HGI-GD017-R3

Use Cases and Architecture for a Home Energy Management Service

August 5th, 2011

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2 Acronyms

BG	Business Group
BSP	Broadband Service Provider
BSS	Business Support System
CF	Communication Flow
CPE	Customer Premises Equipment
CPS	Combined Photovoltaic/Solar System
DSL	Digital Subscriber Line
DSO	Distribution System Operator
EG	Energy Gateway
ESP	Energy Services Provider
GeSI	Global eSustainability Initiative
GHG	Green House Gases
GW/EM	Gateway/Energy Management
HAN	Home Area Network
HEM	Home Energy Management
HEMS	Home Energy Management System
HG	Home Gateway
HGI	Home Gateway Initiative
HN	Home Network
HVAC	Heating, Ventilation & Air Conditioning
ICT	Information and Communications Technologies
IF	Interface
ISP	Internet Service Provider
NAN	Neighbour Area Network
NT	Network Termination
OSGi	Open Services Gateway Initiative
OTT	Over The Top
PDA	Personal Digital Assistant
SEP	Smart Energy Profile
SMS	Short Message Service
SN	Sensor Network
SNC	Sensor Network Center
TOU	Time Of Use
WAN	Wide Area Network

3 Introduction

There is current research and innovation regarding applications and equipment to control energy consumption by means of developments in the following areas:

- more energy-efficient appliances;
- air conditioning systems;
- smart meters;
- sensors and actuators;
- use of different technologies (both wireless and wired) to connect appliances to Sensor Networks (SN);
- energy management systems.

This document describes use cases and an architecture to support Home Energy Management (HEM) services, and is part of HGI's Release 3 specification family. It has been produced by the Energy Efficiency Task Force (ENG) and Business Group (BG) of the Home Gateway Initiative (HGI)

In energy management systems, domestic appliances (washer, heater, etc.) would communicate through a local network while terminal devices (e.g. fixed and mobile phones, home gateways) act as gateways to telecommunication networks. Connection is established with both external platforms (e.g. via the broadband connection) and local agents able to optimise energy usage in the home. This optimisation requires an Energy Gateway Function somewhere in the home which is able to monitor/control the consumption of equipment.

The Energy Gateway function can be instantiated in various physical components, ranging from the smart meter, a dedicated device with specific connectivity, or in the home gateway itself. The choice of location will depend on factors such as the need to preserve the installed base, or a planned new gateway deployment. The HGI architecture supports different scenarios, but focuses on the case where this function is embedded in the Home Gateway.

The HEM project is one of several HGI Release 3 activities addressing energy efficiency and the Digital Home. The need for standardization activities in energy efficiency and the Digital Home related to telecommunications is now widely recognised. For example the European Union, with Directive 2006/32/EC, "Energy End Use Efficiency and Energy Services", has foreseen the installation of Smart Meters in domestic housing. In particular, Article 13 declares that:

1. Member States shall ensure that, in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings, final customers for electricity, natural gas, district heating and/or cooling and domestic hot water are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use. When an existing meter is replaced, such competitively priced individual meters shall always be provided, unless this is technically impossible or not cost-effective in relation to the estimated potential savings in the long term. When a new connection is made in a new building or a building undergoes major renovations, as set out in Directive 2002/91/EC, such competitively priced individual meters shall always be provided.
2. Member States shall ensure that, where appropriate, billing performed by energy distributors, distribution system operators and retail energy sales companies is based on actual energy consumption, and is presented in clear and understandable terms. Appropriate information shall be made available with the bill to provide final customers with a comprehensive account of current energy costs. Billing on the basis of actual consumption shall be performed frequently enough to enable customers to regulate their own energy consumption.
3. Member States shall ensure that, where appropriate, the following information is made available to final customers in clear and understandable terms by energy distributors,

distribution system operators or retail energy sales companies in or with their bills, contracts, transactions, and/or receipts at distribution stations:

a. current actual prices and actual consumption of energy;

b. comparisons of the final customer's current energy consumption with consumption for the same period in the previous year, preferably in graphic form;

c. wherever possible and useful, comparisons with an average normalised or benchmarked user of energy in the same user category;

d. contact information for consumers‘ organisations, energy agencies or similar bodies, including website addresses, from which information may be obtained on available energy efficiency improvement measures, comparative end-user profiles and/or objective technical specifications for energy-using equipment.

Directive 2009/72/EC (the 3rd Energy Package) sets a target of 80% of houses to have Smart Meters by 2020. Others relevant documents are listed in the References. Further information to EU legislation can be found via the following link:

http://europa.eu/legislation_summaries/energy/energy_efficiency/index_en.htm

At the time of publication of this document, the following groups are also addressing aspects of HEM as part of the Smart Grid:

- SMCG - Smart Meter Co-ordination Group CEN/CENELEC/ETSI
- SGCG - Smart Grid Co-ordination Group CEN/CENELEC/ETSI
- ITU-T - Home Networking aspects of energy management (G.hnem, G.hn), Smart Grid Focus Group
- NIST - National Institute of Standard and Technology
- IEEE P2030, P1901.2
- Wi-Fi Alliance
- UPnP Smart Grid
- ZigBee Alliance
- Homeplug Alliance
- HomeGrid Forum
- DECT Forum
- Broadband Forum
- European Smart Metering Industry Group (ESMIG)
- Energy@home
- AIM - A novel architecture for modelling, virtualising and managing the energy consumption of household appliances
- BeyWatch – ICT for Energy Efficient Homes & Neighborhoods
- SmartHouse/SmartGrid

3.1 Acknowledgement

While the HEM service is of interest to many HGI service providers, much of the detailed starting point for this work was received from contributions received by HGI from the projects of Energy@home (via Telecom Italia) and BeyWatch (via Telefonica).

3.2 Goals of HGI's Home Energy Management Activities

The current connected home environment, already widely deployed, and reflected in HGI R1, R2, and R3 requirements documents, is designed to meet the needs of the customer with regards to today's service mixes, in particular triple-play bundles of telephony, internet and TV delivered via the Home Gateway.

Additional services such as HEM are now envisaged which require new capabilities

- Interaction with and control, either directly by the end user, or via mediation of with application logic, of additional end devices, such as smart appliances, smart plugs, lighting, heating, and smart meters.
- Application logic and user interface method that optimise configurations, analyse usage patterns, and allow user control of these end devices, directly and remotely.

These new capabilities may either build on the existing infrastructure, or be based on a new parallel infrastructure if this makes more technical or commercial sense, but the Home Gateway is seen as a key element in either approach.

The specific goals of the HGI Home Energy Management activity are to:

- Document the various business roles that are involved in the HEM scenarios of interest to the HGI service providers.
- Document use cases of common interest to the HGI service providers.
- Build up an architecture common to a significant number of the HGI service providers that defines a set of logical building blocks and related interfaces for the HEM service. While a HEM service has potential global applicability, the HGI approach will take into account national or regional requirements that reflect the HGI service provider makeup.
- Identify a small number of options for the implementation of solutions for that architecture, based on the combined views of service providers and vendors. The scope of solutions can encompass both home gateway capabilities, network-based capabilities, and additional new capabilities on other devices in the home.

4 Scope and purpose of this document

This document covers Phase 3 of the HGI energy efficiency work (as described in the next chapter), and describes Use Cases and an architecture for Home Energy Management (HEM) Services. The topics addressed in the document, are as follows:

- Business rationale
- HEM use cases
- HEM architecture

This document covers architecture and Use Cases for HEM, but in order for this to ultimately result in HGs capable of fully participating in HEM, there will need to be some specific HG requirements defined, e.g. on interface types, authentication, security, analysis capability etc. This will be the subject of a future HGI Requirements Document.

4.1 HGI Energy Efficiency Phases

The HGI has divided its work on energy efficiency into 3 phases as shown in Figure 1.

