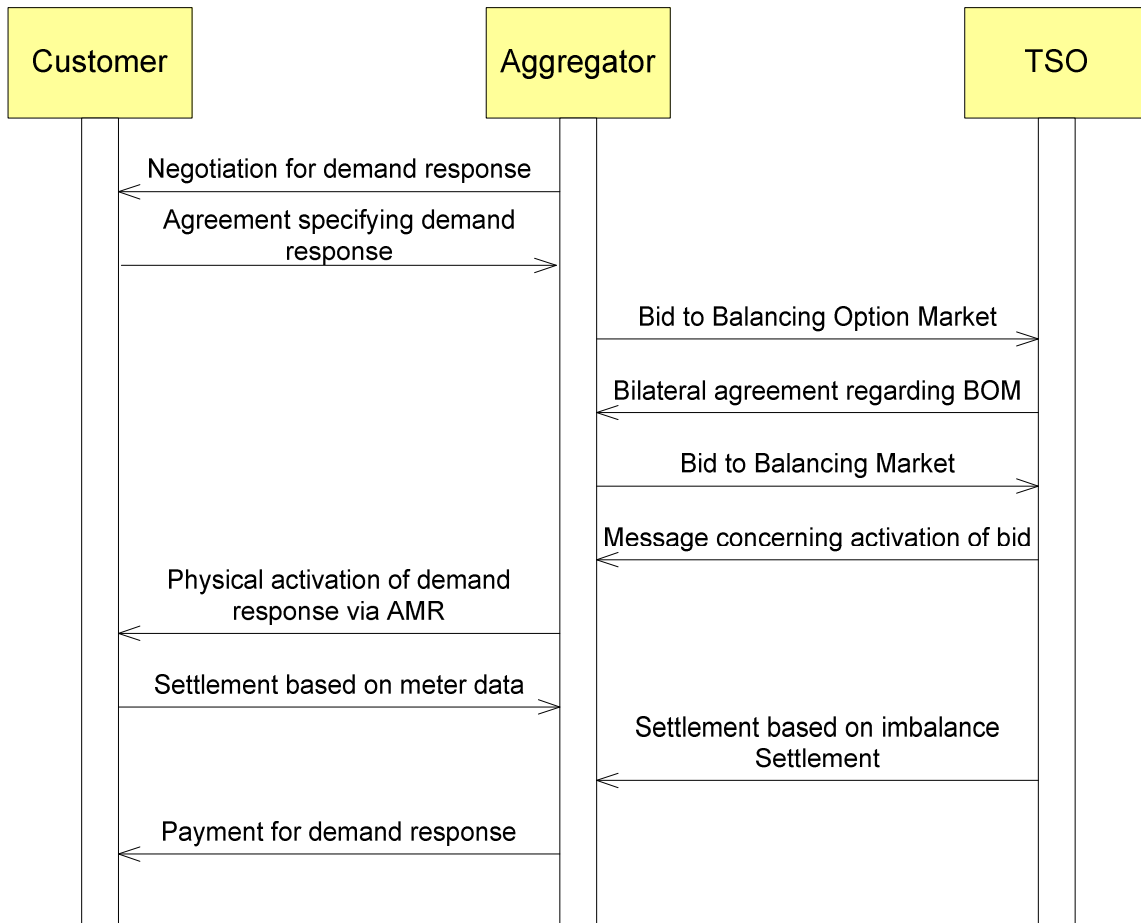


Figure 2. UML representation of flows between actors

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.	<i>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.</i>
DSO	Grid operator	A party that operates one or more grids.	<i>The DSO operates the system control centre.</i>
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.	<i>The TSO is responsible for operating both the Balancing Option Market and the Balancing Market.</i>



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.):

<i>Technology name</i>	<i>Description of functionality</i>	<i>Role which need it</i>
<i>Telephone</i>	Telephone call from TSO to the DSO's system control centre for initiating the disconnection	TSO
<i>Automatic Meter Reading-technology</i>	Remote load control. Sending pulses to signal lamp and BEM-System to start disconnection of flexible loads.	DSO
<i>Building Energy Management System</i>	Performing disconnection of flexible loads	Customer
<i>Customer Information System</i>	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”¹⁹.

