Use Cases

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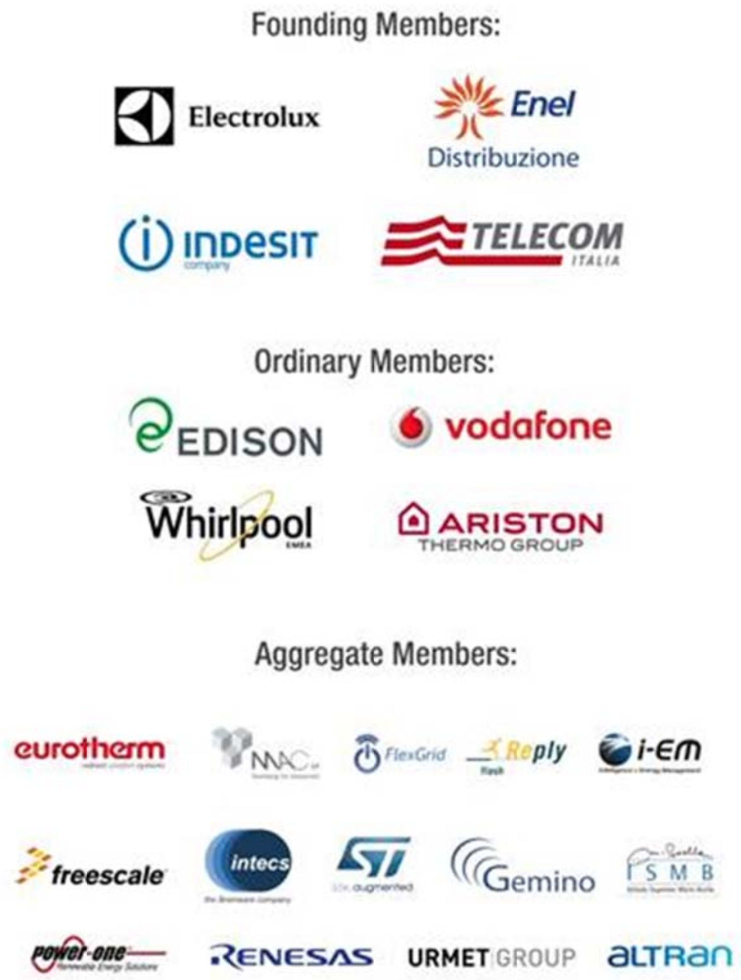
1 Introduction

Energy@home is a no-profit association that aims to develop & promote technologies and services for energy efficiency in the home, for the benefit of the environment, based upon device to device communication. Its goal is to promote the development and widespread of products and services based on the collaboration of the appliances within the household and their integration with the Smart Grid.

The Association was founded on July 2012 by Telecom Italia, Electrolux, Enel Distribuzione, and Indesit Company and it is open to new members. At the time of writing, the Association counts 22 members from different industries: the electrical system industry (Enel and Edison), household appliances manufacturers (Electrolux, Indesit Company, Whirlpool, and Ariston Thermo), telecommunications (Telecom Italia and Vodafone), ICT companies (Altran, Flash Reply, and Intecs), micro-electronics vendors (Freescale, Renesas and ST Microelectronics) and a company for the inverter and storage systems (Power-One), as well as research institutes (Istituto Superiore Mario Boella) and small/medium-sized companies (Fly-By, Flexgrid, Eurotherm, MAC, Gemino, and Urmet).

The Energy@home aims to use the new information technologies and electronic equipment's to transform the home environment in an eco-system of devices that communicate with each other's: the electric meter, household appliances, electrical system, and the network of broadband telecommunications, small renewable power plant and energy storage. Communication allows these devices to be integrated in a smart way, increasing energy efficiency, reliability and security of the domestic energy system, and giving consumers more information and power of choice.
The activities of the Association are organized into working groups and, in addition to the definition of architectures and technical specifications, include the analysis of the use cases and the impact on the regulatory environment, experimenting with pilot projects and the dissemination of the specifications.
Energy@home is an acknowledged contributor to the ZigBee Home Automation 1.2 standard that integrates devices, functionalities and use cases of Energy@home.

Information in this document is preliminary and subject to change, however anyone is encouraged to review and provide comments at the following e-mail addresses: comments@energy-home.it Energy@home reserves the right to publish future versions of these specifications without any prior notice.



2 Scope

The purpose of this document is to provide a set of use cases for implementing Energy@home Association vision.

This documents represents the second release of “Energy@home Use Cases” document with the aim to extend the E@h architecture following consumers and grid needs. In the document additional types of services are defined with respect of the first version. This release has been created taking into account the experience of the partners and constitutes a new step toward a fully integrated Home Area Network. Further versions of the document are envisaged during the development of the project, whenever partners shall identify the chance to implement supplementary categories of services for clients also taking into account additional experiences and points of view.

3 System Architecture

Following the European roadmap for the implementation of the Smart Grid[1], where concepts like flexible demand and generation are taken into account, one of the cornerstone requirement for the support of an efficient integration of renewable energy sources into the energy system is the flexibility that a customer could offer to the Smart Grid actors through a so called “Smart Grid Connection Point”, that represents the physical and logical interface from the customer to the grid. The generic architecture that describes the functions involved in the interactions between the Customer and the Grid actors is reported in Figure 1

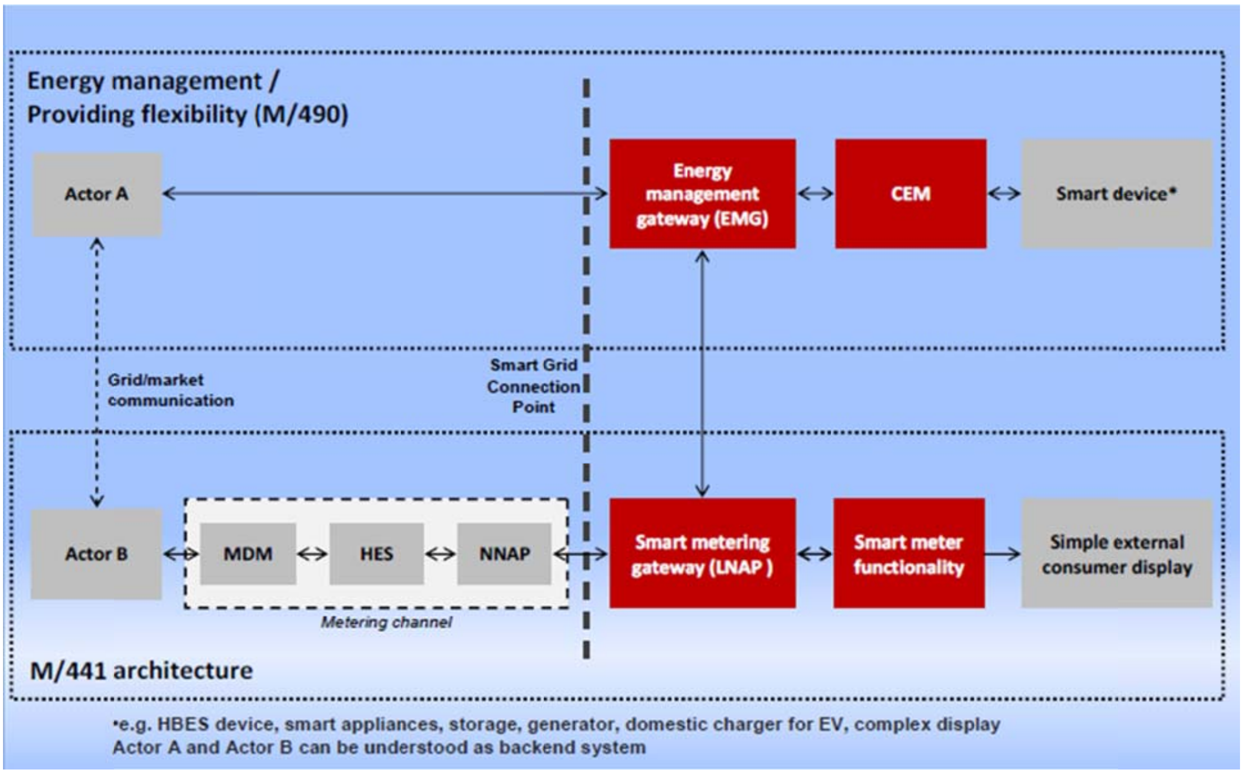


Figure 1: Flexibility functional architecture from SGCG (source Smart Grid Coordination Group)

The functional components represented in this figure could be implemented/aggregated in different systems and devices. In this document it will be shown how this generic functional architecture can be mapped in the Energy@home architecture. The Association adopted the system architecture shown in Figure 2, providing to the customers new value added services ranging from simple energy consumption awareness, up to a fully integrated energy management system. The architecture is expected to increase in scope as a result of the ongoing collaboration activities and interests of the Energy@home members.

[1] Developed by the “Smart Grid Coordination Group” as requested by the European Commission, mandate M/490. Reference: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/xpert_group1_sustainable_processes.pdf

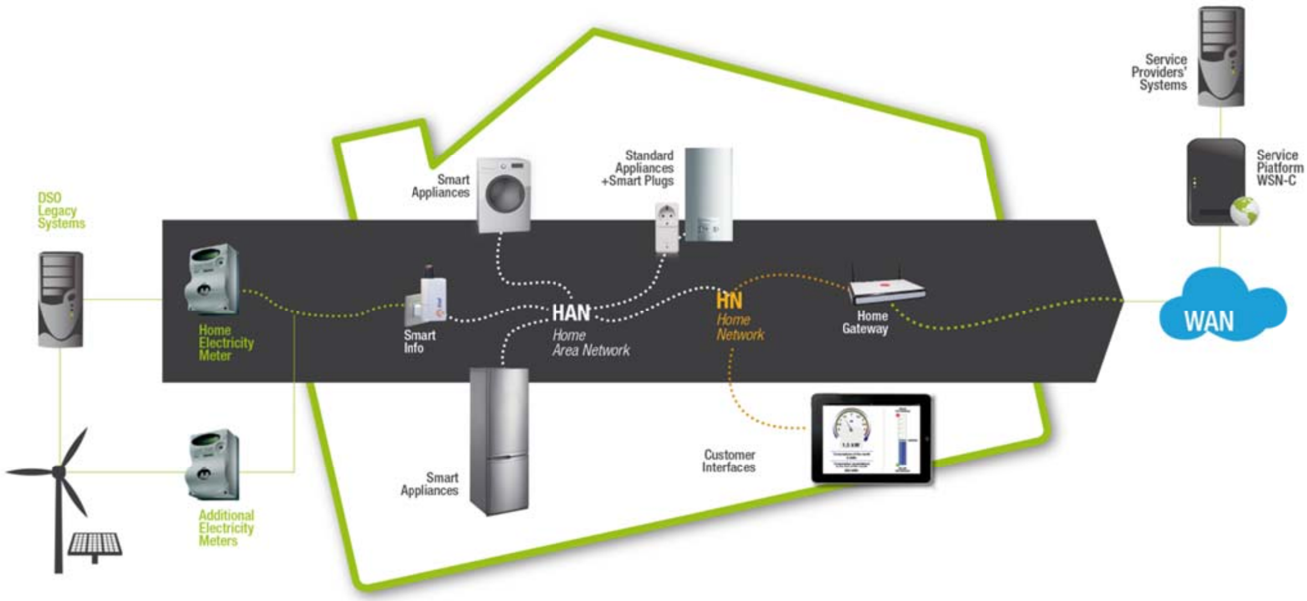


Figure 2: Energy@home architecture

In a Home Domain, that includes both the HAN (Home Area Network) and the HN (Home Network), all the actors (home devices, CEMS, Smart Info and Customer Interfaces) can cooperate through communication mechanism. The aim of Energy@home is to identify and describe the requirements of indoor platform and it is expressly out of the scope the definition of the other interfaces and services provided outside the Home Domain.

Devices in the HAN communicate with each other via the wireless protocol ZigBee Home Automation version 1.2 developed in collaboration between the ZigBee Alliance and Energy@home and officially ratified in July 2013. These international specifications define all levels of communication including the syntax and semantics of application messages exchanged between the user devices. This ensures full interoperability between systems and devices from multiple vendors.

The HAN will interface with the DSO meter using a smart metering gateway (Smart Info) that provides measurement data recorded by the electronic meter communicating with it via the DSO (Enel Distribuzione) power-line protocol. On the other side, this device is part of the Home Area Network and it communicates using the ZigBee protocol: it can be configured to send push data received from the all the DSO meters and can be queried in polling to acquire on-demand data.

The HAN devices are divided into "legacy devices" and " smart devices”. The first are traditional devices that do not implement any communication skills and can only be controlled through a Smart Plug. In Energy@home have been defined all the messages needed to configure these smart plugs, to receive energy data and instantaneous power, and where the load permits, to control the switch on/off remotely. Smart devices are connected devices for which the messages are defined to identify the type of load (e.g., type of appliance, supplier name, firmware version, etc.) as well as to monitor and control the start and the status of operation, to communicate information to diagnose problems as well as the transmission of statistical information and the tunneling of manufacturer proprietary information of the appliance. Every electrical load of a smart device can be planned through a scheduling algorithm that uses the data structure defined in Power Profile.

The Power Profile is a vector which represents the energy needs of a device, in the case of a washing machine each element of the vector represents a phase of the washing. Each element is a schedulable phase not interruptible described by 4 fields: the maximum power required, the estimated time required, the expected energy consumed and, finally, the maximum delay allowed scheduling the phase. The CEMS collects the Power Profile of all devices connected and performs a scheduling algorithm to calculate the delay of each stage for each device; this permits to optimizes the total demand in terms of maximum power and hourly cost of energy that, of course, is always subject to any restriction set by the client (such as the time of termination of a wash) and to the availability of energy from power plants and storage systems in the home.

The main actors in the Home Domain are the following ones:

- **Smart Appliances:** an evolution of the actual and standard white goods; see hereunder some of their possible new functionalities:
  - Display to the customer information on their energy consumptions (e.g. used energy, instant power, etc.)
  - Dispatch in the HAN information on their energy consumptions
  - Autonomously adapt their behavior according to information on energy consumptions coming from the house. (e.g. reduce their load when global house consumptions goes beyond a threshold)
  - Cooperatively operate with other entities in order to optimize the energy usage through load shifting and load shedding

  In any case, the load control operations either performed autonomously or under an external supervision, shall be performed under the complete control of the appliance, which assures the correct execution of its working procedure and its results and performances. For example, a smart washing machine, when requested to modify its consumption behavior, shall assure the result of the washing cycle.

  Smart plugs (able to provide remote metering and to be remotely controlled) could be somehow included in the Smart Appliances category although they can provide no direct control over the effect of remote control activities. In particular, Smart Appliances will not be controlled by Smart Plugs
- **Customer Interfaces:** see hereunder some of their possible functionalities:
  - Display information on energy usage like instant power, historical data, contractual information and similar, from the whole house (coming from the Smart Info) and from every single smart appliance. The level of details and graphical layout of their user interface is freely defined by every device
  - Transmit control message to Smart Appliances to request a modification of their behavior
  - Configure Smart Appliances to modify their power consumption profile (e.g. a personal computer used to configure a thermostat to activate the controlled load only in certain time slots)

  The Customer Interface, from this perspective, is connected in the HN/HAN; it is foreseen the possibility to have Customer Interfaces accessing the house from the WAN through a specific interface, but the definition of this interface is out of the scope of the Energy@home project as previously stated.

  Typical Customer Interfaces are personal computers, Smart Phones, PDAs, ad hoc displays, entertainment systems, in-house monitor and similar. The software application, which implements the user interface, could be local in the device or remotely hosted in another device (e.g. the Home Gateway) and accessed through web-services.

- **Customer Energy Manager System (CEMS)** The CEMS is CEM integrated with communication functionalities, it is the gateway between the HAN, the HN and the WAN (e.g. internet). The CEM is a logical function optimizing energy consumption and or production based on signals received from the grid, consumer's settings and contracts, and devices minimum performance standards. The Customer Energy Manager collects messages sent to and received from connected devices; especially the in-home/building sector has to be mentioned. It can handle general or dedicated load and generation management commands and then forwards these to the connected devices. It provides vice versa information towards the "grid / market". Note that multiple loads/generation resources can be combined in the CEM to be mutually controlled.
- **Smart Info:** it is the element, provided by the DSO, which dispatches energy related information into the HAN. Published data are a sub-set of those already available inside the Home Electricity Meter, hence the Smart Info acts like a proxy of the meter. Additional data could be possibly generated by the Smart Info itself. Noticeably, near real-time instant power (sampled at of about 1 Hertz frequency or higher) should be acquired by another metering device, likely embedded inside the Smart Info. Additional elements (SI') can also be provided by third parties and used to dispatch data generated by other meters into the HAN.