4.1.1 Phase 1 - Energy efficient Home Gateway

Optimize the home gateway energy consumption by analyzing the subcomponents of the home gateway and making use of the individual low power features of these components.

4.1.2 Phase 2 - Energy efficient Home Networking

Optimize the energy consumption of the communication and consumer electronics devices in the home connected to the home gateway. The goal is to achieve overall energy efficiency in the home network so that each device is running in an energy efficient manner. This may include mechanisms to control the power mode of individual devices by the home gateway.

4.1.3 Phase 3 - Home Energy Management

Investigate potential solutions and business requirements for Home Energy Management (Smart Energy), which involve the home gateway in minimizing the energy consumption of various devices and appliances in the home. This can lead to energy savings on a much larger scale than can be achieved by optimising the home gateway alone; HG's tend to consume around 10W while the average household consumption is at least several hundred Watts (this is region dependent and can be as much as several kilowatts). The home gateway can serve as the enabler to monitor and control the large energy consumers in the home. This can be done both locally and remotely using remote management capabilities such as TR-069 and proxy techniques to other protocols. Such an approach will allow holistic power management in the home, and thus a significant reduction in energy consumption.

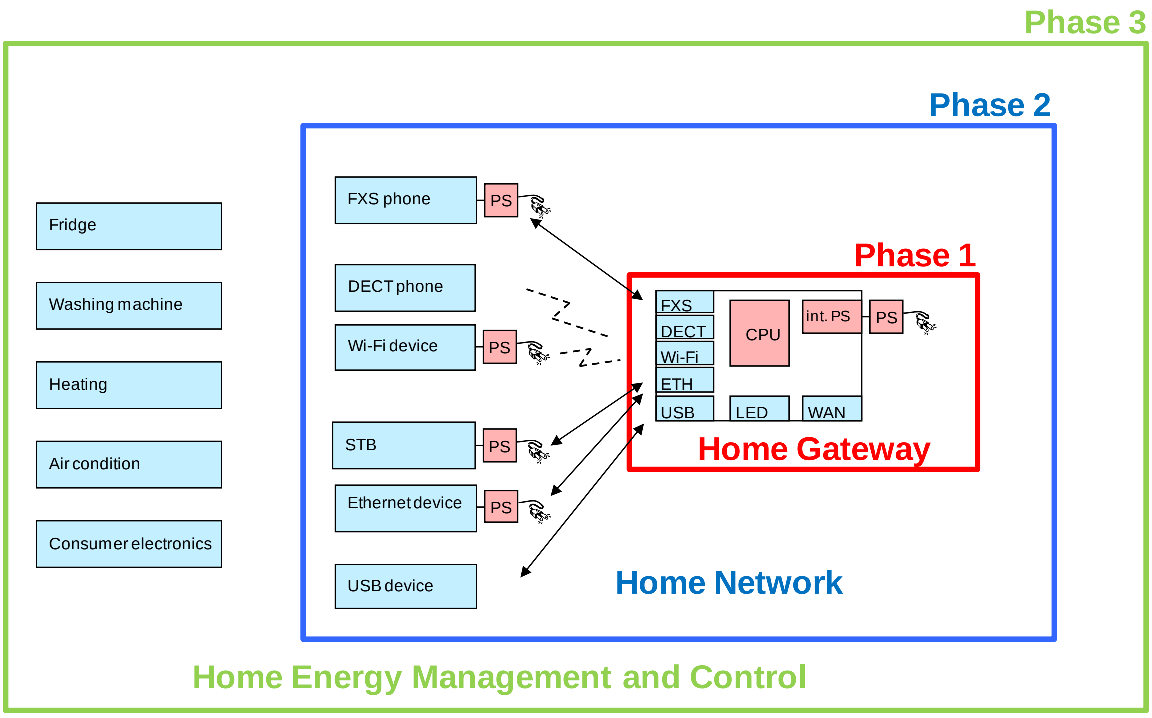

Figure 1 - the HGI phases of energy saving in the home

4.2 Home energy management scenarios

The most widely deployed networks in private homes are the so-called Triple-Play networks that provide basic connectivity to the internet and support value added services such as video and voice. It is relatively easy to add a device to these networks that acts as a gateway to an ‘energy subsystem’ (e.g. a set of sensors on a wireless non-IP network) and connects back to a specific service backend in the cloud. There are already products on the market that can provide this kind of over-the-top energy management to networked homes.

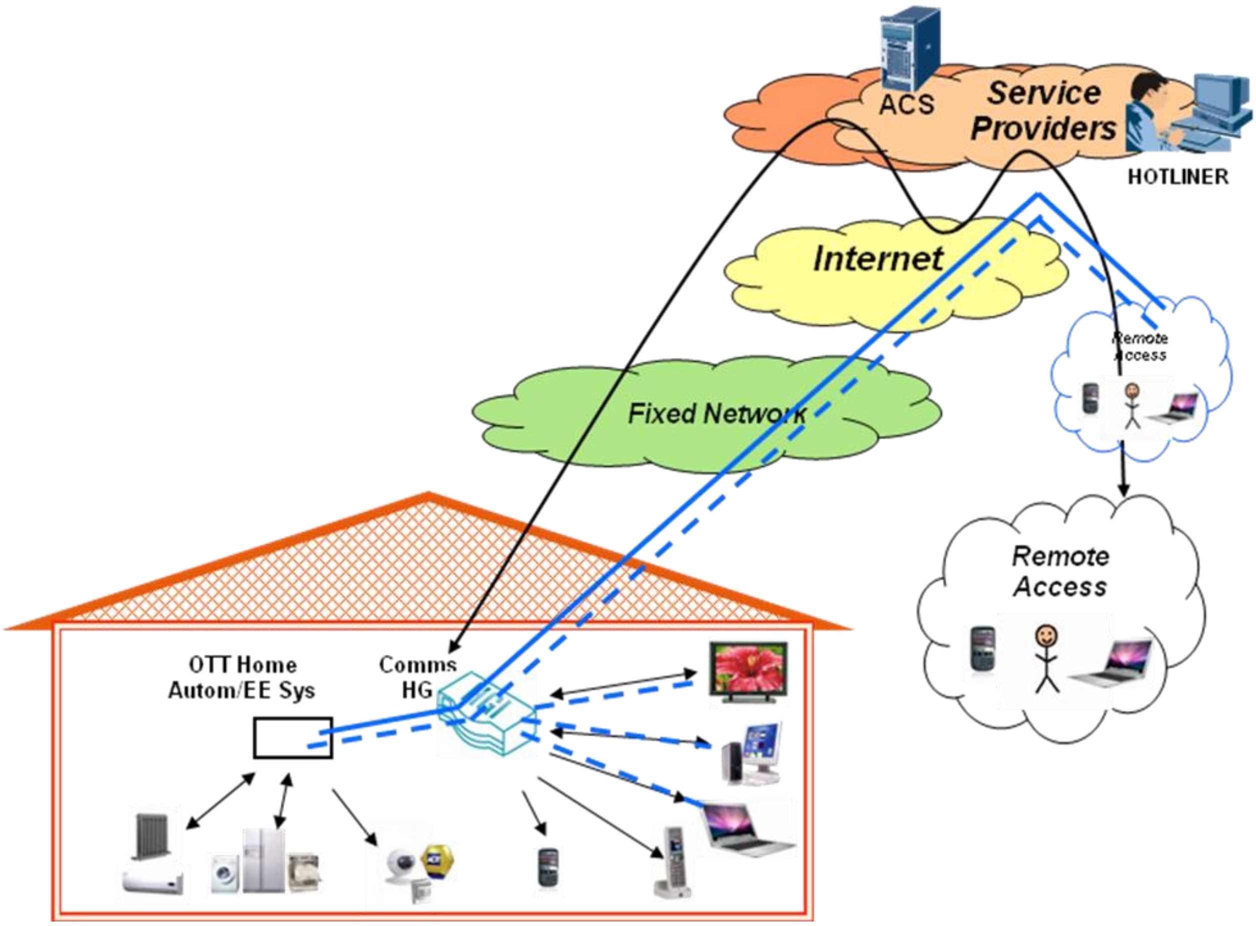

Figure 2 - Self-installed HEM

However such a solution is not integrated into the existing security and management mechanisms of Broadband Service Providers.