In Poland: big consumers²⁰ (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 eligible for agreements separate for transmission-, distribution and power

¹⁹ http://www.ure.gov.pl/portal/en/4/22/Presidents_duties.html

²⁰ 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.
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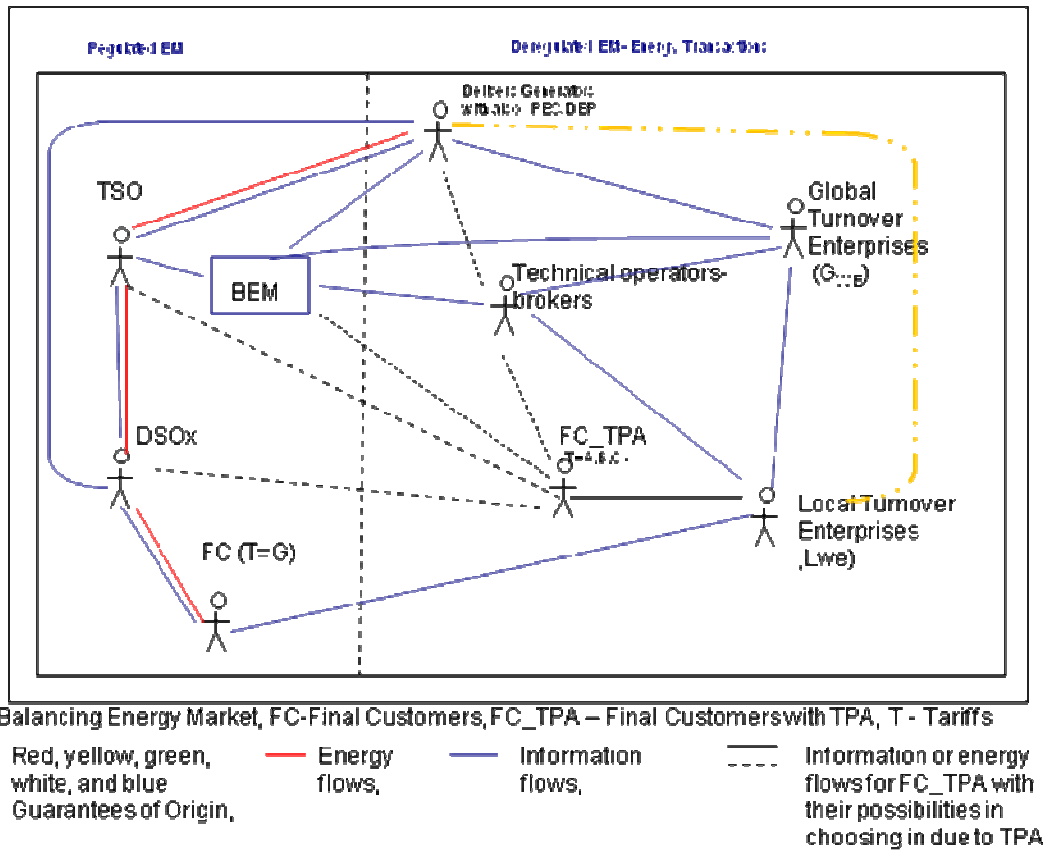


Fig.1. Energy Market Model in PL – relationship

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 NG²¹, 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 LWE²² 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:

²¹ TSO for NG- it means Transmission System Operator for NG system grid

²² 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 between²³ 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