Outstanding components outside the Home Domain are:

- **WSN-C:** Wireless Sensor Network Center: it manages, together with the Home Gateway, the HAN devices and provides service oriented interfaces for the development of third-party applications.
- **Electricity Meter:** An electric meter, able to measure and record usage data in time differentiated registers, and capable of transmitting such data to central utilities system. Moreover, the meter should provide bi-direction communication to allow remote management of the meter.
- **Aggregator:** mediator between consumers and AD buyers, collects requests and signals from the AD buyers, pools flexibilities of consumers to build Active Demand services and makes offers to the markets.

Please note that the proposed classification is mainly intended to identify the main categories of devices in the Home Domain, without any limitation to the possibility for a device to implement functionalities from more than a category. As an example, an advanced Smart Appliance, provided with a rich user interface, could also implement functionalities typical of a Customer Interface. In the same way, while typical smart appliances are smart white goods, also a personal computer, able to perform such operations, should be considered an appliance from this perspective.

4 Use cases

Use cases have been organized into clusters of scenarios and they maintain a unique incremental number in order to make them easily identifiable.
We define different incremental levels of functionalities of the Energy@Home System:

- Customer Awareness
- Appliance Regulation

Moreover it will be important to define some auxiliary use cases related to the set up and maintenance of the Network itself, not strictly related to the Energy Management of the house.
Let’s describe all of them in detail:

5 Customer awareness

The goal of this first level of functionalities is to enhance customer awareness about her/his energy consumption by displaying some useful energy related data. The appliance will not suggest directly to the customer any related action.

5.1.1 Scenario 1: Visualization of current energy and power data

The aim of following use cases is to provide customer with information on the current situation of her/his consumptions.

<table>
<tr><td>Title</td><td colspan="2">1.1 Visualization of global current metering data from Smart Meter and DSO</td></tr>
<tr><td>Description</td><td colspan="2">The customer is presented with information about the global current energy consumption of his/her house. Data are provided by the Smart Info, which retrieved them from the Meter and, possibly, integrates those data with near real-time power, measured by an extra module. Among the data coming form the Meter no information about costs are provided, hence any reference to the current tariff shows just which is the active tariff at the moment, but not the pricing. In this context “current” means near real time data and the consumptions of last few hours or days. Data can be presented in different formats (plain numbers, graphics, tables, etc.) in the Smart Appliance or in the Customer Interface. In this Use Case the CEMS is not strictly necessary; its presence would allow a number of extra functionalities described in the CEMS column.</td></tr>
<tr><td colspan="3">Roles</td></tr>
<tr><td>Smart Info</td><td>CEMS</td><td>Smart Appliances</td></tr>
<tr><td>Provides a sub-set of data contained in the Smart Meter and, eventually, instant power, calculated by the SI itself or another device connected to it.
Data are dispatched upon request and in case of transition (only for slowly changing data). The Smart Info performs no elaboration over the data</td><td>Hosts a Web application that collects data from HAN devices and organizes them for a user-friendly presentation.

Exposes a web-based API over IP HN that can be used by 3rd party applications that wishes to elaborate current data and provides a different visualization.</td><td>Receive over the HAN (from Smart Info) global current metering data and total in-house energy consumption.
Display a sub-set of available data, depending on the richness of its user interface</td></tr>
</table>

retrieved by the Meter, except the basic processing required to retrieve, validate, memorize and dispatch them. For example, load profile shall be dispatched with the same level of resolution available in the meter (e.g. 15 minutes). Any operation needed to change Meter data resolution or to integrate them with instant power, shall be performed by the device which displays data to the customer.	Implements an Execution Environment (e.g. OSGi framework for Java) to host 3rd party applications that wishes to elaborate current data and provides a different visualization. Implements a Trust Agent to manage all security keys of the HAN; this functionality can be implemented via collaboration with the WSN-C Service Platform Implements the communication with the WSN-C Service Platform and provides APIs to mediate communication between local bundles and WSN-C Service Platform.	

Title	1.2 Visualization of global current metering data + cost information	
Description	This Use Case extends UC 1.1 adding also information about the cost of the used energy. According to rules imposed by the Authority, the DSO could not be allowed to provide such information, being the Energy Retailer the only subject entitled to define final rates for clients. (see notes below).	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
At least the same as UC 1.1 In addition, in case of time-of-use (TOU) pricing, the Smart Info can emit signal in the HAN, whenever a tariff change is taking place. (see notes below).	Same as UC 1.1 The CEMS hosts a dedicated algorithm, the *Energy Cost Algorithm*, to evaluate energy costs obtaining (either via a proper code or a proper form to be filled by user or a remote web site to gather the information) the cost information. Moreover, implements a proper web application to display both cost and energy consumption. In addition, this interface shall also provide a way to obtain the cost per kWh. The exact moment when a tariff change occurs can be obtained by the Smart Info (this operation could also require to evaluate the possible difference between CEMS and Meter real-time clocks) Distributes over the HAN network the cost information to interested devices.	Same as UC 1.1 + cost information if this last info is available (see notes below)

Title	1.3 Visualization of current energy consumptions and power of Smart Appliances+ global current metering data	
Description	In this Use Case, the customer is also informed on the current energy consumptions of the single appliance. The level of detail, frequency and quality of data could be different among different devices. It should be possible for clients to display such disaggregated data together with total house consumptions; such functionality shall be performed by Customer Interfaces.	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
At least the same as UC 1.1 In addition, near real time instant power information is to be provided in order to allow Smart Appliances to calibrate its energy consumptions.	Same as UC 1.1 Provides to user appliances a single point of contact to publish their respective current energy consumption information.	Each appliance ▪ displays its own energy consumption/power drawn data ▪ dispatches it own energy consumption data over HAN ▪ receives over HAN (from Smart Info) the total house energy consumption ▪ displays the total house energy consumption

Title	1.4 Visualization of current energy consumptions and power of Smart Appliances + global metering data + cost information	
Description	Similar to UC 1.3 with information on costs	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 1.2 plus UC 1.3	Same as UC 1.2 Same as UC 1.3	Same as UC 1.3 + cost information if this last info is available (see note below)

Title	1.5 Visualization of estimated energy consumption of Smart Appliances and its cost before starting to run	
Description	One of the most important goals of this use case is to educate the consumer in selecting the parameters of the cycles feedbacking her/him their costs and energy consumption, before the start button will be pressed. Many studies show that, only by displaying this information, a energy consumption saving of 10-15 % could be achieved on the single appliance. The Smart Appliances estimate the energy that will be consumed during its next operation (ex: cycle). If possible, they give information also about the energy cost and the next operation cost by requiring to the CEMS to perform energy cost evaluation.. Moreover, in case of time-of-use (TOU) pricing, the appliance receives information about which tariff is currently in use.	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 1.3	Provide the HAN with information about energy tariff profiles, energy costs and clock time.	The Smart Appliances: ▪ estimate the energy to be consumed to perform the next operation

		▪ display the estimated energy value ▪ receives the information of energy cost through HAN ▪ display this cost

Title	1.6 Visualization of a warning if available total power (in the home) is not sufficient to run a Smart Appliance	
Description	The Smart Appliance estimates the maximum power that will be consumed during its next operation (ex: cycle). If the total available power in the home is not sufficient to run, the Smart Appliance notifies the user	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 1.3		The Smart Appliances: ▪ estimate the maximum power to be consumed to perform the next operation ▪ receive the information of total available power in the home through HAN ▪ display a warning to the user if it is not possible to run ▪ eventually send the information that it is not possible to run through the HAN

Notes:

In a fully “unbundled” framework, the DSO (owner of the SI) is not in charge of defining energy rates and to bill final customers. Nevertheless, the DSO, being the subject entitled to perform metering activity, knows all the metering data needed for billing, being the final price evaluated by the Energy Retailer on the basis of these metering data sent by the DSO. For example, in Italy, TOU schedule (number of tariff and start and stop time) is pre-configured into the Meter according to the requirement set out by the AEEG. In this way, the AEEG has frozen the timetable for electric offers, being each energy retailer free to decide the price for energy in tariff (i.e. each time slot).

Usually energy is priced higher during peak time and lower in off-peak; however it is also possible for the energy provider to charge every tariff the same, or even offer a flat rates for energy (already available in the market) similar to telecommunication rates (note that in case of flat rates the concept itself of euro-per-kWh itself is meaningless). The price could also depend on previous consumptions, for example in case the rate changes according to the overall consumptions in a given billing time (e.g. a year). Moreover, the price could increase given the maximum peak of power in a given period (e.g. a day). Whichever the conditions, the Energy Retailer shall rely on the metering data provided by the DSO.

To evaluate the price of used energy, the Smart Info shall provide the metering information to another device, which shall implement a dedicated algorithm, the ***Energy Cost Algorithm***. The *Energy Cost Algorithm* calculates the price of energy at a given time (e.g. € per kWh from 08:00 to 19:00) replicating the conditions applied by the Energy Retailer. The *Energy Cost Algorithm* to get the price could be quite complex, and, in any case, defined by each Energy Retailer. The *Energy Cost Algorithm* shall be hosted on the CEMS and should be ideally provided by the Energy retailer as a “plug-in” dedicated to price evaluation. In the scope of Energy@Home, the interfaces of the *Energy Cost Algorithm* shall be defined by detailing the input and output parameters. For example, to estimate the price of a forecasted consumption, possible input parameters are:

- The content of all metering registers from the Smart Meter
- The time boundaries of the different TOU tariffs
- The time in which the energy consumptions is going to take place, possibly with separate indication of the different TOU tariffs
- Other additional data should be collected by the *Energy Cost Algorithm* itself possibly via a direct machine-to-machine connection to the Energy Retailer server.

The output of the *Energy Cost Algorithm* could be a pair, including:

- The estimated price in euros
- An estimation error (percentage of estimated price)

.
Every actor in the HAN shall have access to the *Energy Cost Algorithm* via a dedicated service offered by the CEMS.

A simplified mechanism, without a CEMS, could be envisaged defining a ***Simplified Tariff Profile*** to be exchanged in the HAN. The *Simplified Tariff Profile* shall be standardized and shall provide enough flexibility in order to evaluate, with sufficient accuracy, most common tariff offers. A possible content of the *Simplified Tariff Profile* is a sequence of time slots and the correspondent price (in euros per kWh) for each time slot. The actor that provides the Simplified Tariff Profile shall autonomously take into account all the relevant factors that influence the tariff, such as current time or differences between working and holiday days. The *Simplified Tariff Profile* could be provided by an actor present in the HAN and used by any other actor to perform approximated evaluations of the energy cost.
It should be noted that this solution should be considered as a sub-optimal one, to be used in case no actor in the HAN is able to offer the *Energy Cost Algorithm*.

A common requirement, for both cost evaluation mechanism, is that the evaluation process is completed within a time compatible with the proposed services. In particular, it shall comply with typical man-to-machine interface response.

5.1.2 Scenario 2: Visualization of historical data

The aim of the following use cases is to provide customers historical and statistical information on their energy consumption, disaggregating the global energy time variations with the one coming from the Smart Appliances.

Title	2.1 Visualization of historical data for the single customer (Global in-house and Smart Appliances)	
Description	The customer may access the historical data and verify how he used energy during time.	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
Retrieves, from the Meter, available historical data (i.e. the in-house power profile) and possibly internally generated instant power samples. Data resolution and number of samples could vary, according to meter configuration. The Smart Info itself does not perform operations to change time resolution of data coming from the Meter. Any needed operation, or integration with additional data, shall be performed by the Customer Interface device.	The access to the network platform, allows the storage of the total and single appliance's energy consumption. The CEMS can access and aggregate those data to present them to the user through a Browser. The CEMS allows external applications in the HN to retrieve the stored data	The Smart Appliances can display some specific data concerning their energy usage, considering the intrinsic limitations of their User Interface It will provide to the HAN its information on energy consumption.

Title	2.2 Visualization of historical data compared with a benchmark	
Description	The customers may compare their own energy consumptions with other customers to be able to check their behavior against virtuous references.	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 2.1	Guarantee a simple access to the application in the network in order to enable comparison with other users.	None

Title	2.3 Visualization of historical data compared with a user community	
Description	The customers may compare their own energy consumptions with user communities	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 2.1	Guarantee a simple access to the application in the network to compare the energy usage with a community of users.	None

5.1.3 Scenario 3: Alarm

Title	3.1 Notification of Home Domain Overload

Description	The customer is promptly informed when the overall power drawn exceeds the maximum available power, hence causing a Home Domain Overload. The notification shall be notified local alarms (e.g. acoustic). The customer can also access to an historical view of any alarm.	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
The Smart Info receives from the Meter, or generates itself, a max-power-alarm, indicating that power is beyond a contractual threshold. The Smart Info, consequently, emits an alarm in the HAN to all the Customer Interfaces, Smart Appliances and to the CEMS, providing indication about the percentage of power beyond the threshold (if available). It should be defined whether the alarm is to be sent to all paired devices or only to those which have been previously registered for receiving the alarms. The alarm could be emitted more than once, before the Meter opens the breaker.	It can activate the local alarm through an in house TI terminal. It allows the user to set the priorities for the house device/appliance alarm activation (i.e. TI terminal, dishwasher machine, ect.)	The appliances can echo the general alarm

Title	3.2 Black out	
Description	In case of energy black out the CEMS, equipped with an UPS, is able to guarantee the correct activity for a minimum time (< 60 sec.). It can alert the customer about the event with an alarm (e.g SMS, phone call)	
Roles		
Smart Info	**CEMS**	**Smart Appliances**
In case of black out the Smart Info will not be able to reach the Meter, hence it shall not emit any dedicated message toward the HAN.	Activate a SMS or a voice call alarm	None

5.1.4 Scenario 4: Other energy information

The Execution Environment, available in the CEMS, enables further applications dedicated to customer awareness. For example, the energy retailer could deploy an application able to provide clients with the **energy sources mix** used to supply his/her appliance, specifying the percentage of renewable sources, the CO2 footprint and similar information.

6 Appliance regulation

The appliance regulation can be performed according to 2 increasing levels of performance and system complexity: a coordinated regulation among the devices of the HAN or a self-regulation operated autonomously by the Smart Appliances. The goal of both approaches is to provide the customer automatically with suggestions and assistance on how to improve the energy management of the house.

6.1.1 Coordinated Management appliances regulation

In this configuration, all the Smart Appliances in the house cooperate together to regulate their behavior according to global energy information of the house, their current state and priority when the regulation is needed. The type of regulation performed by the appliance could vary according to the type of appliance. The regulation logic could be centralized or distributed but in any cases coordinated and harmonized. Only knowing the entire energy and power status of the Home Domain System, the full performances of the system could be guaranteed; on the other side, the involved algorithms will be the most complex, having to take into consideration the different and time variable energy states of the Smart Appliances and standard electrical loads in the house.

6.1.2 Self Management appliances regulation

In this configuration, the single Smart Appliance regulates its behavior according to global energy information of the house, such as current instant power and energy price. The type of regulation performed by the appliance could vary according to the type of appliance and its current state when the regulation is needed. No cooperation with other appliances is involved.
Since in this level there is no coordination with other Smart Appliances and thus knowledge of their power consumption (and of other independent electrical loads of the house), the full performances of the system could not be guaranteed; this is why the output of the use cases of this scenario should be considered as suggestions: the customer nevertheless will be in charge of coordinating the use of other Smart Appliances and independent electrical load of the house. She/he will always decide if accepting or not the suggestions from the system.

6.1.3 Scenario 1: Home Domain Overload management

In this scenario, the single appliance regulates its behavior upon home power availability. The aim of following use cases is to foster the use the appliances when there is enough power in order to avoid overloading. The power peak management can leverage both on coordinated and self-management regulation as indicated in the use cases.

<table>
<tr><td>Title</td><td colspan="2">5.1 Home Domain Overload management in case of smart and non-smart appliances</td></tr>
<tr><td>Description</td><td colspan="2">The Energy@Home system can optimize the use of power in order to avoid Home Domain Overload.

Coordinated management:
The customer can define/modify the load shedding priorities and strategies in case of a Home Domain Overload, to be applied to smart and non-smart appliances (Smart Plugs could be used to manage power disconnection priorities for non-smart appliances). A central unit located inside the house will implement the coordination logic. An alarm (e.g. acoustic) can be generated to notify to the customer the critical condition.
In order to simplify the process, default configurations could be considered.
The Smart Appliances can activate enhanced features that guarantee to the whole set of devices a maximum energy consumption (peak limit).