The existing systems can include a mix of comfort (heating/cooling), security, light, and energy-efficiency features. However they are generally unaware of other networked devices and so cannot take a whole house approach to energy efficiency. Integrating the functionality with a home gateway allows the connection of multiple (non-IP) home automation networks, the deployment and updating of the control software, and the storage and analysis of historic data, all of which can increase the overall effectiveness of such systems.

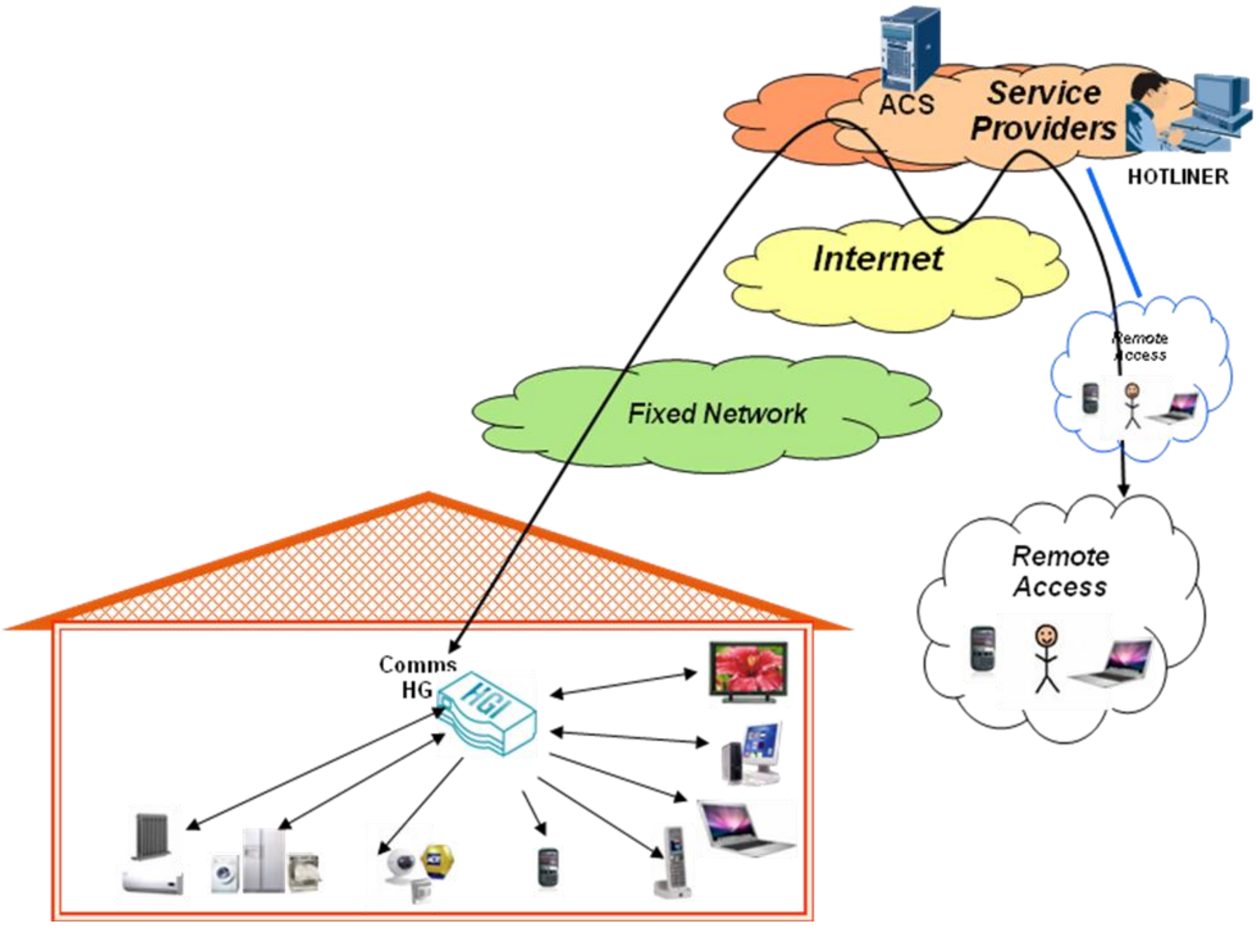

Figure 3 - HEM from/through the service provider

There are other approaches to home energy management which focus more on the use of the smart meter. These approaches are sometimes adopted due to regulation and do not allow the customer the same opportunity to buy and install systems from the retail market. There is much more emphasis on consumption and tariffs. Note that at least some of this information might also be available to the above OTT solutions (either through local connection to the meter or via the cloud).