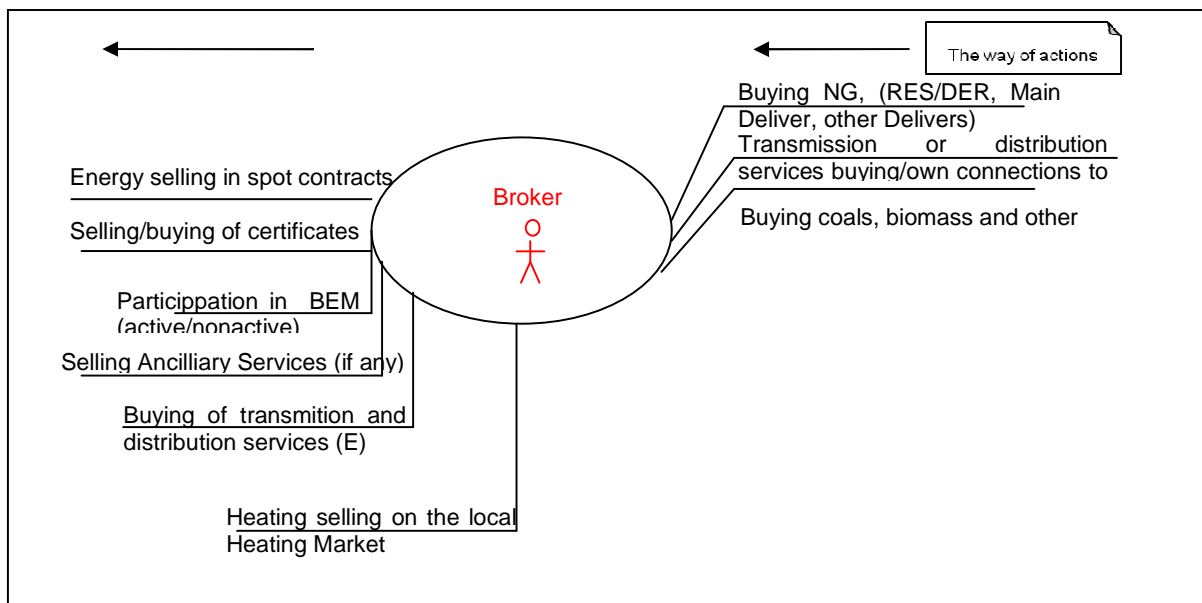


Fig 2.Graphical description of broker's functionality.

²³ According to agreements for transmission- and distribution grid services

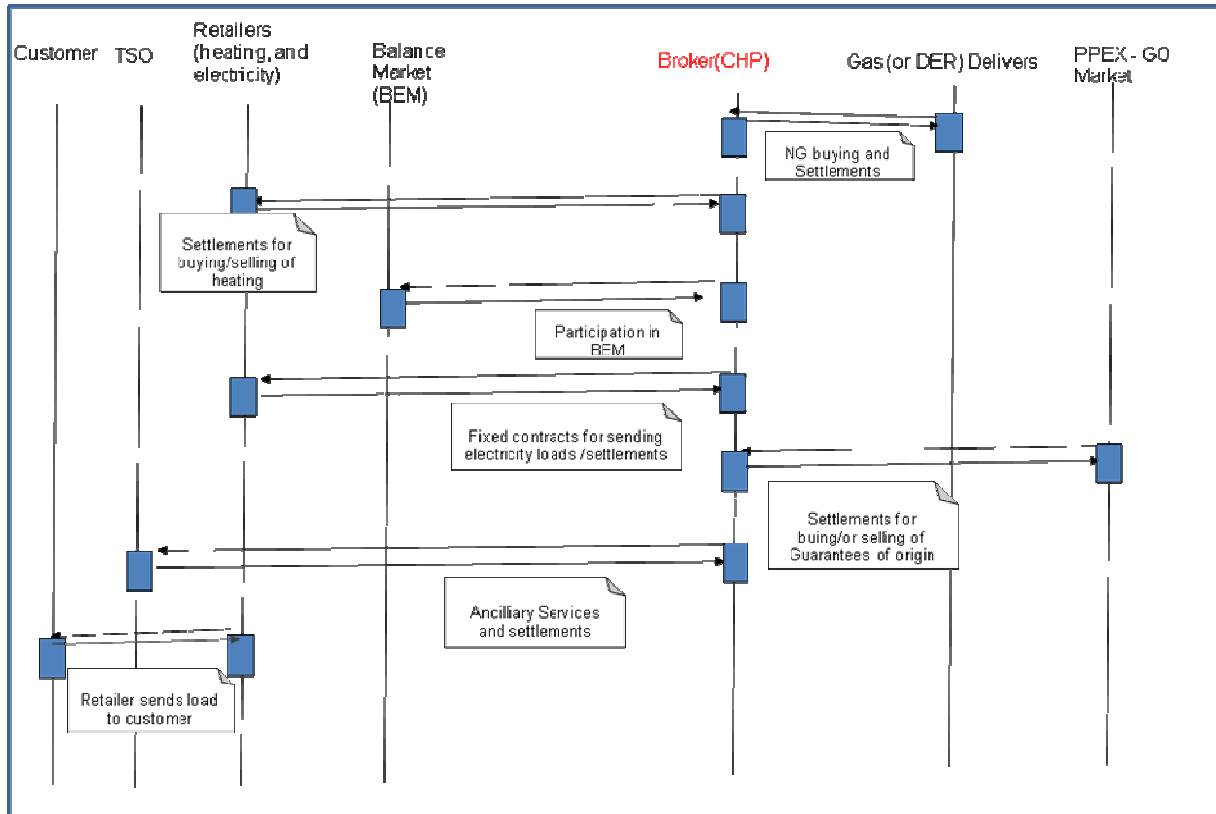


Fig. 3 Proposed Business Model - sequence diagram

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, CO₂, 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.