Self management:
While working, the Smart Appliance can perform load shedding, modifying its behavior in order to reduce or adapt its power consumption to the overall status of the house.</td></tr>
<tr><td colspan="3" align="center">Roles</td></tr>
<tr><td align="center">Smart Info</td><td align="center">CEMS</td><td align="center">Smart Appliances</td></tr>
<tr><td>Same as UC 1.3 + UC 3.1</td><td>Coordinated management:
The CEMS hosts the application that allows the Home Domain Overload Management. The macro functionalities could be:
Allow the Customer to define its own overload rules (i.e. appliances priority)
Allow the Customer to associate to the Smart Plug a non-smart appliance (not yet connected to the HAN)
Receive from Smart Appliances info’s about the estimated appliance power profile of the program activated by the Customer
Coordinate the appliances in order to avoid the overload condition</td><td>Coordinated management:
The Smart Appliance
receives through HAN the coordination signals
executes the relative actions, as a function of its status
displays an information to the user
before starting, informs the central unit about the appliance power profile
Self management:
The Smart Appliance receives from HAN the available power in the Home Domain. Using this information, it adapts its behavior by some load shedding actions. In addition, it notifies its appliance power profile change in the HAN and,</td></tr>
</table>

	• Inform the Customer about any activated action (i.e. acoustic warning) • …. The CEMS also provides a web customer interface for these functionalities. ***Self management:*** The CEMS should be notified of the modified behavior (appliance power profile change) of the Smart Appliance.	if possible, in its UI.

Title	5.2 Request of confirmation to start if available power (in the home) is not sufficient to run a Smart Appliance	
Description	The Energy@Home system may require explicit confirmation from the Customer if the use of a Smart Appliance may lead to power overload. ***Coordinated management:*** The Energy@Home system checks if the total available power in the home is not sufficient to run the Smart Appliance, depending on its power profile estimation, on other Smart Appliances estimated power profile and on the current total in house consumption. The Smart Appliance notifies the Customer and asks the confirmation to start. ***Self management:*** The Smart Appliance estimates the appliance power profile about its next operation (ex: cycle). If the total available power in the home is not sufficient to run, the Smart Appliance notifies the user and asks to the customer the confirmation to start	
	Roles	
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 1.3	***Coordinated management:*** The CEMS hosts the application that allows the Customer to coordinate the Smart Appliances according to the available power and to knowledge of the potential activity schedules of other Smart Appliances in the HAN (e.g. due to pre-programmed schedules). ***Self management:*** The CEMS should be notified of the state of the Smart Appliance.	***Coordinated management*** The Smart Appliance: ▪ sends the estimated appliance power profile to the central unit and receives from it the information about the power overload risk ▪ interacts with the customer to avoid starting the cycle in case of potential overload by asking for confirmation ***Self management*** See UC1.6 Interacts with the customer to avoid starting the cycle in case of potential overload by asking for confirmation.

6.1.4 Scenario 2: Optimize energy cost in case of multi-tariff contract

In this scenario the E@H system performs actions in order to reduce and optimize the energy cost. The optimization of energy cost can leverage both on coordinated and self-management regulation as indicated in the use cases.

Title	6.1 Multi-tariff energy use optimization in case of smart and non-smart appliances
Description	The Energy@Home system provides an optimization of appliances usage in order to optimize energy cost according to the variable energy tariffs. This Use Case is meaningful for all those appliances which are activated by the customer and perform a specific operating cycle, such as a washing machine, oven and dishwasher. The most important exception is the fridge, which operates continuously. ***Coordinated management:*** The customer can define/modify the house rules for the energy costs optimization in case of single or multiple appliances. For any appliances the customer can set parameters like the operational time interval allowed for the device (e.g. from 6:00 to 24:00). Smart Plugs could be used to manage operational time interval for a set of non-smart appliances (e.g. a boiler). In order to simplify the process, default configurations could be considered. The Smart Appliances can activate enhanced features that guarantee to the whole set of devices to minimize user cost according to the variable tariffs. ***Self management:*** The customer prepares the Smart Appliance for its operating cycle (i.e. a washing program) and sets the needed condition for activation, e.g. the lowest energy price time. The Smart Appliance automatically waits until the given condition is met.

Roles

Smart Info	**CEMS**	**Smart Appliances**
Coordinated management and Self management: Same as UC 1.4	***Coordinated management:*** The CEMS hosts the application that allows the Customer to optimize the energy use. The macro functionalities could be: • Allow the Customer to define for each time interval the priority appliances list (i.e. from 19:00 to 23:00 priority to the washing machine) • Allow the user to associate to the Smart Plug a non-smart appliance (not yet connected to the HAN) • Receive from Smart Appliances info's about the estimated	***Coordinated regulation:*** The appliance before starting informs the central unit about its estimated power profile: the received appliance power profile data are used by the central unit to calculate the time when the appliance can start (according to the user desiderata, the total power availability and the tariff policy). ***Self-regulation:*** The Smart Appliance: ▪ Possibly performs the same activities as in UC 1.5.

	appliance power profile of the program activated by the Customer. • Control the appliances in order to optimize energy costs and life quality • …. The CEMS also provides a web customer interface for these functionalities. ***Self-regulation:*** Same as UC 1.5 As a function of the complexity of the optimization algorithm and of the Smart Appliance, some specific software in the CEMS could help the determination of the optimal start time.	▪ Implements or delegates to the CEMS the implementation of the delay determination logic ▪ Offer to the customer the possibility to activate a delayed start. This operation can be performed in several ways and with different level of complexity according to the built-in User Interface capabilities. For example, a simple appliance can have just a button for starting when the lowest tariff is used. A more complex appliance can offer a rich interface showing the tariff profile in time and letting the customer to choose when to start. ▪ If the customer accepts the delayed start, the Smart Appliance waits until the required condition is met. ▪ Display the actual cost of the required cycle and the relevant “delayed start” economical saving (depending on the richness of its User Interface)

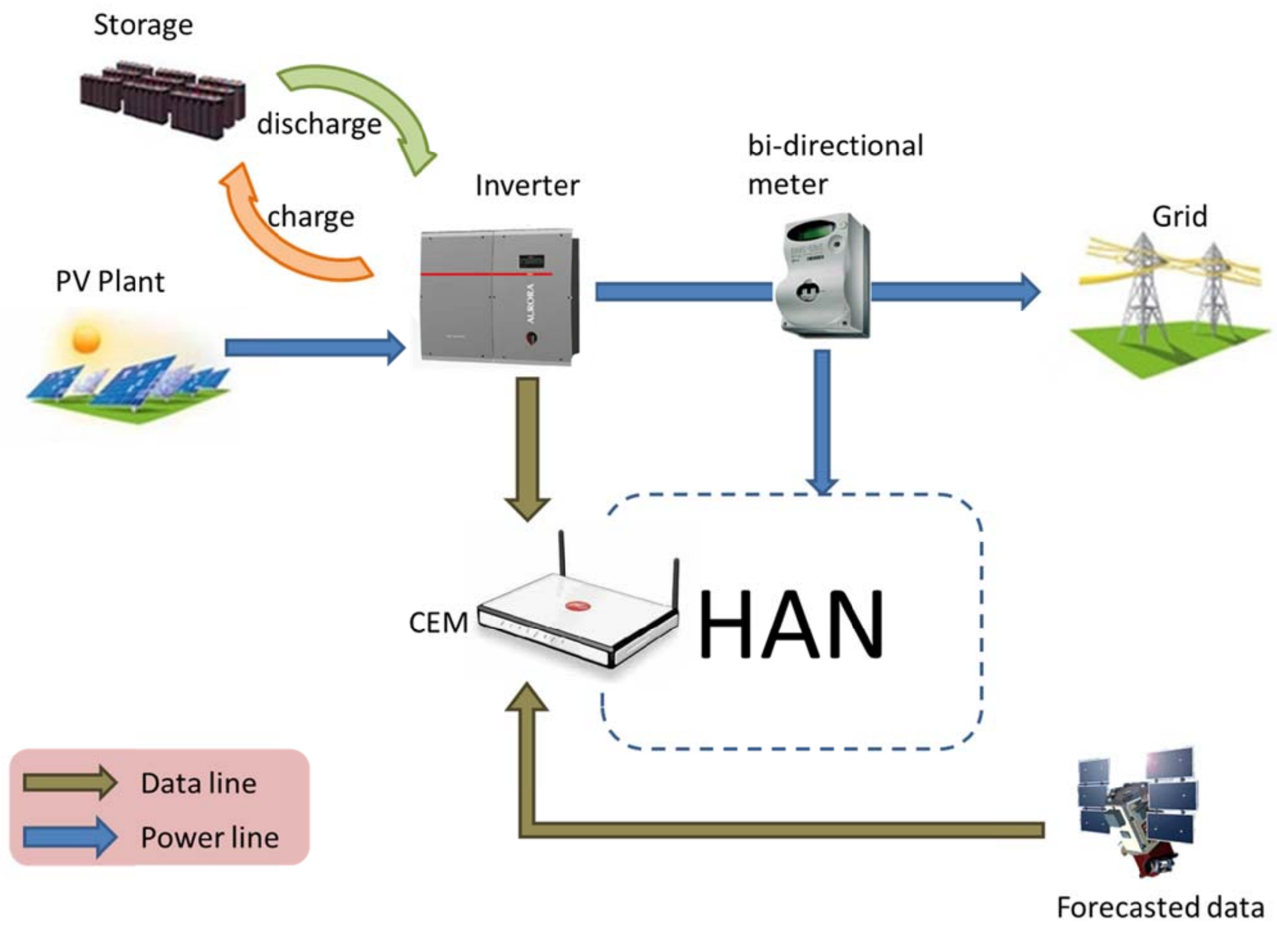
Title	6.2 Automatic time shifting of some phases or functions of the Smart Appliance for favorable economic conditions
Description	This Use Case foresees Smart Appliances’ capability to delay some of its specific functions (either activated by the customer or automatic inside the cycle) according to current tariff and energy cost. ***Coordinated management:*** The coordination between the different actors in the house and their needs in terms of power consumption will allow take into consideration the overall power consumption forecast and thus better optimize the energy costs and prevent overloads. ***Self management:*** The single Smart Appliances regulates time shifts its phase optimizing its own costs.

Roles		
Smart Info	**CEMS**	**Smart Appliances**
Same as UC 6.1	***Coordinated management:*** The CEMS hosts the application that allows the user to optimize the energy cost. ***Self management:*** Same as UC 1.5 As a function of the complexity of the optimization algorithm and of the Smart Appliance, some specific software in the CEMS could help the determination of the optimal start time.	• Possibly performs the same activities as in UC 1.5. • The customer is warned about the appliance's choices. ***Coordinated management:*** The Smart Appliances coordinate together in order to find the best overall strategy in order to perform the shifting of the phase to optimize costs and to prevent overloads. ***Self management:*** The Smart Appliances decide autonomously the logic to time shift or adapt part of its cycle or some specific functionalities according to the energy cost.

7 Energy production/storage

The goal of this use case is to integrate the production from domestic photovoltaic (PV) plants and the storage systems that could be linked to a PV plant in the Energy@Home architecture.

This integration aims to have a dual benefit for the final user: on the one hand user will be able to monitor from a user-friendly interface all the significant quantities that regard the production system: current power, energy production, battery state of charge, forecast data, etc…
On the other hand information about current and forecasted energy production will be used inside the algorithm that defines the best execution time in which an appliance should start.
Currently this algorithm includes only current and expected consumptions of the other appliances.
This integration will produce a more accurate result for users with domestic PV plants.



1- Production and storage architecture in Energy@Home

The storage component is installed inside the inverter and it is managed by inverter controller. The inverter/storage_system will communicate PV plant and storage information to the CEMS through a **zigbee** module. The CEMS will be able to retrieve forecast information invoking a remote **Web Service**.

7.1 Scenario 1: Visualization of production information

The aim of this scenario is to provide customer with information on the current/expected situation of her/his plant production.

<table>
<tr><td>Title</td><td colspan="2">1.1 Visualization of production information</td></tr>
<tr><td>Description</td><td colspan="2">The customer is presented with information about the global current energy production of his/her house. Data are provided by the Inverter and the forecast service.
Specifically, the following information will be sent to the CEMS and provided to the customer:
From the inverter:
• Current power
• Overall energy produced by the plant
• Current energy available in storage (if present)
• Instantaneous power available from the battery (note from Power One)

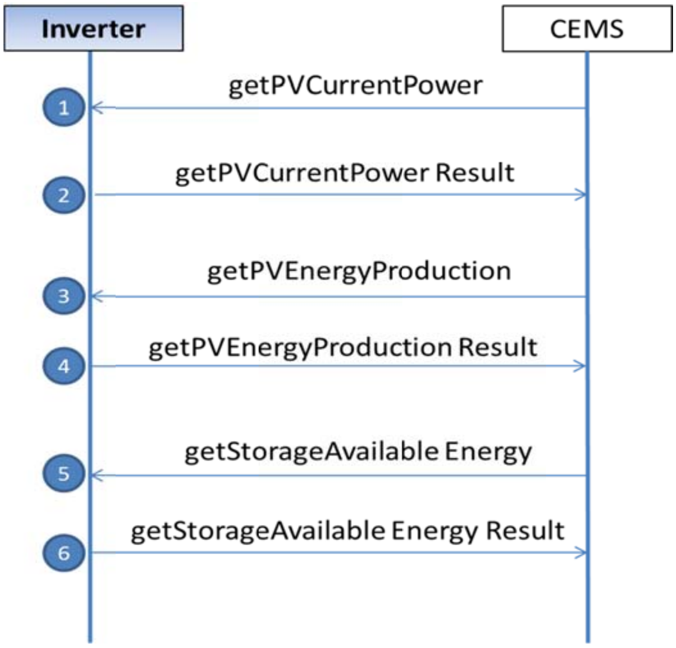
From the forecast service:
• Expected PV power from now up to 72 hours
CEMS will periodically retrieve these data and maintain them in a proper database in order to be immediately retrieved when requested by the customer, and to keep historical information.</td></tr>
<tr><td colspan="3" align="center">Roles</td></tr>
<tr><td align="center">Inverter/Storage_system</td><td align="center">CEMS</td><td align="center">Forecast Web Service</td></tr>
<tr><td>Provides a set of data retrieved by photovoltaic plant production status and, possibly, by the storage system. The storage system is included inside the inverter, so there is direct communication between the storage and the CEMS. Data are dispatched upon request. Data sent by inverter represents exclusively current values, so CEMS will store these data to keep historical data.</td><td>Hosts a Web application that collects data from Inverter and forecast service and organizes them for a user-friendly presentation.

Data collection will be triggered by the CEMS periodically every a certain amount of time, depending on the component to query (e.g. once a day for the forecast, once a minute for the inverter).</td><td>Makes available a service that when invoked returns a collection of expected plant power values for the plant installed in a specific home.

The service gives 72 power values, once an hour for the next 72 hours.</td></tr>
</table>

7.1.1 Inverter data acquisition

Sequence diagram



Description of the phase
Periodically the CEMS starts the inverter data acquisition process: the CEMS makes 4 requests to the Inverter asking for:

- **Current PV power**
- **Overall energy produced by the plant**
- **Current energy available in storage** (if present)
- **Instantaneous power available from the battery**

The inverter responds to these requests with 4 values that are stored by CEMS in a database to let them be available by user when he/she requests the plant production information.