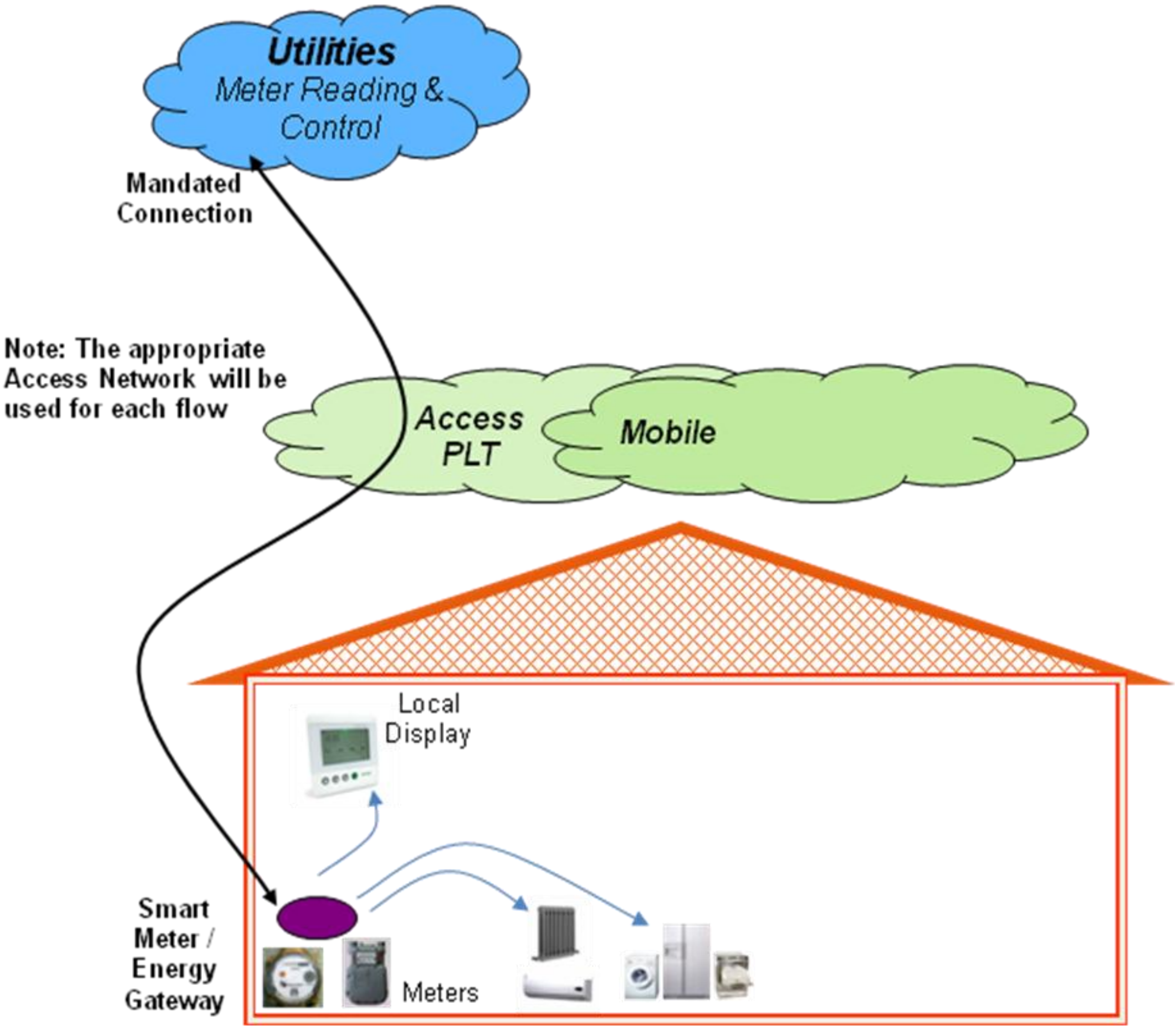

Figure 4 - HEM from the utility

Integration with the existing customer network is a key requirement in order to optimise the efficiency of home energy management, and so fits well with the scope of the HGI.

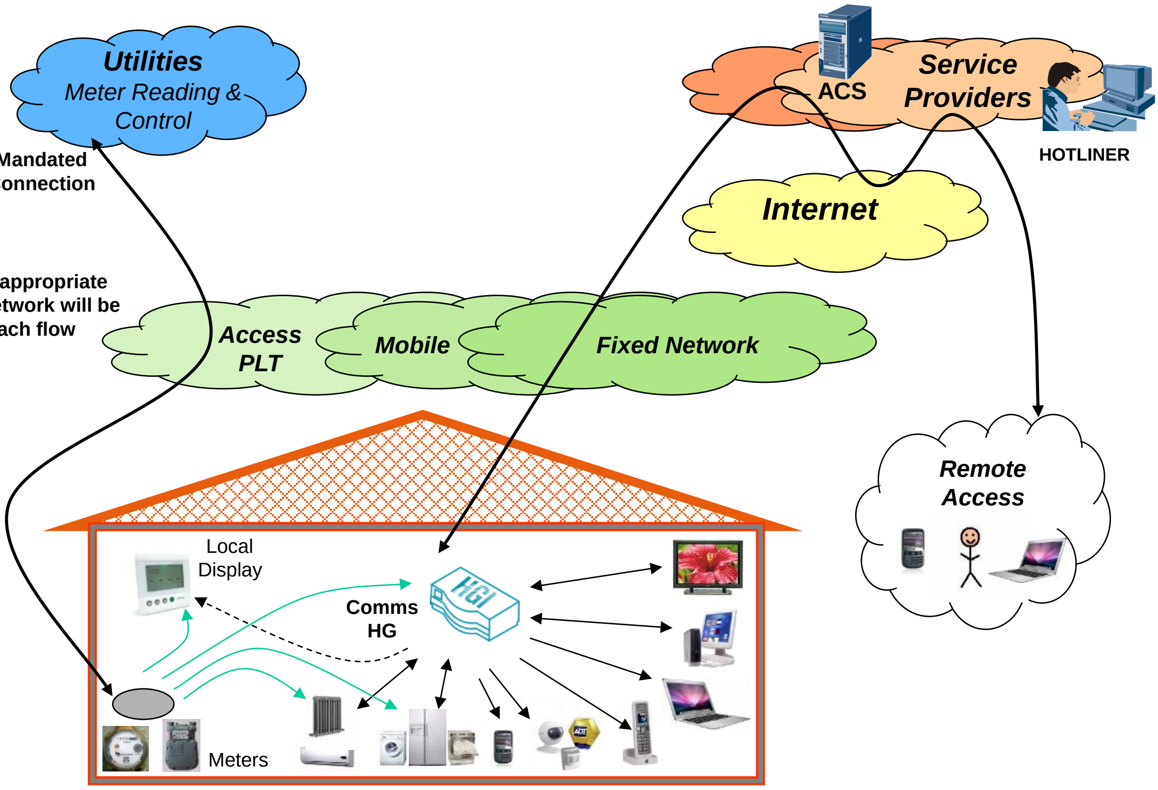

Figure 5 - HEM simultaneously provided by utilities and SPs

5 Business rationale

Environmental degradation and global warming are among the major challenges facing society. Strong action is needed at a global level to better manage water resources, halt the loss of biodiversity, make prudent use of natural resources and rare materials, reduce greenhouse gas emissions and tackle climate change. The most pressing challenge is to reduce the rate of increase of greenhouse gases in the atmosphere and ultimately to decrease the absolute level of these gases.

ICT has a major role to play in improving environmental performance and addressing climate change across all sectors of the economy. ICT technologies can help reduce energy consumption and manage scarce resources, improve efficiency and contribute to cutting carbon emissions. Europe recognizes the importance of ICT solutions in achieving energy efficiency. This was clearly underlined in 2008 at the world's biggest computer trade exhibition (Centre of Office and Information technology - CeBIT) when the European Union Commission's President Barroso said that "Europe must more than double its rate of improvement in energy efficiency and there is tremendous untapped potential in using ICT. The real gain in energy efficiency will come from ICT as an enabler to improve energy efficiency across the economy. ICT matters for energy reduction, especially in transport and the energy intensive sectors. ICT's ability to organize and innovate is a key factor."

Smart Metering, Smart Buildings and Smart Grids, are among the most important ICT-enabled solutions with the highest potential to reduce CO_2 emissions.

5.1 Smart Metering

ICT can reduce electricity demand by communicating real-time electricity usage and price through a smart meter. Smart Metering refers to the use of intelligent energy meters and measuring instruments in order to make the energy consumption in buildings more visible and to enable automatic energy management. Smart meters bring an end to estimated bills and home visits from meter readers because they can record and report electricity consumption information automatically and remotely. These new meters provide customers and energy suppliers with accurate information on the amount of electricity (and gas) being used; instead of measuring energy use at the end of each billing period, smart meters provide this information at much shorter intervals. Energy companies want to invest in smart metering infrastructure to become more efficient and effective in how they engage with their customers. Energy companies will also be able to innovate and offer their customers new types of tariffs that will allow customers to take advantage of cheaper deals at off-peak times. In the future, smart metering will play an increasingly important role in residential and commercial buildings. The reasons are:

a) preparing monthly bills, as is customary in some countries (e.g. USA, Sweden, Denmark) and is expected in the future in all European countries following the implementation of the EU Energy Performance of Buildings Directive;

b) monitoring buildings for damage or non-standard conditions (e.g. burst water pipes);

c) informing tenants about their consumption patterns, e.g. to save energy costs;

d) preparing energy bills at short notice, when there is a change of tenants;

e) obtaining comprehensive information about the use of energy in a building for the purpose of producing an energy certificate;

f) obtaining information about the energy consumption patterns of whole properties (e.g. in order optimize the distribution of energy and avoid peak loads);

g) complying with EC Directive 2006/32/EC on Energy End-use Efficiency and Energy Services (see Article 13 above), which sets out that the energy bills for household customers have to be sufficiently detailed and served frequently enough for customers to be aware of their energy consumption and control it accordingly.

5.2 Smart Building

Energy use in residential and commercial buildings is responsible for about 40% of the EU's total energy consumption and represents about 36% of CO_2 emissions in the EU and about 40% in the US. Therefore, buildings should be at the centre of any solution to reduce GHG emissions. Ideally, new buildings should be built for energy efficiency from the outset. Smart buildings rely on a set of technologies that enhance energy efficiency and user comfort as well as the monitoring and safety of the buildings. Technologies include new and efficient building materials as well as ICT. The energy efficiency improvements of smart buildings range from making better use of sunlight and natural ventilation to the proper sizing of heating, ventilation and air conditioning systems.

5.3 Smart Grid

The Climate Group, a non-profit organisation working with governments to advance smart policies and technologies to accelerate a low carbon economy, defines "smart grid" as a set of software and hardware tools that provides specific and real-time information to end-users, grid operators and distributed generators with the aim of reducing energy losses, improving network operational efficiency, achieving better quality and reliability of energy supply, allowing customer to control their energy use and, finally, reducing GHG emissions. The smart grid is an innovation that has the potential to revolutionize the transmission, distribution and conservation of energy. ICT achieves this by:

a) transitioning the grid from a radial system to an interconnected network, where distributed sources and end-users are connected;

b) automating processes using distributed intelligence;

c) enabling, through smart metering, two-way communication between customers and suppliers to create a real-time marketplace for energy consumption.

ICT can help modernize the electrical grid reducing transmission and distribution losses, reporting real-time usage and cost data to increase consumption awareness and integrating renewable energy.

In our Smart Grid scenario the architectural developments, as described later, are concentrated on the Home Area Network (HAN), where many devices (smart appliances, smart plugs, home displays, micro-generation systems, etc.) interact and a Gateway unit controls and manages the energy consumption. This is done in conjunction with the smart electricity meter (possibly part of a Neighbour Area Network, NAN) and the Wide Area Network (WAN). Further, connection with a Home Network (HN) is provided to inform the user about their energy consumption. The gateway device needs to satisfy specific requirements in order to perform its role: first of all it must be always on (24/7) to respond to the needs of energy distribution in the domestic environment. Secondly, it needs to be connected to the communication network, to receive from energy retailers the energy prices which might change, and to let other entities (the distributor, the users themselves) interact with the domestic system. Finally, it must communicate with all smart appliances.

In this scenario clear business opportunities for a Telecom Operator managing a Home Gateway arise:

1. Provision of energy management services
    - Advanced information/analysis services that present information to the user regarding energy consumption, appliances and pricing
    - Control of smart appliances to reduce their power consumption
    - Dynamic tariffs and pricing
2. Provision of an application platform to other service providers

5.4 HGI Business Model

In order to achieve the points listed above, the business model shown in Figure 6 has been developed.

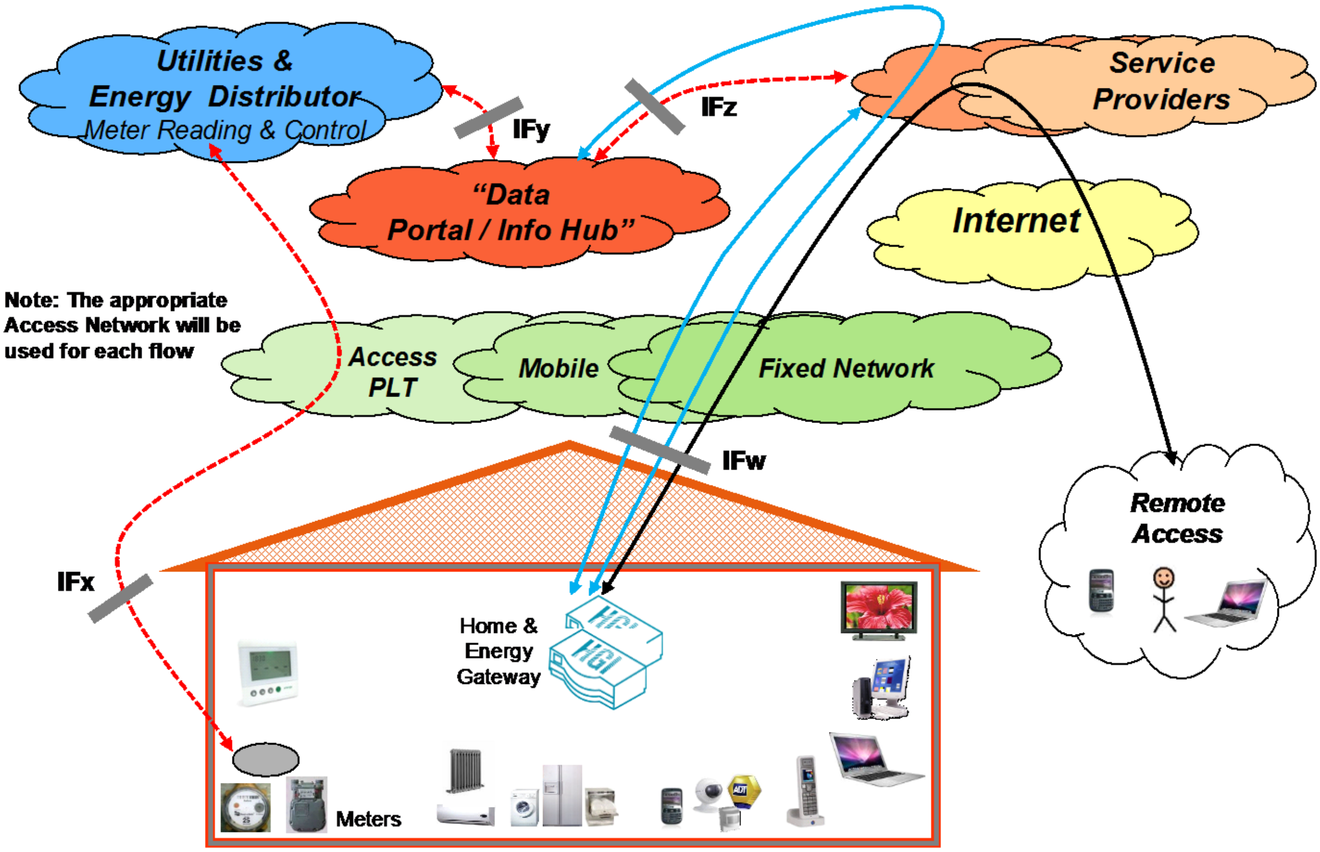

Figure 6 - Business Model for HEM

The following entities are considered in the model:

- **Utilities**: utilities include the DSO (Distribution System Operator) and the Energy Retailer, selling energy distributed by DSO (see Annex for definitions of utilities' business entities). In some cases the DSO and Energy Retailer are the same company. Their main roles are to:
    - Manage Electricity, Gas & Water
    - Generate, acquire and manage the supply of their commodity
  - **DSO** : The DSO is in charge of managing the distribution network
      - Their main role is to read meters at regular (short) intervals
  - **Energy Retailer**
    - Main roles :
      - Bill the customer
      - Set tariffs for energy according to their costs/demands
      - May also act as an Energy Service Provider (ESP) to manage end customers' energy usage
- **Broadband Service Providers** (BSP in HGI terminology) or Access-aggregation Network Operators offer IP connectivity with their main roles being to:
  - Manage Mobile & Fixed (Cable, Telco or Powerline) Access
  - Provide connectivity for Utilities & Service Providers

- The BSP may also be contracted by the Utility to provide connectivity to customer meters on their behalf
- The BSP role in HGI includes the ISP role (supply the IP address and Internet connectivity) and potentially one or more Application Service (such as VoIP, IPTV)
- The BSP also manages the home gateway