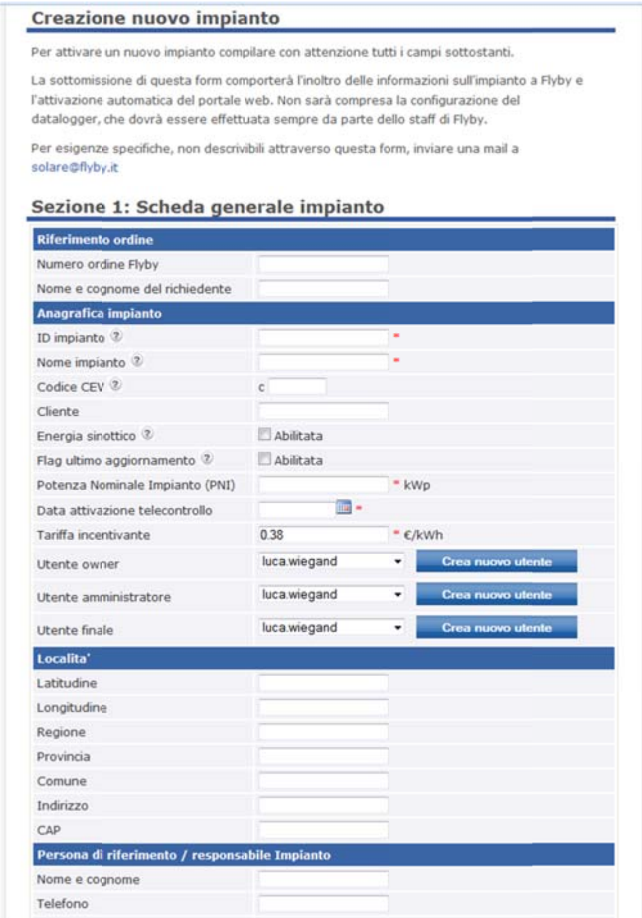
Message exchange

ID message	From	to	Description	parameters
1	CEMS	Inverter	CEMS queries the Inverter for the current PV power	None
2	Inverter	CEMS	Inverter returns the current PV power	Current power (kW)
3	CEMS	Inverter	CEMS queries the Inverter for the PV Energy production	None
4	Inverter	CEMS	Inverter returns the current PV Energy production	Total Energy production (kWh)
5	CEMS	Inverter	CEMS queries the Inverter for the Storage available energy	None
6	Inverter	CEMS	Inverter returns the Storage available energy (if any)	Storage available energy (kWh)
7	CEMS	Inverter	CEMS Asks for the instantaneous power avalaible from the battery (if any)	None
8	Inverter	CEMS	Inverter returns the Peak power deliverable from the battery	Peak power from the battery

ID Message 7 and 8 could be included in 5 and 6 respectively: If a “classical” PV or Wind inverter is used, information related to the energy stored, or peak power from the battery, will be missing. If a storage system is used, both data are needed in order to evaluate the storage system contribution to the home power needs. (e.g. Avaliable energy = 1.8kWh, Peak power = 600W → can sustain a 600W load for 3h but not a 900W load for 2h)
It is important that the Power One storage system has access to the rates of the DSO through the Gateway (and in general in perspective can "sniff" the state of the various components of the system). In fact, the battery management is the responsibility of the Power One logic and our system needs to know if the cost-effectiveness is in hiring the energy produced to the house or keep it in the battery for future use. Obviously, the CEM will contribute to the efficiency modulating the domestic loads on the basis of information made available from the inverter or system storage.

7.1.2 Plant Forecast registration

The CEMS User Interface is expected to provide a registration form where the user is requested to register his/her PV plant. An example is reported in the following Figure



Creazione nuovo impianto

Per attivare un nuovo impianto compilare con attenzione tutti i campi sottostanti.

La sottomissione di questa form comporterà l'inoltro delle informazioni sull'impianto a Flyby e l'attivazione automatica del portale web. Non sarà compresa la configurazione del datalogger, che dovrà essere effettuata sempre da parte dello staff di Flyby.

Per esigenze specifiche, non descrivibili attraverso questa form, inviare una mail a solare@flyby.it

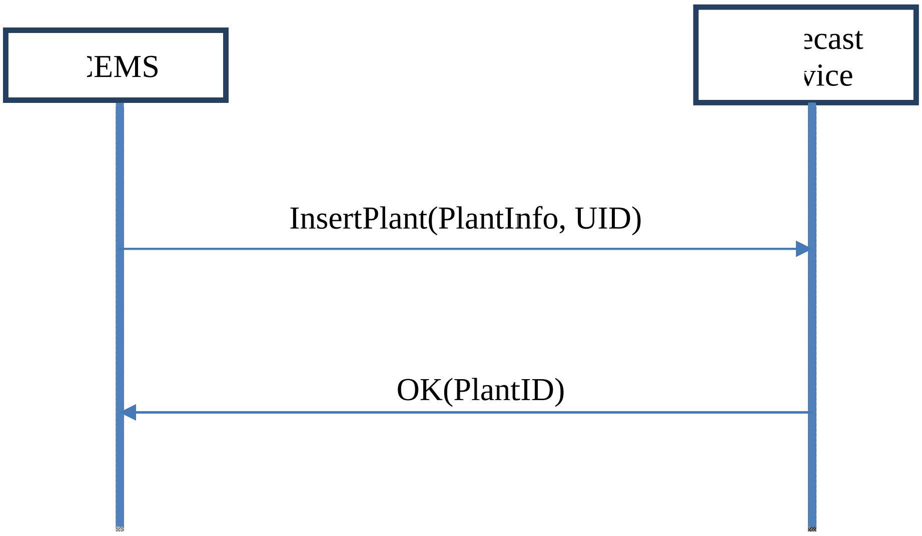
Sezione 1: Scheda generale impianto

Riferimento ordine	
Numero ordine Flyby	
Nome e cognome del richiedente	
Anagrafica impianto	
ID impianto	*
Nome impianto	*
Codice CEV	c
Cliente	
Energia sinottico	Abilitata
Flag ultimo aggiornamento	Abilitata
Potenza Nominale Impianto (PNI)	* kWp
Data attivazione telecontrollo	*
Tariffa incentivante	0.38 * €/kWh
Utente owner	luca.wiegand · Crea nuovo utente
Utente amministratore	luca.wiegand · Crea nuovo utente
Utente finale	luca.wiegand · Crea nuovo utente
Localita'	
Latitudine	
Longitudine	
Regione	
Provincia	
Comune	
Indirizzo	
CAP	
Persona di riferimento / responsabile Impianto	
Nome e cognome	
Telefono	

Figure 3 - Example of the PV plant registration form

Sequence diagram

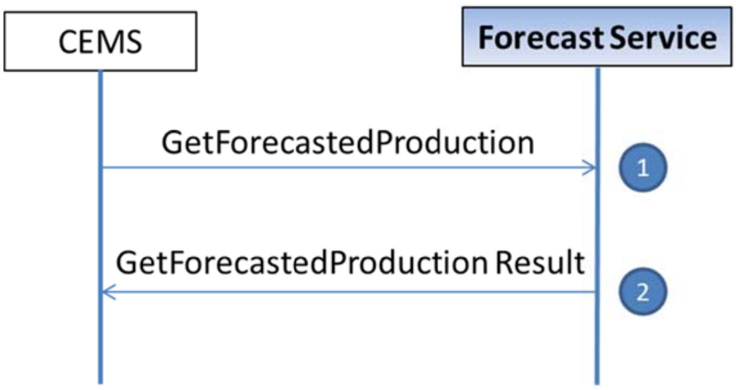
When the user submits the registration form, the CEMS is required to send all data to the PV Forecast Service by using an identifier of the CEMS itself.



As a result of the registration, the Forecast Service is going to return a PlantID to be used for further references. The CEMS is required to store this PlantID and use it for any further requests to the Forecast Service.

Forecast data acquisition

Sequence diagram



Description of the phase

Periodically the CEMS starts the forecast data acquisition process: the CEMS makes a request to the Forecast Web Service asking for the expected plant power of the next hours.

Forecast service returns a sequence of expected powers in a specific date time that is stored by CEMS in a database to let it be available by user when he/she requests the expected plant production information.

The Forecast service returns 72 power values, once an hour for the next 72 hours.

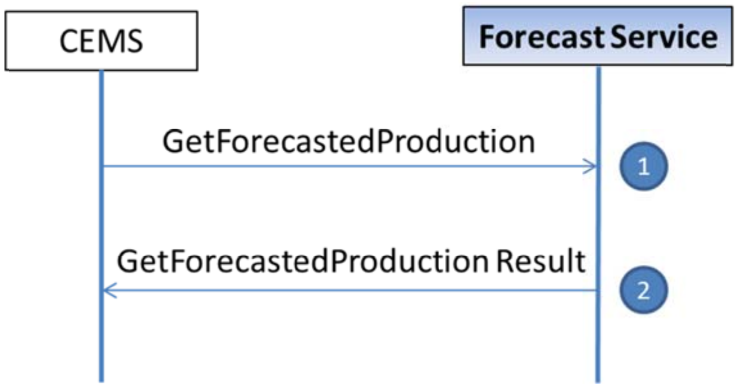
Message exchange

ID message	From	to	Description	parameters

1	CEMS	Forecast Service	CEMS asks the forecast service for the current PV power	• `String` **`plantID`** • `String UID` • `String` **`quantityType`** • `DateTime` **`date`**
2	Forecast Service	CEMS	Forecast service returns the expected plant power	Sequence of: • `String` **`quantityType`** • `DateTime` **`timestamp`** • `Double` **`value`**

7.1.3 Forecast data acquisition

Sequence diagram



Description of the phase

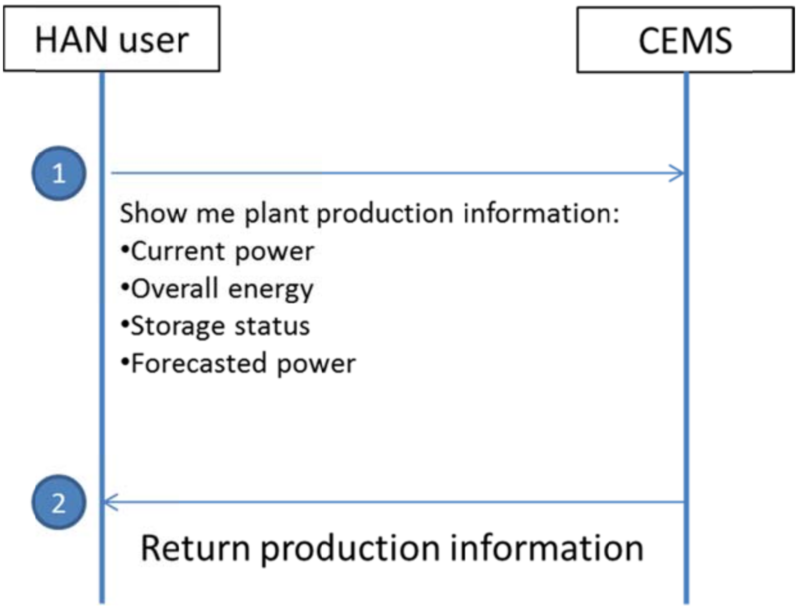
Periodically the CEMS starts the forecast data acquisition process: the CEMS makes a request to the Forecast Web Service asking for the expected plant power of the next hours.
Forecast service returns a sequence of expected powers in a specific date time that is stored by CEMS in a database to let it be available by user when he/she requests the expected plant production information.
The Forecast service returns 72 power values, once an hour for the next 72 hours.

Message exchange

ID message	From	to	Description	parameters
1	CEMS	Forecast Service	CEMS asks the forecast service for the current PV power	None
2	Forecast Service	CEMS	Forecast service returns the expected plant power for next 72 hours	Sequence of 72 [Date time, expected power(kW)]

7.1.4 User visualization

Sequence diagram



Description of the phase
User requests information about his/her Energy Production System to the CEMS through the Home Gateway web application.
CEMS shows this information in a user-friendly interface.

Message exchange

ID message	From	to	Description	parameters
1	User	CEMS	User requests information about the Energy Production System	None
2	CEMS	User	CEMS shows this information in a user-friendly interface	None

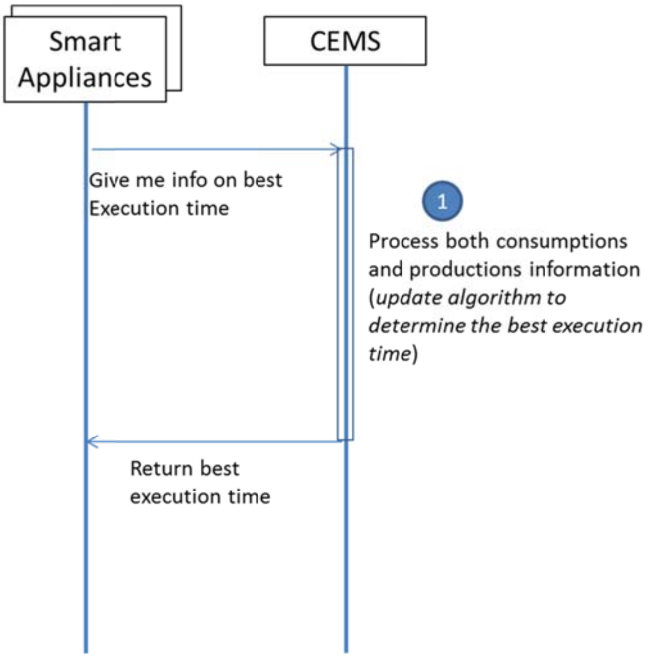
7.2 Scenario 2: peaks/costs optimization

The aim of this scenario is to embed plant production information in the existing algorithms to establish the best execution time for smart appliances starting, in order to optimize costs and reduce consumption peaks.

Title	1.1 peaks/costs optimization
Description	This scenario doesn't need any further message in addition of the existing messages. It is simply an updating of the algorithm that establishes the best appliances execution time. CEMS (due to the previous scenario) has already stored in its database the production information required in the algorithm, in particular: • **Current power** • **Overall energy produced by the plant** • **Current energy available in storage** (if present) • **Expected PV power from now up to 72 hours** CEMS has to use these new information in addition to the existing used information, such as appliances current and

	expected consumption and overall home consumption.

Sequence diagram



Message exchange

This scenario doesn't need any further message in addition of the existing messages

8 Interaction between CEMS and the aggregator

With the development of renewable resources, supply energy is becoming more difficult due to the unpredictability and this could be managed by using the aggregated flexibility offered by small commercial and domestic consumers. In this context, it is always more plausible in the near future to have the active participation of domestic consumers to balance services.

For a description of this use case we recall some definitions:

Aggregator: it is the key mediators between the consumers on one side and the markets and the other power system participants on the other side:
- The aggregator collect the requests and signals for AD-based services coming from the markets/AD buyers.
- Pools "flexibilities" of consumers to build Active Demand services and makes offers to the market.

It should be emphasize that the "flexibility" is provided shifting consumers' consumption.
The aggregator sells a deviation from the forecasted level of demand, and not a specific level of demand.

Active Demand (AD): it is the active participation of residential consumers in the power system markets and in the provision of flexibility to the different power system participants by participating in AD service.

AD service: is a request sent from the aggregator to the consumers to maintain a certain power level in a period of time. The aggregator will give an incentive (€ as a function of kW actually consumed) for the fulfillment of the program.

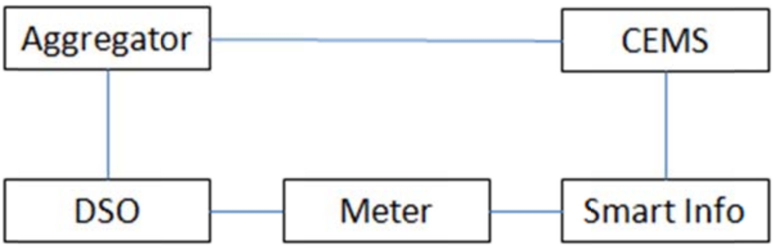
This use case only considers the services offered by the aggregator. It will provide to aggregate the flexibility of small commercial and domestic consumers and sell it in the market for balancing and ancillary services.

This use case doesn't consider the direct management of the electrical equipment by the network operator and it doesn't consider network services that requires real-time answers and even services for the management of the dynamic tariff of electricity.

In this use case will be not analyzed the relationship between aggregators and DSO and the way in which the AD programs are generated and sent to the consumers.

We will not consider also the planning and optimization activities carried out within the HAN needed to answer to the aggregator requests. These activities are developed in other use cases.

The figure below shows the actors and their relationships needed to carry out this use case.



8.1 Scenario 1: Active Demand and Energy System Interaction

Title	1.1 AD and Energy System Interaction
Description	Today, Thursday morning, the aggregator, based on the consumption profile of its customers, send to a selection of its customers an AD request to reduce electric consumption between 17.30 to 18.00 on Friday. The CEMS alert Mary and John about the request received. Mary leave the Energy@home system in automatic mode and it can optimize the power consumption in their house. On Friday at 17 John realizes that he urgently needs to start the washing machine and forces the manual operation of the washing machine overriding the signal sent by the aggregator. CEMS reassesses the optimization of the electrical loads of the house and

	optimizes energy consumption taking into account the load curve received by the washing machine. At 18 Mary and John' CEMS acquire the consumption data from the smart info. Mary was able to meet the AD service and her CEMS sends a message of AD fulfillment to the aggregator. After verification of the data with information coming from DSO, the aggregator will carry out the payment to Mary. John fails to meet the AD service request sent by the aggregator. CEMS closes the activity and does not send any signal to the aggregator.	
Roles		
Smart Info / Smart Meter	**CEMS**	**Aggregator**
The Smart Meter provides customer consumption. The Smart Meter uses the Smart Info as a communication bridge to the user devices in the consumers premises.	It collect AD requests from Aggregator and send to Aggregator AD service fulfillment. It collects data from HAN devices and optimize them for a user-friendly presentation. It implements the logics decision of the overall customer system and it takes care of dispatching events to HAN devices. It can exploit forecast algorithms, the implementation of these algorithms are outside the scope of these specifications. Implements a Trust Agent to manage all security keys of the HAN; this functionality can be implemented via collaboration with a Service Platform in the cloud. Implements the communication logics with a Service Platform in the cloud.	It collects the requests and signals for AD-based services coming from the markets/AD buyers It pools the "flexibilities" of consumers to build AD services and makes offers to the market. It manages the AD requests with its customer. It sells "flexibilities" to the different power system participants through the markets or bilateral contracts.