- **Service Providers**, also called Application Service Providers in HGI terminology (ASPs). They can be fixed and/or mobile and often also act as the BSP. They can:
  - A Broadband Service Provider who:
    - Offer Energy Management services to their customers
    - Access Utility tariff data from the Trading Portal and manage the customer's usage for least cost
    - Remotely manages services for their customers
  - Energy Service Providers (ESP)
    - This is a potential new entity which sells Energy Management services to end customers
    - Access Utility tariff data from the Trading Portal and manage devices in the customer environment 'over the top' via the customer's broadband network
    - Provide their own Energy Gateway to the customer.
- **Data Portal/Information Hub**: this is a new entity, either independent or managed and run by a utility or SP. Its main roles are to:
  - Aggregate customers on ALL types of access network
  - Provide SPs secure access to customer usage data
  - Provide access to the published Utility tariffs (in the limit, for each x minute period of the day/week/month/year)
- **Smart Meter**: The meter is part of the grid but there are various ownership scenarios. The Smart Meter:
  - is able to provide real time consumption measurements
  - supports interfaces to other devices in the customer environment
  - some smart meters are able to push information and get tariff information on a regular basis from the grid / DSO through technologies like powerline
  - applies tariffs for pay as you go
  - disconnects/reconnects the whole home power supply when required
- **Energy Gateway** (EG) is a functional entity that can be located in the smart meter, in the HG[1] or in a separate energy gateway which does the following:
  - gets information including meter data from Smart Info
  - records and stores usage, produces usage statistics & sends to Local Display
  - controls major energy using devices such as HVAC & white goods
- **Communications Home Gateway (HG).** This is the typical HG with broadband connectivity, and also has multiple LAN technologies for communicating with a wide range of devices and displays within the home. It is owned by the customer or the BSP or ISP. Possible roles include:

[1] In this case the Energy Gateway is embedded in the Home Gateway

  - recording and analysing usage, producing usage statistics & sending information and alerts to various display devices in the home e.g. PCs, TVs, Local Display & DECT phones
  - Sending alerts to mobile devices outside the home
  - Controlling major energy use devices directly or via the Energy Gateway
- **Local Display:** connects to the Energy and/or Communications HG and displays usage statistics/costs etc.
- **Other devices** in the customer environment which use energy. These include:
  - Heating, Ventilating & AirCon and White Goods, that could be controlled by the Energy or Communications HG
  - Brown Goods, Security sensors / cameras etc., PCs / Laptops, TV & STBs, Display Phones / DECT Phones, likely to only connect to the Communications HG (also remotely in case of PCs)
  - Mobile Phones, able to connect to the Communications HG from anywhere in or out of the home via the ISP

In Figure 6, Interfaces x,y,w,z represent B2B interfaces for potential future consideration, including possible interfaces between Energy Utilities and the Distributor that allow the energy retailer to modify rates. These are out of scope for this document.

At the application level the following relationships between entities are relevant for a home energy management service:

CF1 HG/EG←→smart appliance

- ←individual real-time consumption
- →commands (start, stop)
- ←request to perform a task including the expected power consumption
- ←device status (including alarms)

CF2 HG/EG←smart meter

- Provide overall real-time consumption
- Zone information
- Tariff information

CF3 HG/EG←→backend (utilities & energy distributor, service providers, data portal / info hub)

- ←zone information
- ←tariff information
- ←CO_2 information
- ←benchmark information
- →consumption information (historical, aggregated or sub sampled)
- ←demand response commands

- ←→authentication

CF4 HG/EG←→Internet

CF6 HG/EG→mobile network

CF7 HG/EG←→inhome display(s) (regulated displays)

CF8 HG/EG←→smart phone/tablet/PC/TV widget

- →visualization information:
  - usage data (current and historical)
  - current tariff and zone data
  - alarms
  - device (and scenario) status
- ←user interface input configuration (e.g. device priorities)
- ←user interface input control (start, stop)

CF9 HG←sensors
CF10 HG→actuators
CF11 Smart meter←→smart appliance
CF12 Smart meter→in-home display(s) (regulated displays)

6 HEM Architecture

The HGI HEM architecture is shown in Figure 7. The part of the system inside the dotted red line (i.e. including both the HAN and the HN) is the user's Home Domain, where all the entities (Smart Appliances, Home Gateway, User Interfaces, and Smart Info) can communicate via some mechanism.

The larger the power consumed by a device, the greater the impact that HEM can have in reducing or shifting consumption. However there are obvious security issues with being able to remotely control a large population of high-power devices. Therefore robust security (including authentication, customer awareness/involvement) must be a central part of any HEM system, and the system must be able to be upgraded easily to cope with any security breaches.

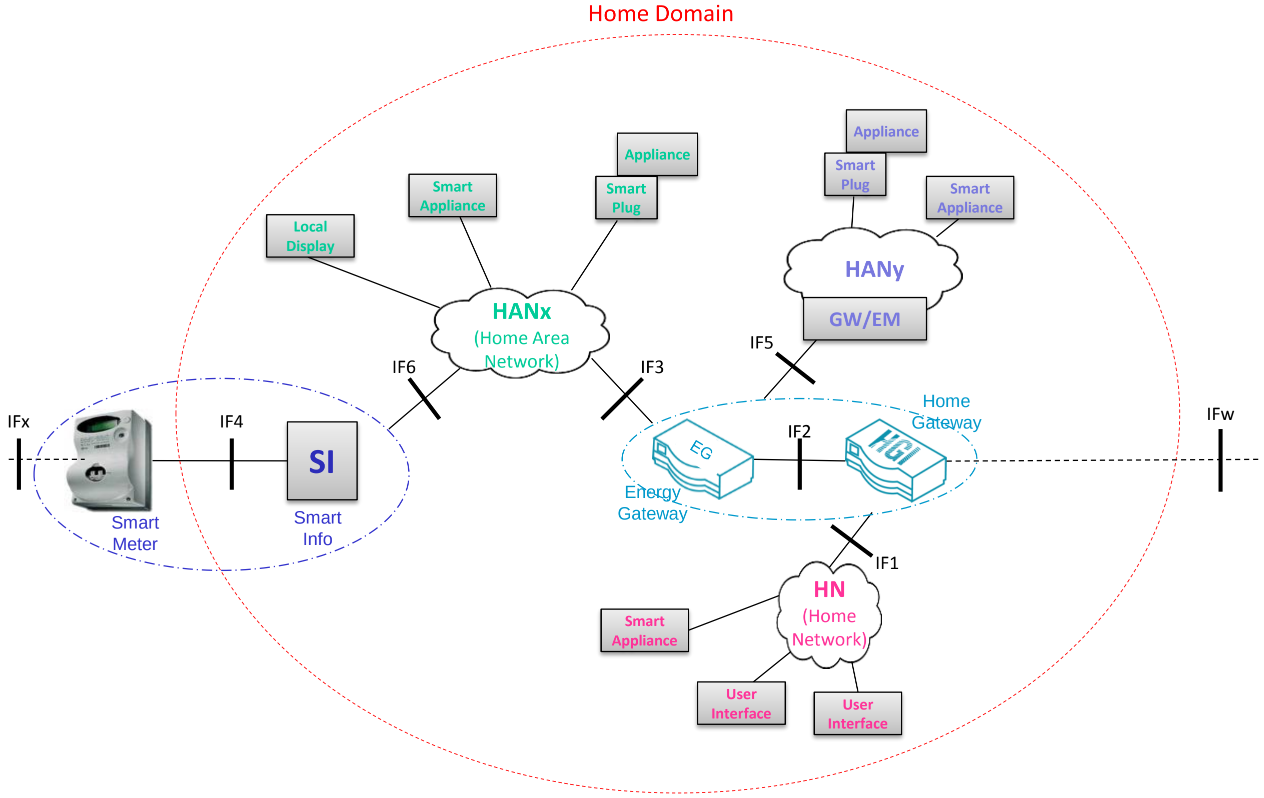

Figure 7 - HEM system architecture

Typically the Home Area Network (HAN) consists of specialized technologies such as ZigBee, Z-Wave, G.hnem, KNX, etc. developed for Home Automation and Control. The HAN interconnects the entities dealing with home energy management. There is a large variety of HAN technologies so it is possible that more than one such technology will be present in a given home. This is shown in Figure 7 by HANx and HANy but the general concept is extensible to more than 2 different HANs. For example HANy could be an already deployed home automation bus that is connected into the home energy management system via a gateway[2] which may include energy management functionality (GW/EM). There are 3 different ways to interface with a given HAN technology:

1. Directly integrate the HAN interface into the energy or home gateway

[2] This is a gateway that is used to make a link between non-IP electrical bus and the IP world connected to the Home Gateway or Energy Gateway. Moreover, this element includes the specificities of the electrical appliance manufacturers to manage and control the electrical appliances. The GW/EM needs connectivity to the WAN (service provider, utility or data portal) for updates on tariffs or for remote management.