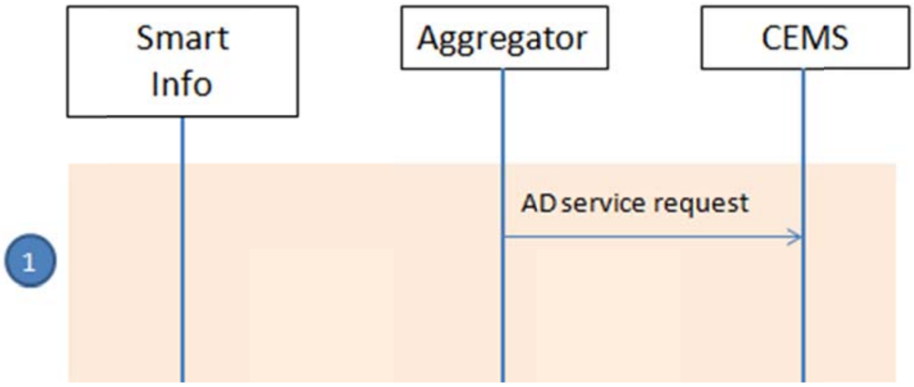
The use cases is described through a set of phases, each phase is described by a sequence diagram.

Id	Phase Name	Description
1	Request of AD service	Describes how the aggregator sends to the customer the signal to activate the AD program.

2	Result of AD service	Describes how the CEMS follow the signal sent by the aggregator and consumers preferences and at the end of the service send an AD fulfillment message.

8.1.1 Request of AD service

Sequence diagram



Description of the phase

The aggregator sends to its customers the signal to activate an AD request.

The signal contains the value of the incentives offered to customers if consumption is maintained in a defined time interval within a range of power.

An example:

AD service request	
Message ID	Xxx
Customer ID	Yyyy
Activation time	hh:mi yyyy/mm/dd
Duration	xx min
Combined volume and price signal	Incentive of X € (kW)
Less than 0,6 kW	Incentive of X € (kW)
0,6 kW<=Power< 0,9 kW	Incentive of X € (kW)
More than 0,9 kW	No incentive

The unit of time is multiple of 15 minutes. Power measurement and incentives are calculated in multiples of 15 minutes. The power of the 15 minute period is calculated on the energy consumed in that period.

Consumers will receive an incentive (€ as a function of actually consumed kW) with no reference to the absolute values if they will follow the signal sent by the aggregator.

CEMS schedule the Energy@home system in order to follow the AD program and the preferences set by the consumers.

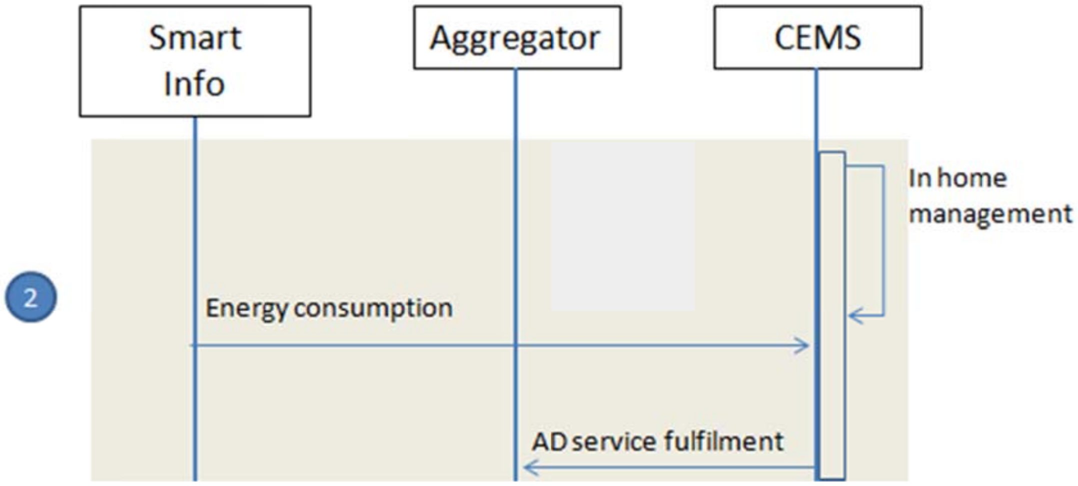
Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
1	CEMS	HAN device	The CEMS request the HAN device to reduce its absorbed power at a given time in the future	Watt: Severity of event (0\1\2). 0=all is ok; 1=request for reduction but no emergency 2=emergency Time: starting time for this reduction Duration: duration of the reduction	Aknowledge message from the appliance varies according to the severity of request: 0 \Ack not needed 1 \ appliance replies yes\no and % power reduction 2 \ appliance replies yes\no and % power reduction
2	HAN [2]Device	CEMS	Sends a new powerProfile	OldPowerProfile: the power profile before this change NewProfileProfile: the new changed power profile	ACK needed
3	CEMS	HAN Device	With this message the CEMS notifies that it was not able to find a safe schedule for this power profile	None	ACK is required

[22] N.B. This approach supposes that the smart appliance has the capability to reason about and modify its power profile. In alternative, we can implement an approach where this reasoning capability is directly done by the CEMS and the new power profile is simply notified to the smart appliance

8.1.2 Result of AD service

Sequence diagram



Description of the phase

At the AD activation time, CEMS, according with the preferences set by the consumers and the signals sent by the aggregator, activates electrical devices and manage power consumption in order to optimize the received request.

At the end of AD service CEMS acquires data consumption from the Smart Info and check if they are in line with the request done by the aggregator. If it was true CEMS sends the AD request fulfillment message to the aggregator.

An example.

AD service fulfillment	
Message ID	Xxx
Customer ID	Yyyy
Activation time	hh:mi yyyy/mm/dd
Duration	xx min
Measure:	
1-15 minute max power	xx W
2-15 minute max power	xx W
3-15 minute max power	xx W
4-15 minute max power	xx W
5-15 minute max power	xx W

Afterwards the aggregator will request to the DSO the consumer consumption during the period of AD request. Looking at the actual consumption of the consumers based on the measurements made by the meter and acquired by the DSO, the aggregator will provide to pay the incentive to the customer.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
2	CEMS	Aggregator	AD service fulfillment	AD service fulfillment (message ID, Customer ID, Duration, Average power in each 15 minutes intervals of AD service …)	ACK needed

9 Overload Management

This use cases manages those scenarios related to the maximum contracted power being exceeded, so called peak overload management. The purpose of the use case is to manage a peak overload in order to take any appropriate action such as alerting the user, reducing peak consumption of residential electrical loads, providing a report to the user related to this event.

As a matter of fact, the use case distinguishes among the following sub-cases:

- Ex-ante. This is the case when the system exploits a forecast algorithm to prevent an overload situation or the case when there is enough time between the overload warning notification event (when any component/device of the overall system notices that the maximum contracted power is being exceeded) and the breaker disconnection, i.e. there is time sufficient to react to this event, be it the user, or the Home Energy Management System, or a smart appliance to react. In order to better understand the sequence diagrams in the following pages, it is worth to remind how the overload is regulated in Italy by using as an example a typical contract with 3 kW contracted peak power:
  - The meter allows for an excess of 10% of the contracted peak for an unlimited amount of time, i.e. no warning up to 3.3kW of absorbed power.
  - The meter allows for a current absorption between 3.3 kW and 4.1 kW (i.e. +25%) for a limited amount of time (usually 2 hours), after this time the breaker disconnects
  - The meter allows for a current absorption between 4.1 kW and 14 kW for a very short amount of time (usually 2 minutes), after this time the breaker disconnects
  - Finally, if the meter measures a current absorption higher than 14 kW, for safety reasons, the breaker immediately disconnects.

  The use case intends to adopt an approach where a combination of consumption forecast methods and notifications directly sent by the meter is used in order to prevent as well as to notify the overload warning.

- Ex-post. This scenario deals with what happens after the breaker disconnection happened, when the system notifies the user and the devices in the HAN that this event happened.

- Post-mortem. In this scenario the Home Energy Management System makes a post-mortem analysis in order to estimate why the event happened, e.g. the contracted power was exceeded because the washing machine and the hair dryer were running at the same time. This type of analysis is useful both to educate the users as well as to train an automatic learning system in order to avoid it can happen again in the future. This scenario seems not to require so far any specific specification for new message exchanges between user devices.

9.1 3.1 Scenario 1: Overload management ex-ante

<table>
<tr><td>Title</td><td colspan="2">1.1 Overload management ex-ante</td></tr>
<tr><td>Description</td><td colspan="2">At 8:00 AM Mary, the end user of this story, wakes up and switches on the washing machine. After half an hour, her daughter switches on the hair dryer. The total house consumption exceeds the maximum contracted power and the system notifies this event.
There is no need to get the attention of Mary because fortunately Mary has smart appliances (flexible HAN devices) and thanks to their flexibilities the CEMS is able to automatically reduce their power consumption and\or postpone the starting of high power absorbing phases (e.g. the start of a water heating phase in a washing machine) and prevent the blackout without any user intervention and without degrading the quality of the washing cycle.
When Mary will launch again the CEMS app, the app will tell Mary that the event was well managed automatically thanks to the support of the washing machine.

The same events happened at the John's house premises but John has no smart appliance. Therefore, the Customer Energy Management System of John decides to use the user notification devices (e.g. buzzer, text messaging) in order to get the user attention and ask the user to manually switches off some loads. John was quick enough to see the notification sent by a text message (SMS) on his mobile and switches off the hair drier to prevent the blackout. But, several other times happened that John was not quick enough and he had to switch on again the meter located in the basements; in this case the CEMS app reminds John that a smart appliance would have avoided such a problem.</td></tr>
<tr><td colspan="3">Roles</td></tr>
<tr><td>Smart Info / Smart Meter</td><td>Customer Energy Management System</td><td>Smart Devices</td></tr>
<tr><td>The Smart Meter provides useful information to the system such as the contracted maximum power and the current absorption. It also notifies a warning event when the total house consumption exceeds the maximum contracted power.</td><td>It collects data from HAN devices and organizes them for a user-friendly presentation.

Generally speaking, it implements the decision logics of the overall customer system and it takes care of dispatching events to HAN devices.</td><td>They provide to the CEMS information about their load profile.

They can also exhibit some degree of flexibility to react to requests from the CEMS to reduce the power absorption at</td></tr>
</table>

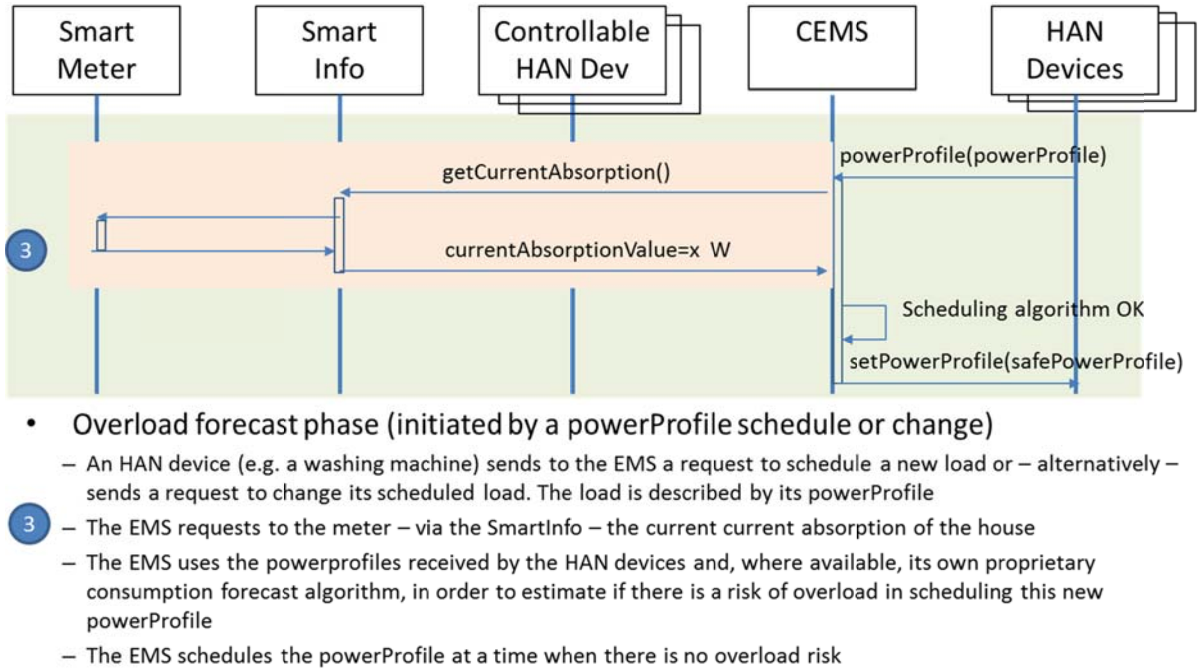
The Smart Meter uses the Smart Info as a communication bridge to the user devices in the home premises.	It can exploit forecast algorithms, the implementation of these algorithms are outside the scope of these specifications. Implements a Trust Agent to manage all security keys of the HAN; this functionality can be implemented via collaboration with a Service Platform in the cloud. Implements the communication logics with a Service Platform in the cloud.	different levels down to 'pause' level. At the startup time, they announce and register their capabilities with the CEMS. At the registration phase they have also to indicate their capability to get the user attention (e.g. via a display, a buzzer, a text message).

The use cases is described through a set of composable phases, each phase is described by a sequence diagram.

Id	Phase Name	Description
1	Power Profile scheduling	An HAN device requests the CEMS to schedule a power profile. This phase shows the case when the CEMS is able to return a safe schedule. When a new cycle is planned, the appliance will provide the cycle power profile where for each block of the cycle is reported if load can be reduced or not. How much the load can be reduced depends on the type of product and the manufacturer choice. NOTE even if the load can be reduced in a certain part of the cycle, it does not mean the appliance will comply with the request.
2	Unschedulable Power Profile	An HAN device requests the CEMS to schedule a power profile. This phase shows the case when the CEMS is NOT able to return a safe schedule
3	Overload Warning	The Smart Meter notifies the CEMS that there is an overload warning
4	Overload warning cleared up	The Smart Meter notifies the CEMS that the overload warning was cleared up and the situation is now back to the normal functioning
5	User Notification	The CEMS requests the HAN devices with user notification capability to notify the user of a given event (in this case the overload warning). When an HAN device gets the user attention, it notifies back the CEMS

9.1.1 Power profile scheduling

Sequence diagram



Description of the phase

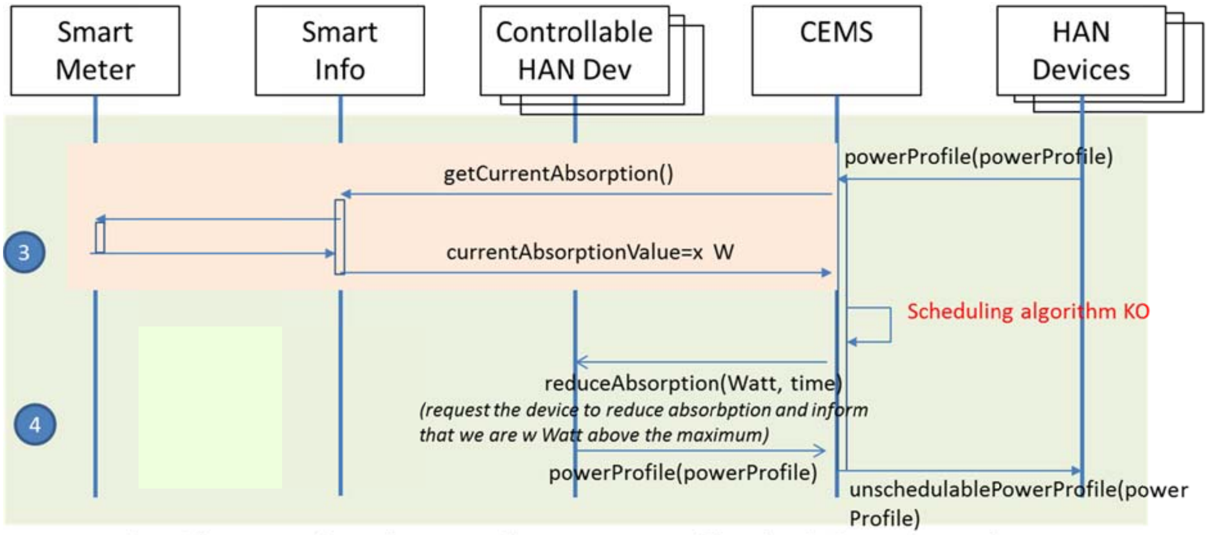
An HAN device sends to the CEMS a request to schedule a new power profile, or to change its schedule. The CEMS retrieves via the Smart Info the current total house power absorption, eventually uses a forecast algorithm, and returns a safe power profile schedule. When a new cycle is planned, the appliance will provide the cycle power profile where for each block of the cycle is reported if load can be reduced or not. How much the load can be reduced depends on the type of product and the manufacturer choice. NOTE even if the load can be reduced in a certain part of the cycle, it does not mean the appliance will comply with the request.