2. Use a USB dongle that provides the HAN functionality
3. Connect via an external gateway which is typically connected via IP to the home gateway

It is also possible that Smart appliances are controlled via the Home Network (HN). The Home Network provides connectivity for triple-play applications and typically uses LAN technologies such as Ethernet, Wi-Fi or high-speed PLT.

Smart Info[3] is an optional element that could be provided by the utility (DSO), which distributes a subset of the information available from the Smart Meter, therefore acting as a proxy for the Smart Meter. Additional data could also be generated by the Smart Info itself. It is also possible that the Smart Info functionality is directly embedded into the Smart Meter which is shown by the dotted line around those two entities.

The Energy Gateway function can be instantiated in various physical components, ranging from the smart meter, a dedicated device with specific connectivity, or in the home gateway itself. The choice of location will depend on factors such as the need to preserve the installed base, or a planned new gateway deployment. The HGI architecture supports different scenarios, but focuses on the case where this function is embedded in the Home Gateway; this is depicted by the dotted line around the home and energy gateway.

Considering Figure 7, the following logical interfaces (IF) can be defined:

IF1 Between the Home Gateway and the Home Network

IF2 Between the Home Gateway and the Energy Gateway

IF3 Between the Home Gateway/Energy Gateway and the Home Area Network

IF4 Between the Smart Meter and the Smart Info

IF5 Between the Home Gateway and a gateway to another home area network technology

IF6 Between the Smart Info/Smart Meter and the Home Area Network

Note that all these interfaces are logical and not necessarily physical. This particularly applies to IF2 that connects the Home Gateway (as defined in HGI-RD001) to the energy gateway. The IF2 could simply be a logical, internal interface in an enhanced HG, or could be both logical and physical, connecting a separate energy gateway box to the current HGI HG, or to an HG with additional features from the point of view of application layer support.

In order to take into account already deployed home automation solutions (some of which have been on the market for at least 15 years), it is necessary that the Home Energy Gateway Function can address legacy home area network technologies such as ZigBee (Smart Energy Profile, HA profiles), Z-Wave, KNX and X2. Further technologies may be needed in the business market. Electrical appliances that are managed using some other technology are accessed via a gateway/energy manager (GW/EM) as shown in Figure 7 via IF5.

It is worth noting that these networks do not necessarily use IP which then requires an IP gateway for easier connection to the home gateway. In any case the EG+HG functional block must be able to expose at IP layer the elements of those Home Area Networks; and this is done through the interface IF1 between that gateway and the HN.

More precisely, the interface should include the following functions:

- IP Gateway + electrical bus controller
- Energy Management Gateway functions for synchronisation and coordination of the different electrical appliances possibly using different protocols
- Connection to the Home Gateway

[3] Smart Info is a specific term used in Energy@home architecture. It is not the energy gateway referred to in this document.

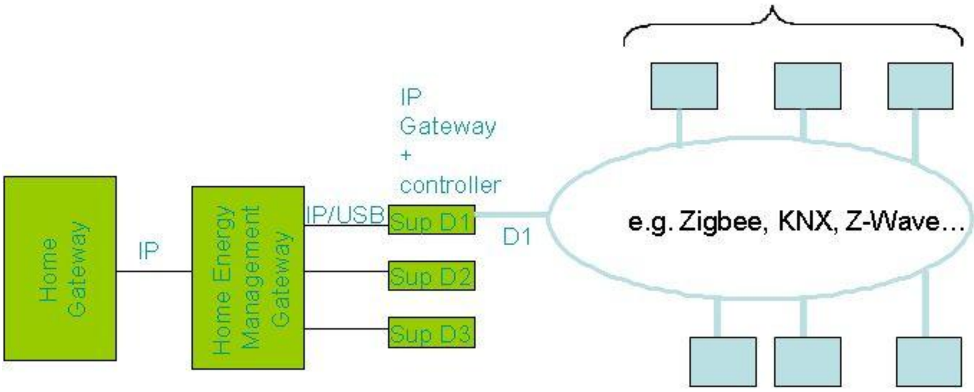

Figure 8 - Energy gateway interfacing with different HANs

However, due to the complexity involved in such flexibility, it seems appropriate to limit the number of different buses that could be managed simultaneously at the Energy Gateway level. According to initial analysis, the maximum number of protocols/interfaces would be about 5, either provided by USB dongles or as a native implementation in the Energy Gateway using Ethernet, Wi-Fi, PLT, etc.

This flexibility requires some coordination at the Energy Gateway among different protocols which also require some high level functions to facilitate communication between different electrical appliances on different electrical home area networks using different technologies.

6.1 Appliance software abstraction layer for a SWEX-enabled Home Gateway

This sub-section deals with a software abstraction layer for HAN appliances to be incorporated into HEM application running on top of a software execution platform (in this case an OSGi service platform) as defined in RD008-R3. The goal is to provide unified APIs for application developers independent of the actual home area network technologies used within a user’s home.

The high-level rationale for such an abstraction layer is:

- There is no “one size fits all” HAN system.
- There should be no limitations on supported HAN technologies, as long as they provide a USB-based or IP interface.
- While standardized HAN protocols are preferable, the large installed base of some proprietary systems means they have to be supported.
- USB home automation adapters to non-IP networks need native code drivers
- Native code drivers are “translated” to OSGi based drivers using the Java Native Interface (JNI).
- On the same level, there should be a standardized appliance abstraction layer.
- An appliance abstraction layer is crucial for incorporating third parties into application development.

The approach can be described as in the following figure, where dashed lines describe how the HANx devices are exposed to the Home Network at IP layer. It is as well possible to expose HANy devices to the HN in the same way via the API in the HG. In addition or alternatively HANy devices are exposed directly to the IP-based HN through the GW/EM.