Message exchange

This use case is already covered by current Energy@home specifications, no new message exchange need to be specified so far.

9.1.2 Power profile is unscheduled

Sequence diagram



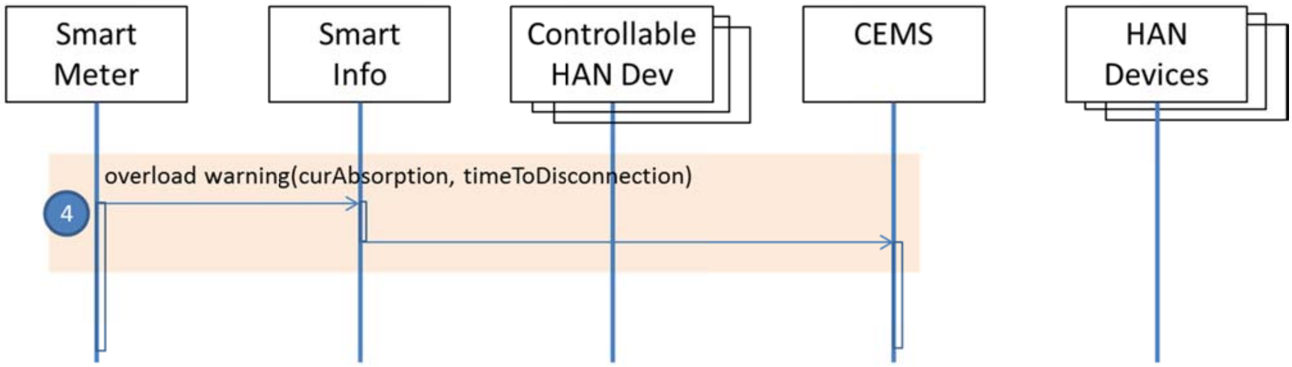
- Overload forecast phase (initiated by a powerProfile schedule or change)
  - An HAN device (e.g. a washing machine) sends to the EMS a request to schedule a new load or – alternatively – sends a request to change its scheduled load. The load is described by its powerProfile
  - The EMS requests to the meter – via the SmartInfo – the current current absorption of the house
  - The EMS uses the powerprofiles received by the HAN devices and, where available, its own proprietary consumption forecast algorithm, in order to estimate if there is a risk of overload in scheduling this new powerProfile
  - The EMS is not able to schedule this powerProfile because of overload risk

Description of the phase

This is a slight variant of the previous phase. In this case the forecast & scheduling algorithm of the CEMS is not able to return a safe schedule for this power profile. Therefore the CEMS requests the flexible HAN devices to change their schedule if possible. If an HAN device accepts to change its schedule, the CEMS runs again the scheduling algorithm and try to find a safe schedule

9.1.3 Overload Warning notification sent from the Meter

Sequence diagram



- Overload Warning Notification phase (initiated by the SmartMeter)
  - The Smart Meter, through the Smart Info, notifies the CEMS that there is an overload warning
  - 4 Two parameters are here required to be sent to the CEMS:
    - Measured current absorption (in Watt)
    - time before disconnection if the current absorption does not reduce (in sec)

- N.B. The Smart Meter is requested to use its best effort to notify again the CEMS when:
  - the time before disconnection changes (e.g. when a new power threshold is reached)
  - the overload warning is cleared up

Description of the phase

The Smart Meter, through the Smart Info, notifies the CEMS that there is an overload warning. The Meter is requested to provide two parameters: the measured power absorption, the time before disconnection.

Notice that the Smart Meter is requested to do its best effort to notify again the CEMS when some condition changes:

- The time before disconnection changes because a new alarm threshold was reached
- The overload warning is cleared up and the system can returns to its normal state

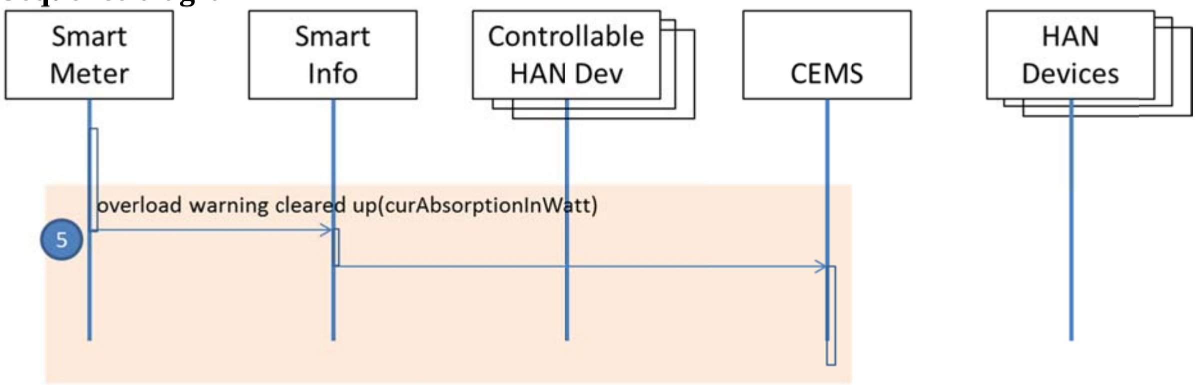
Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
1	Smart Meter	CEMS	Overload warning	**Watt**: measured power **Time**: time to disconnection (in	Ack needed

				seconds)	

9.1.4 Overload Warning ClearedUp notification sent from the Meter

Sequence diagram



- Overload Warning is cleared up
  - the Smart Meter is requested to be state-full and recognizes that it passes from an overload warning state to a clearing of this state

5

Description of the phase

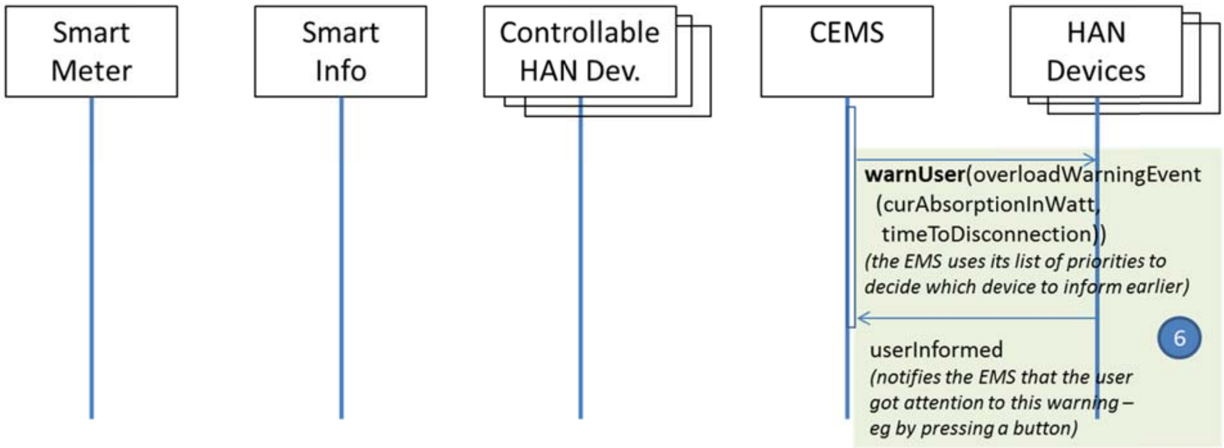
The Smart Meter, through the Smart Info, notifies the CEMS that the overload warning is cleared up and the system is returned to its normal state.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
1	Smart Meter	CEMS	Overload warning Cleared Up	Watt: measured power	Ack needed

9.1.5 Notification of the Overload Warning Event to the User

Sequence diagram



- User Notification phase (this phase is parametric of the event Type)
  - The EMS requests the HAN devices with user notification capabilities to notify the user an Event. In this case the event is overload Warning event which is described through 2 parameters:
    - Measured current absorption (in Watt)
    - time before disconnection if the current absorption does not reduce (in sec)
  - It is implementation-dependant the order in which the EMS selects the notification devices, of course the EMS should try to minimize the user comfort impact by using the most appropriate notification devices
  - The HAN device that got user attention is requested to notify back the EMS about that. Such a notification allows the EMS to avoid scaling-up the means to get the user attention, e.g. by sending an SMS or activating a buzzer

6

Description of the phase

The CEMS notifies an Event to the user. It is responsibility of the CEMS to select which HAN device (or which set of HAN devices) should be requested to notify the user.
It is responsibility of the HAN device, if it gets the user attention, to notify back the CEMS in order to avoid the CEMS scales up the notification to another notification device.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
1	CEMS	HAN Device	Notifies an Event to the user	Event. The Warning Event is represented by two parameters: Watt: current power absorption	Ack needed

				Time: time to disconnection (in seconds)	
2	HAN Device	CEMS	The user was notified	None	none

9.2 Scenario 2: Overload Management ex-post

Description

This case is expected to occur when the system wakes up after the trip of the circuit breaker due to unhealed overload.
The CEMS could send to the customer a report about home and appliances consumption before the event as described in **use case 4, Power Loss Notification and Analysis**.

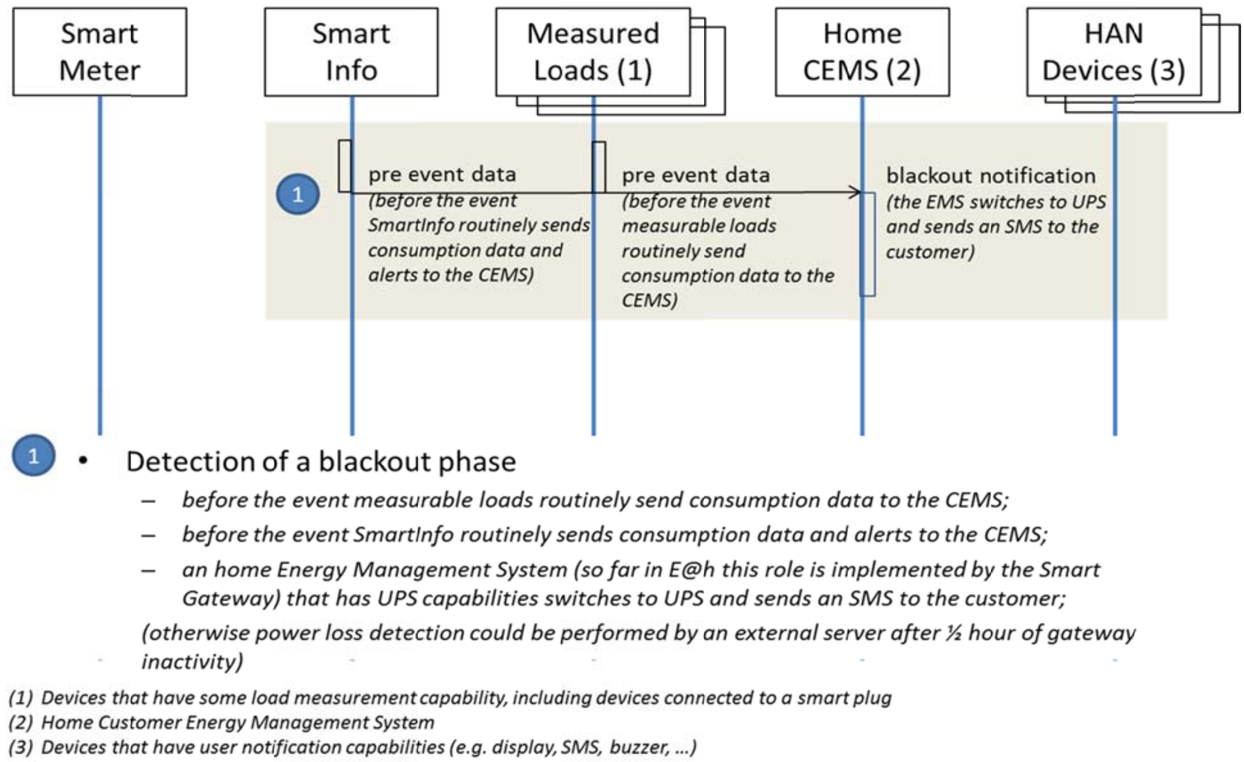
10 Power Loss Notification and Analysis

The aim of following use case is to help the customer to understand the cause of a power loss event and to manage proper load recovery after it. The event could be a blackout on the external grid or a trip of the circuit breaker due to unhealed overload or other causes. This is typically the "ex-post" scenario of the Overload Management use case.

<table>
<tr><td>Title</td><td colspan="2">Power Loss Notification and Analysis</td></tr>
<tr><td>Description</td><td colspan="2">The Customer Energy Management System sends an SMS to the customer to inform him that a power loss event occurred. At the end of the event the CEMS restarts sending to the customer a report about home and appliances consumption before the event; the user can eventually choose to do something to reduce the loads.</td></tr>
<tr><td colspan="3" align="center">Roles</td></tr>
<tr><th>Smart Info / Smart Meter</th><th>Customer Energy Management System</th><th>Smart Devices</th></tr>
<tr><td>None during the power loss event
At the end of the event the Smart Meter provides to the CEMS the alert occurred before the event. CEMS will have the possibility to calculate the duration and and type of the event (blackout on the grid/circuit breaker trip)
The Smart Meter uses the Smart Info as a communication bridge to the user devices in the home premises.</td><td>The Customer Energy Management System sends an SMS to the customer if it has UPS capabilities otherwise power loss detection could be performed by an external server, e.g. after ½ hour of gateway inactivity.</td><td>The Smart Appliances:
▪ before the event routinely send consumption data to the CEMS
▪ at the end of the event return to the status they were before the event.</td></tr>
</table>

10.1 Detection of a power loss event phase

Sequence diagram



Description of the phase

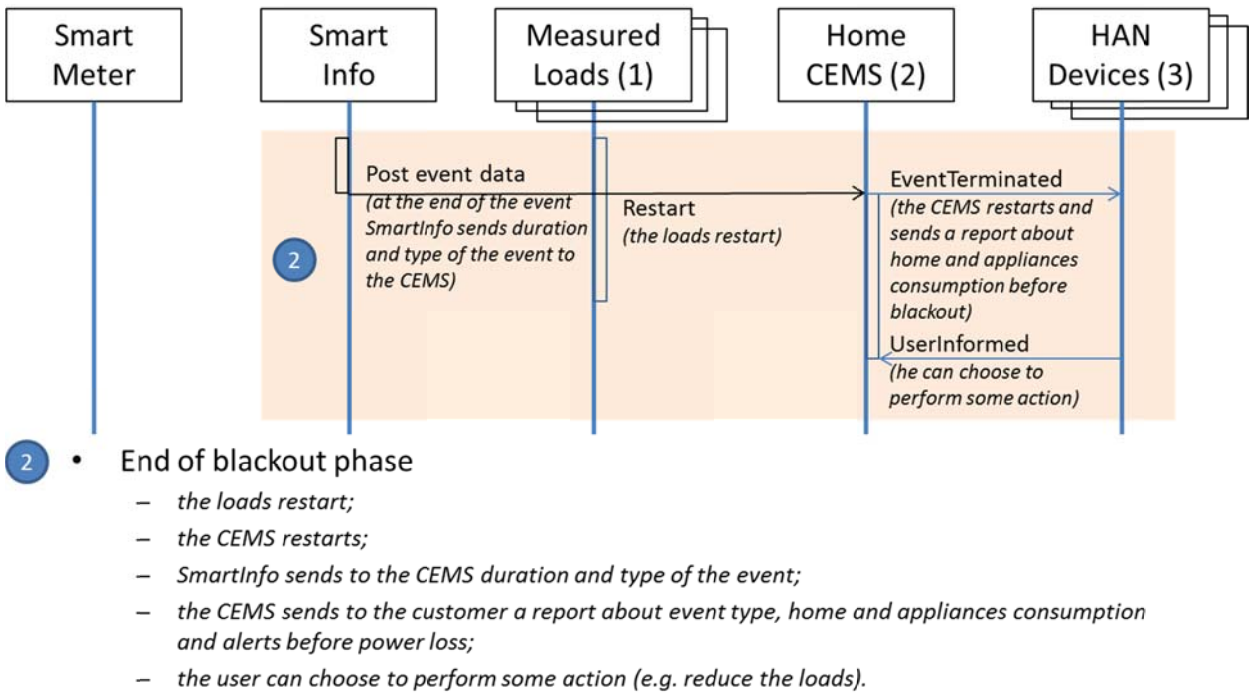
Before the power loss measurable loads routinely send consumption data to the CEMS. Also SmartInfo routinely sends global consumption and alerts. Immediately after the power loss, the Customer Energy Management System (so far in E@h this role is implemented by the Smart Gateway) if has UPS capabilities switches to UPS and sends an SMS to the customer.
If UPS capability is not available or fail, power loss detection could be performed by an external server, e.g. after ½ hour of gateway inactivity.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
1	measurable loads/smart plugs	CEMS	routinary consuption data	actual consumption	Ack not needed
2	smart meter/ SmartInfo	CEMS	global consumption and alert	consumption alert	Ack not needed
3	CEMS	Customer	Power loss notification	consumption alert	Ack not needed

End of power loss event phase

Sequence diagram



Description of the phase

At the end of the power loss event , the customer has to be informed about the type and cause of the power loss (*ex post* analysis) and can make appropriate choices to avoid e.g. a new trip of the circuit breaker. The loads restart following their own procedures. Smart Appliances will restart in the same state they were when black out occurred. The CEMS restarts, receives from the SmartInfo the alert occurred before the event, and calculate the duration and type of the event (blackout on the grid/circuit breaker trip) and sends to the customer a report containing also home and appliances consumption before power loss .The user can eventually choose to do something to reduce the loads.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
1	smart meter/ SmartInfo	CEMS	alert before the event	alert	Ack not needed
2	CEMS	HAN Devices	Power loss Terminated	Type of event Previous Consumption: home and appliances consumption before the event, alerts	Possible some feedback from user

11 Devices monitoring and control

The Energy@home specification provides an entire set of commands allowing the connected devices to exchange information related to the energy and to others functional properties.
Furthermore, the specification describes the potential use cases focused on the energy awareness and energy coordination. Some examples of these use cases are the Customer Awareness and the Appliance Regulation.

This chapter describes 2 new use cases not related to the energy management but concerning the user direct management of the connected devices in order to monitor and control their status and functionalities. For a white good, for example, some functionalities that can be monitored and controlled can be the OFF/RUNNING/END status of the appliance or the Spin value for a washing cycle or the Temperature for a cooking cycle.

The new use cases will leverage on the existing set of commands that E@h have defined but some extension could be required.

Washing machine monitoring and control interface, example

11.1 Scenario 1: Device initialization

Title	1. Device initialization	
Description	Before starting any monitoring and controlling activities, the remote user interface must know which are the capabilities that the local remote interface implements in terms of number and type of programs and options and of relationship between them (i.e. compatibility between cycle and options or between 2 options) . An example of the general information to be retrieved from the appliance to the remote user interface to enable a complete remote navigation could be: • Available programs • Available regulations with range and step, for example temperature min 20°C max 90°C, step 5°C (or list of possible values) • Available options with range and steps, for example extrarinse min 0 max 1 • Compatibility between regulations (e.g. extrarinse not allowed with ecomode) Besides these general information, others information related to a selected programs can be exchanged.	
	Roles	
Connected device	**CEMS**	**Remote GUI/Backend**
The device is able to provide its capabilities in term of user interface navigation The device prepares the Init Data and sends it to the CEM when requested	It acts as a tunneling device forwarding the request Init Data from the remote GUI to the device and sending back the response from the device to the remote GUI Depending on the adopted technical solution, the CEMS can act as a simple tunnel between the device and the Remote GUI or can implement some type of parsing of the data received.	It provides to the users a numeric, textual and graphical visualization of the device status, events, alarms When the remote user opens the remote interface, it sends to the CEMS the request for the device Initialization Data After received the Initialization data, the remote user interface applies the rules of navigation derived from the init data.

11.1.1 Initialization description

Description

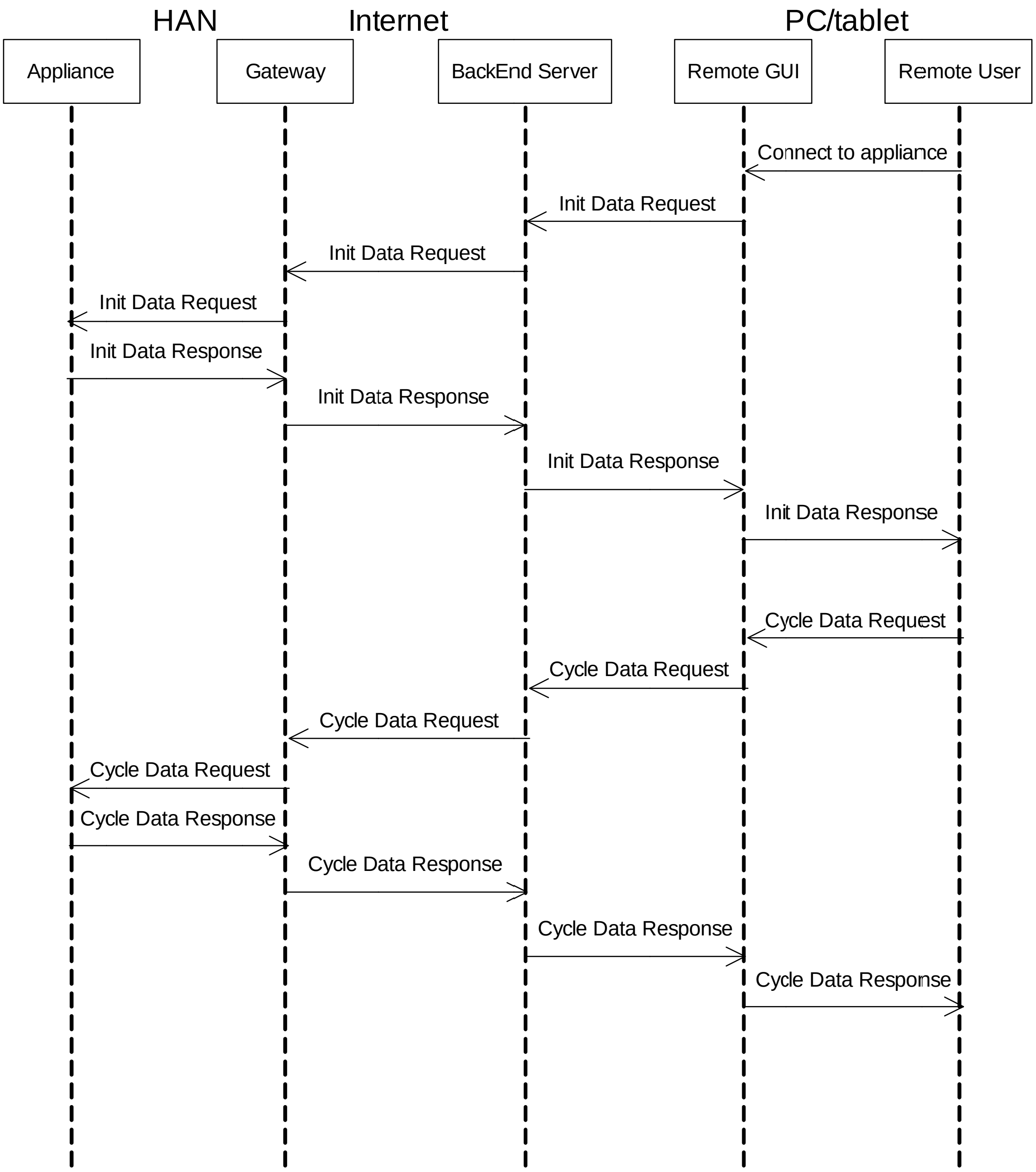
When the remote GUI is opened, it requests the initialization data to the connected device through the CEM. This phase can be also repeated periodically, after an update of the device or after some special event (for example power on reset).

Message exchange

Message	From	to	description	parameters	Ack message (if any)
Init Data Request	Remote GUI/BackEnd	Appliance	BackEnd requests initialization data to the appliance	none	Ack not needed
Init Data Response	Appliance	Remote GUI/BackEn d	Appliance responds to the Initialization data request	Available programs Available regulations Available options Compatibility between regulations	Ack not needed
Cycle Data Request	Remote GUI/BackEnd	Appliance	BackEnd requests initialization data for the specific cycle to the appliance	Cycle id	Ack not needed
Cycle Data Response	Appliance	Remote GUI/BackEn d	Appliance responds to the Initialization data request for the specific cycle	Options/functions range/limitation inside the selected cycle	Ack not needed

Sequence Diagram

In the following sequence diagram the message exchange is reported for the Initialization phase.



11.2 Scenario 2: Device monitoring

<table>
<tr><td>Title</td><td colspan="2">2. Device Monitoring</td></tr>
<tr><td>Description</td><td colspan="2">The user can receive remotely (inside or outside home) on his PC/mobile the status of his devices to let him monitoring the appliances, the lighting system, the HVAC sytem, the alarm system.

Some information to monitor e.g. for an appliance can be:

• the current status (Running, End, Pause, Delay, …)
• the current phase (e.g. for a washing machine Heating, Rinse, Spin, …)
• the selected program
• the selected options (temperature, duration, spin, …) and special functions (prewash, extrarinse, superfreeze, …)
• the remaining time to end the cycle

Furthermore some event/alert can be defined and monitored to inform the user of special events that occurred (e.g. the washing machine has just finished, the fridge door remained open, the oven has reached the heating temperature, some faults occurred on the dish washer)

For every subsystem to be monitored (lighting system, HVAC sytem, alarm system ,…) the available information must be defined even if some basic information are always applicable (the on/off status, the program/option selected, the alarm/event notification…).</td></tr>
<tr><td colspan="3">Roles</td></tr>
<tr><td>Connected device</td><td>CEMS</td><td>Remote GUI/Backend</td></tr>
<tr><td>The device is able to provide information about his conditions (device status)

The device spontaneously informs the CEMS about any status change.

The status change can result from:

- the interaction of the user with the device
- the normal evolution of the functional phases over the time</td><td>It collects the status notification , events, alarms sent from the devices over the HAN

It receives from the Remote GUI the request to start or to stop the device status notification toward the Remote GUI.

It sends the device status notification to the Remote GUI when the start request is received and after any status notification received from the device , until it receives the stop request from the Remote GUI.</td><td>It provides the secure access of the user to the monitoring page

It provides to the users a numeric, textual and graphical visualization of the device status, events, alarms

It sends to the CEMS the request for monitoring the devices or to stop the monitoring phase.

It can adds reacher information on the device usage, help online, user guide online.</td></tr>
</table>

- the alarm/event occurrence Note: the device is also able to respond on-demnad on his status	Depending on the adopted technical solution, the CEMS can act as a simple tunnel between the device and the Remote GUI or can implement some type of parsing of the data received.	

The use case can be described through a couple of different phases that are described in the following table.

Id	Phase Name	Description
1	Monitoring disabled	In this phase the remote GUI doesn't request the notification of the status of the device, so no monitoring is occurring.
2	Monitoring enabled	In this phase the remote GUI requests the notification of the status of the device to monitor the current condition of the device

11.2.1 Phase 1: Monitoring disabled

Description of the phase

In this phase the devices and the CEMS share the information over the HAN but the CEMS doesn't forward it to the remote GUI. The CEMS knows the updated status of the devices, uses it for the standard intended activities (execute alghoritms, log the data on a database, …) but doesn't notificate it remotely.

Message exchange

Message	From	to	description	parameters	Acknowledgment message (if any)
Status Notification	Device	CEMS	The device spontaneously informs the CEMS about any status change	The status packet includes all the information related to the condition of the device, e.g. for an appliance can be: • Running, End, Pause, Delay, …) • Heating, Rinse, Spin, … • selected program • temperature, duration, spin, … • prewash, extrarinse, superfreeze, …	Ack not needed

				• remaining time to end the cycle	

11.2.2 Phase 2: Monitoring enabled

Description of the phase

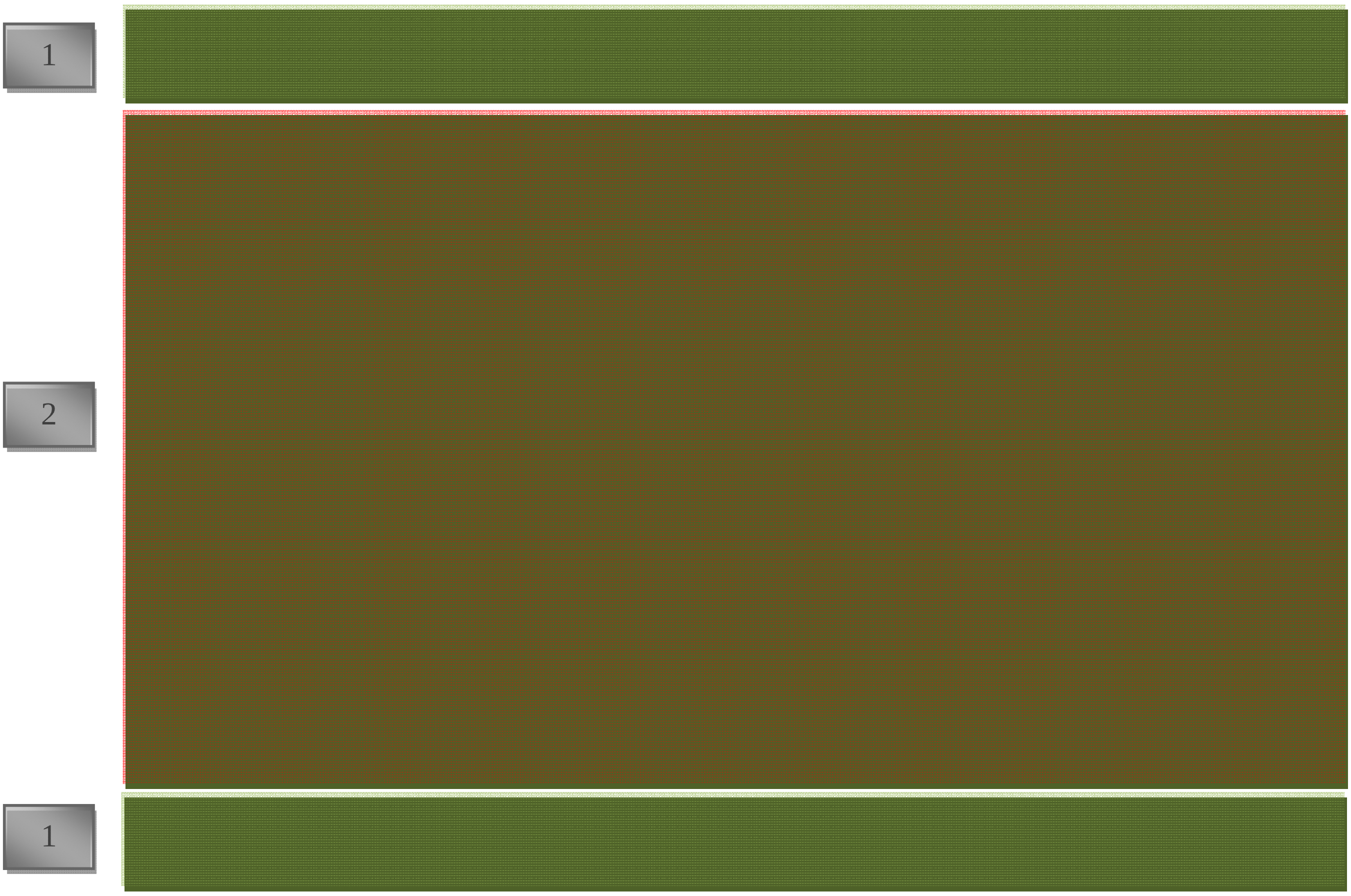
In this phase the devices and the CEMS share the information over the HAN and the CEMS forwards it to the remote GUI to let the user monitor the status of the devices. This phase is started and ended by the remote GUI the asks to connect or disconnect to the devices.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
Start Status Notification Request	Remote GUI	CEMS	The Remote GUI asks the CEMS to open the forwarding of the devices status	-	Ack not needed
Status Notification	CEMS	Remote GUI	This packet is the mirroring of the Status Notification sent by the device over the HAN. The CEMS has always the update value for the status since the dispatching from the device is always enabled.	The status packet includes all the information related to the condition of the device, e.g. for an appliance can be: • Running, End, Pause, Delay, …) • Heating, Rinse, Spin, … • selected program • temperature, duration, spin, … • prewash, extrarinse, superfreeze, … • remaining time to end the cycle	Ack not needed
Stop Status Notification Request	Remote GUI	CEMS	The Remote GUI asks the gateway to close the forwarding of the devices status	-	Ack not needed

Sequence Diagram

In the following sequence diagram the message exchange is reported, both for the monitoring disabled phase (phase 1) and the monitoring enabled phase (phase 2)



11.3 Scenario 3: Device Control

<table>
<tr><td>Title</td><td colspan="2">3. Device Control</td></tr>
<tr><td>Description</td><td colspan="2">The user can control remotely (inside or outside home) the status of his devices using his PC/mobile, setting the required functionalities on the appliances, the lighting system, the HVAC sytem, the alarm system.

Some parameters to control e.g. for an appliance can be:

• ON/OFF status of the appliance
• Required cycle
• Required washing/cooking/freezing temperature, spin speed, duration
• Required options and functions (superwash, rapid wash, super cooling, …)
• Start, Stop, Pause commands

For every subsystem to be controlled (lighting system, HVAC sytem, alarm system ,…) the available information must be defined even if some basic information are always applicable (the on/off status, the program/option selection, …).</td></tr>
<tr><td colspan="3">Roles</td></tr>
<tr><td>Connected device</td><td>CEMS</td><td>Remote GUI/Backend</td></tr>
<tr><td>The device is able to modify his status conditions (device status) according with the commands dispatched by the remote GUI and according with the constraints selected by the user (e.g. remote control enabled)

The device spontaneously informs the CEMS about any status change.

The status change can result from:
- the interaction of the user with the device, both locally and remotely
- the normal evolution of the functional phases over the time
- the alarm/event</td><td>It collects the status notification , events, alarms sent from the devices over the HAN

It receives from the Remote GUI the request to modify the status of the devices (e.g. selection of a cycle, ON/OFF of the device, start/stop commands)

It sends the modification request to the devices over the HAN

It sends the device status notification to the Remote GUI

Depending on the adopted technical solution, the CEMS can act as a simple tunnel between the device and the Remote GUI or can implement some type of parsing of the data received.</td><td>It provides the secure access of the user to the monitoring page

It provides to the users a numeric, textual and graphical visualization of the device status, events, alarms

It sends to the CEMS the request for the modification of their status

It can adds reacher information on the device usage, help online, user guide online.</td></tr>
</table>

occurrence		

The use case can be described through a couple of different phases that are described in the following table.

Id	Phase Name	Description
1	Setup	In this phase the remote user is selecting the required options/cycle/status before confirming the selected configuration.
2	Command	In this phase the remote user confirms the selected configuration so the control commands are dispatched to the CEMS.

11.3.1 Phase 1: Setup

Description of the phase
In this phase the remote user selects the required status (cycle, temperature, duration, …).
To avoid generating unnecessary data traffic over the complete communication chain (backend – CEMS – device), the system could border the communication on the backend side until some confirmation is given by the user. This is only a technical and implementation choice and the confirmation can be a direct confirmation or a periodical automatic confirmation (e.g. each 10 “) or (as described in the sequence diagram) until a direct command is given (turn ON, start, …)

Message exchange

Message	From	to	description	parameters	Acknowledgment message (if any)
Select a cycle	Remote GUI	Backend	The Remote GUI asks the backend to set the required cycle on the device	Type/number of cycle	Ack not needed
Change one parameter	Remote GUI	Backend	The Remote GUI asks the backend to set the required parameter	Type/value of parameter	Ack not needed

11.3.2 Phase 2: Command

Description of the phase
In this phase the remote user has given the confirmation to the required change so the complete appliance configuration is dispatched from the backend to the CEMS and then to the appliance. The appliance modifies his status according with the remote commands and informs the backend/remote GUI about his updated status.

Message exchange

ID message	From	to	description	parameters	Acknowledgment message (if any)
Send all data & Set start cycle	Remote GUI	Backend then CEMS then appliance	Once the Remote GUI confirms the selected options with a direct command such as Start cycle (or with a direct confirmation command or after a periodical time basis), all the information releated to the required appliance configuration is dispatched from the backend to the CEMS and from the CEMS to the appliance	Type/number of cycle Type/value of parameter Type of command to execute	Ack not needed
Status Notification	Appliance	CEMS then backend	After the appliance executed the remote request, status change , the updated status is dispatched over the network	The status packet includes all the information related to the condition of the device, e.g. for an appliance can be: • Running, End, Pause, Delay, …) • Heating, Rinse, Spin, … • selected program • temperature, duration, spin, … • prewash, extrarinse, superfreeze, … remaining time to end the cycle	Ack not needed

Sequence Diagram

In the following sequence diagram the message exchange is reported, both for the Setup phase and the Command phase

1

2

12 Energy@Home provisioning and maintenance

In order to enable the scenarios above described it is required to ACTIVATE, REMOVE and MAINTAIN the appliances in the HAN. Access to those three functionalities is required to guarantee the customer the desired level of security in order to prevent unauthorized control of the devices connected to the HAN.

In case of a ZigBee network, the admission of any new device into the HAN is charged to the coordinator of this network. It is assumed that the CEMS could play the coordinator role. In case of unavailability of the CEMS, another device in the HAN should provide a subset of its capabilities including the connection to the Internet. This device shall be, by instance, a smart meter, which provides the Smart Info data and some of the CEMS functionalities.

12.1.1 Add a new device

The user buys a Smart Appliance and would like to start it up in the Energy@Home HAN with the simplest human interaction possible. The admission procedure is required to guarantee the interconnection of the Smart Info, Smart Appliances and CEMS owned by the same customer.
If the HAN was previously activated by the CEMS, through a web interface, the user starts the admission procedure, identifies the new ZigBee device checking manufacturer and model and allows the new Smart Appliance to join the Energy@Home solution. The same procedure could be activated for the Smart Info.
In case the CEMS is not available, the admission procedure should be managed by another device, which shall provide user with a user-friendly interface.

12.1.2 Remove a device

In case of both joining of not desired device to the HAN and replacement of broken ones, the customer is provided with this procedure. The user experience could be similar to ADD one.

12.1.3 Maintenance

If the customer experienced some problems with Energy@Home a Web application on the CEMS could present the status of the HAN including the devices list, the devices status (i.e. joined to the HAN but not responding), etc. Also Warning and Alarm could be activated in case of communication problems.
If the CEMS is not available, this functionality is critical to be provided.

13 Revisions

Data	Revision	Author	Note
03/07/2013	1	New Use Cases Group – Energy@home Association	First release, presented at General Meeting, Catania
03/07/2013	2	New Use Cases Group	Modification

		– Energy@home Association	proposed by Lucio Bianchi
10/09/2013	3	New Use Cases Group – Energy@home Association	Modification proposed by Marco Signa
16/09/2013	4	New Use Cases Group – Energy@home Association	Check by Enel Distribuzione
27/03/2014	5	New Use Cases Group – Energy@home Association	Initialization scenario added on Chapter 5

14 Glossary

Term	Description
AG	See HG
Aggregator	Aggregator is a player in the energy market. It has the mission to aggregate many small clients and to operate into the energy market presenting them as a whole. The Aggregator shall reply to market needs offering services such as: • Power limitation within a given geographical region and temporal slot • Peak clipping • Peak shifting
Active demand	Active Demand (AD): it is the active participation of residential consumers in the power system markets and in the provision of flexibility to the different power system participants by participating in AD service.
AD service	AD service is a request sent from the aggregator to the consumers to maintain a certain power level in a period of time. The aggregator will give an incentive (€ as a function of kW actually consumed) for the fulfillment of the program.
Appliance Power Profile	The Appliance Power Profile is a data structure containing information about the energy consumption of an appliance (load profile related to its cycles) and some other useful information for load shifting or load shedding its usage.
Blackout	The total absence of voltage in the electric distribution grid managed by the operator (the legal person who is assigned the management of the local portion of the national electricity grid).
CEMS	Customer Energy Manager System. The CEMS is CEM integrated with communication functionalities, it is the gateway between the HAN, the HN and the WAN (e.g. internet). The CEM is a logical function optimising energy consumption and or production based on signals received from the grid, consumer's settings and contracts, and devices minimum performance standards. The Customer Energy Manager collects messages sent to and received from connected devices; especially the in-home/building sector has to be mentioned. It can handle general or dedicated load and generation management commands and then forwards

	these to the connected devices. It provides vice versa information towards the “grid / market”. Note that multiple loads/generation resources can be combined in the CEM to be mutually controlled.
Customer Interfaces	An appliance or Smart Info User Interface extension. Its goal is having a remote, more verbose, portable, remote, user friendly, configurable device. It could be a physical device or, more commonly, it is only a logical component, which can be visualized by a PDA, a pc or a Smart Phone (connected in the HAN or HN). Typical implementations are through Web pages or custom software written for each of these devices.
Demand Side Management	Demand side management (DSM) entails actions that influence the quantity or patterns (load profile) of use of energy consumed by end users, such as actions targeting reduction of peak demand during periods when energy-supply systems are constrained. Noticeably techniques are load shifting and load shedding.
DSO	In electrical power business a Distribution System Operator is an operator that carries and delivers electricity to the consumer from the TSO's distribution lines.
Energy Cost Algorithm	Algorithm, to obtain the price of energy at a given time (e.g. € per kWh from 08:00 to 19:00) replicating the conditions applied by the Energy Retailer. The Energy Cost Algorithm to get the price could be quite complex, and, in any case, defined by each Energy Retailer. The Energy Cost Algorithm shall receive as inputs a Power Profile, either actual or estimated, and all the needed metering data.
Energy Regulation Algorithm	Energy Regulation algorithm is any procedure which defines the strategy for coordinating Smart Appliances behavior, in order to reach energy consumption or cost optimization and to guarantee the overall performance of the system, using as inputs the global energy consumption, its cost, Appliances Power Profile and their status. Main control techniques involved in the Energy Regulation algorithm are load shifting and shedding .
Energy Retailer	Companies that participate in the retail energy market providing a service (energy) to the end user.
HAN	A home area/automation network is a residential local area network, usually characterized by low throughput. It is typically used for communication between devices within the home such as sensors, smart plugs, smart thermostats and household appliances. It can be a Wireless network (e.g. ZigBee) or wired (e.g. Power Line Communication). This is often referred to as PAN (Personal area network)

HG	Home Gateway: it is the gateway between the HAN, the HN and the WAN (e.g. internet). It is able to interface Smart Appliances and Customer Interfaces through the communication protocol(s) used in the HAN and HN (ZigBee, WiFi, etc.) and to provide a broadband connection to internet (usually via a standard ADSL connection). Moreover, the Gateway is able to collect energy data, from the Smart Info and from the user's appliances, and publish them in the HN and WAN.
Home Domain	It identifies a boundary of the wired/wireless communication system (HAN and HN), covering Smart Appliances, Customer Interfaces, Smart Info and CEMS. This boundary is usually the customer's House.
Home Domain Overload	Condition which takes place when aggregated home load exceeds a given power limitation. Power limitation can be determined by different causes according to the regulation in place. For example, in South Europe countries, domestic connections are subject to a maximum contractual power (eg. 3kW). Note that maximum contractual power limitation process is managed by the Meter, which is the only actor entitled to sense threshold exceeding and to perform needed action. In some circumstances, the Meter will open the breaker immediately, without emitting any alarm. In other countries, the limitation is imposed by physical limitation of the home equipment and apposite safety devices are installed to prevent the overload.
Home Energy Monitor	A Home Energy Monitor is a device providing the consumer a prompt and convenient feedback on electrical (or other) energy use. These devices may also display cost of energy, estimates of greenhouse gas emissions, near real time consumption of some electrical loads inside the house. Usually its display is remote from the measurement point and portable inside the house, communicating with the sensor/Home Electricity Meter using a wired (e.g. power line communications) or wireless methodology.
HN	A home network is a residential local area network, typically characterized by high throughput. It is used for communication between digital devices typically deployed in the home, usually personal computers, printers, gateways. The home network can be wireless (e.g.Wi-Fi) or wired (e.g. Ethernet).
Load Profile	Load profile is the variation in the electrical load versus time. A more specific definition is the Power Profile, which takes into account the power used by the load.
Load Shedding	Energy utilities' method of reducing demand on the energy generation system by temporarily rationing distribution of energy to different geographical areas; this can be done by forcing the switch off of some electric loads in the grid or by reducing the power consumption of some of those (thus altering their load profile). The most drastic kind of load shedding are rolling blackouts, the last resort measure used by an electric utility company in order to avoid a total blackout of the power system.

	Smart Appliances could significantly help to avoid these last resort measures, reducing temporarily their power consumptions: load shedding could be performed by the appliance control logic itself changing its power consumption profile (load profile) during its working operations . This action implies an information coming from the Utility through the Smart Grid to the Smart Appliance in order to to signal the need, carrying usually also a severity level. Their performances should not be greatly or noticeably affected by the load shedding operation. It belongs to the Demand Side Management techniques.
Load Shifting	Load Shifting is an electric load management technique that aims to shift the pattern of energy use of a device (load profile), moving demand from the peak hours to off-peak hours of the day. It belongs to the Demand Side Management techniques. In the Smart Appliance context, the load could be each single electric load of the appliance or, more generally and commonly, the overall working cycle of the appliance (which consists of a complex sequence of activation of those single loads, in order to achieve the needed performance of the machine).
Overload interruption	Trip of the circuit breaker due to unhealed overload
Peak Demand or Peak Load	Peak demand or peak load are terms used in Demand Side Management describing a period in which electrical power is expected to be provided for a sustained period at a significantly higher than average supply level. Peak demand fluctuations may occur on daily, monthly, seasonal and yearly cycles.
Power Profile	Power profile is the variation of power consumption of an electrical load versus time, thus specifying the [[Load Profile]] concept. It will vary according to customer type (typical examples include residential, commercial and industrial), temperature and holiday seasons. In the Smart Appliances context, the more specific concept of Appliance Power Profile is used.
SI	Smart Info: is the element, provided by the DSO, which provides energy information into the HAN. Published data are a sub-set of those already available inside the Home Electricity Meter, hence the Smart Info acts like a proxy of the meter
Simplified Tariff Profile	It is a simplified structure of the energy tariff offered to the client by the Energy Retailer. The content of the Simplified Tariff Profile is a sequence of time slots for a configurable amount of time (e.g. the next 24 hours) and the correspondent price (in euros per kWh) for each time slot. The actor that provides the Simplified Tariff Profile shall autonomously take into account all the relevant factors that influence the tariff, such as current time or differences between working and holiday days.

Smart Appliance	It is an appliance connected in the HAN and equipped with some intelligence to cooperate with the other home actors in order to provide new services to the consumer, like for instance energy consumption awareness, demand response. The Smart Appliance plays an active role in the home system complying with the system policies, satisfying the user whishes and always assuring its best performance. Most of these technologies imply some information transfer from the Smart Grids to the Smart Appliance (thus a communication channel within the HAN and outside the Home Domain) and an additional control and supervision logic (inside and/or outside the appliance).
Smart Plug	Device provided with a HAN interface (e.g. ZigBee) that typically has a power meter able to calculate the power/Energy consumption of the connected load and is typically provided with a Relay that can be used to remotely power on/off the load.
TSO	Transmission System Operator. In electrical power business, a transmission system operator (TSO) is an operator that transmits electrical power from generation plants to regional or local electricity distribution operators (DSO).
WAN	Wide area Network: it is a computer network that covers a broad area (i.e., any network whose communications links cross metropolitan boundaries) This is different than personal area network (PANs), Local area network (LANs) which are usually limited to a room, building, campus respectively.