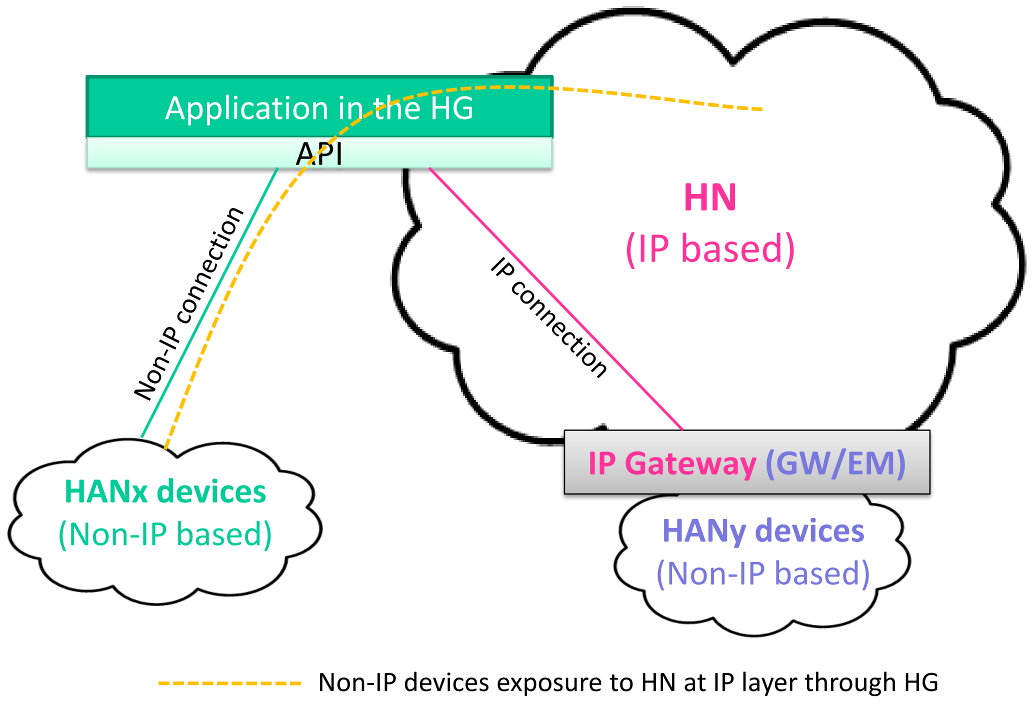

Figure 9 – Schematic approach to API supporting HEM architecture

Technical details will be analysed by HGI in the future.

7 HEM Use Cases

The following Use Cases, coming principally from Energy@home and BeyWatch projects, have been organized into clusters of scenarios. While a combined (HG+EG) or separated implementation is possible, the roles attributed to the Home Gateway in the following Use Cases refer to the combined case. In a separated implementation, some of these roles may be split out to the Energy Gateway.

7.1 Use Case 1: Visualization of current energy and power data

The aim of this set of use cases is to provide information to the customer on their current energy consumption.

Title	Description	Home Gateway
1.1 Visualization of total current energy consumption based on data from Smart Meter	The customer is presented with information about the total current energy consumption of their house. This data is provided by the Smart Info, which retrieves it from the Smart Meter and possibly integrates this data with near real-time power measurements. No information about costs is provided; hence any reference to the tariffs just means the currently active tariff, but not the pricing. 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 Home Gateway is not strictly necessary but its presence would allow a number of extra functionalities described in the Home Gateway column.	Hosts a Web application that collects energy data from HAN devices and organizes it for user-friendly presentation. Exposes a web-based API that can be used by 3rd party applications that wish to elaborate the data and/or provide a different representation. Provides an Execution Environment (e.g. OSGi framework for Java) to host 3rd party applications Implements a Trust Agent to manage all the security keys of the HAN; this functionality can be implemented via collaboration with the SN-C Service Platform. Implements the communication with the SN-C Service Platform and provides APIs to mediate communication between local bundles and the SN-C Service Platform.
1.2 Visualization of total current consumption + cost information	This Use Case extends UC 1.1 by adding information about the cost of the energy.	Same as UC 1.1 An *Energy Cost Algorithm* should be hosted by the Energy Gateway function. The *Energy Cost Algorithm* is used to evaluate energy costs and display both cost and energy consumption. In addition, this interface must 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 may need an allowance for possible differences between the Gateway and Meter real-time clocks) Distributes the cost information over the HAN to interested devices.
1.3 Visualization of current energy	The customer is also informed of the current energy consumption of	Same as UC 1.1

consumption of Smart Appliances + total consumption	individual appliances. Clients will be able to display such data together with total house consumption on Customer Interfaces.	
1.4 Visualization of the current energy consumption of Smart devices + total house consumption + cost information	Similar to UC 1.3 with information on costs	Same as UC 1.2 Same as UC 1.3
1.5 Visualization of estimated energy consumption of Smart Appliances and the cost before starting the Appliance	Inform the consumer of the energy implications of selecting different operational modes, in particular different washing machines cycles, before initiating the activity. Studies have shown that an energy saving of 10-15 % could be achieved as a result. In the case of time-of-use (TOU) pricing, the appliance will need to receive information about which tariff is currently in use.	Provide the HAN with information about energy tariff profiles, energy costs and time of day.
1.6 Information on energy mix	The energy retailer may be interesting in providing clients with information about the energy sources mix used to supply their electricity e.g. by specifying the percentage of renewable sources, the CO_2 footprint and other information.	However this information could simply continue to be provided as a Web page by the retailer.

7.2 Use Case 2: Visualization of historical data

The aim of the following use cases is to provide customers with historical and statistical information on their energy consumption, providing both the total energy consumed with time, and that of individual appliances.

Title	Description	Home Gateway
2.1 Visualization of the historical data for the customer (total in-house consumption and that of individual Smart Appliances)	The customer may access the historical data and see how energy was used over time.	Access to the sensor network would allow the storage of the total and single appliance energy consumption. The Home Gateway can access and aggregate this data to present it to the user through a Browser. The Home Gateway would also allow external applications in the HN to retrieve the stored data.
2.2 Visualization of historical data compared with a benchmark	The customer may compare their own energy consumption with other similar customer/ communities types.	Enable simple access to the application in the network in order to enable comparison with other users.
2.3 Visualization of historical data charged at a new tariff	The customer can see how their energy spending would change if they switched to a different tariff.	The Home Gateway allows external applications in the HN to retrieve the stored data.
2.4 Visualization of consumption data compared to that in previous time intervals.	The customers may compare their energy consumption against that at different times, for example this week with last week, or this year with last year…etc. The time interval and start date would both be configurable.	The Home Gateway allows external applications in the HN to retrieve the stored data.

7.3 Use Case 3: Alarms

Title	Description	Gateway
3.1 Notification of potential Home Domain Overload	The customer is informed promptly when the overall power drawn is near the maximum available power, hence indicating a potential Home Domain Overload. The notification could be done via acoustic alarms and/or SMS. The customer can also access the alarm history.	The HG can relay or activate alarms on a variety of devices. The user can set alarm priorities.
3.2 Notification if a user configured limit is reached	The customer is informed promptly when the overall power drawn exceeds a limit which has been configured by the user. The notification could be done as per 3.1. The customer can also access the alarm history.	The HG can relay or activate alarms on a variety of devices. The user can set the limit when the alarm should be sent.
3.3 Black out	In case of energy blackout the Home Gateway, if equipped with an UPS, is able to guarantee the correct activity for a minimum time (< 60 s). It can alert the customer about the event with an alarm (e.g. SMS, phone call)	Activate a SMS or a voice call alarm
3.4 Abnormal appliance consumption	The customer is informed promptly in the case of abnormal appliance consumption (e.g.: possibly indicating a fridge with a door left open).	The HG can relay or activate alarms on a variety of devices. The user can set alarm priorities.

7.4 Use Case 4: Home Domain Overload management

In this scenario, individual appliances have their behaviour regulated based upon home power availability. The aim of these use cases is to encourage the use of appliances when there is enough power in order to avoid overloading.

Title	Description	Home Gateway
4.1 Home Domain Overload management for smart and non-smart appliances	The system can optimize the use of power in order to avoid Home Domain Overload. The customer can define/modify the load shedding priorities and strategies in the case of a Home Domain Overload. This can be applied to smart and non-smart appliances (via Smart Plugs). A central unit located inside the house will implement the coordination logic. An alarm (e.g. acoustic) can be generated to notify the customer of any critical condition. In order to simplify the process, default configurations could be considered.	***Coordinated management*:** The Home Gateway hosts the application that allows the Home Domain Overload Management. The macro functionalities could be: • Allow the customer to define their own overload rules (i.e. appliance priority in the event of overload) • Allow the customer to associate a Smart Plug with a non-smart appliance • Receive from Smart Appliances information about the estimated appliance power profile of the program activated by the customer • Coordinate the appliances in order to avoid the overload condition • Inform the customer about any activated action that may trigger an overload (i.e. via an acoustic warning) The Home Gateway can also provide a web user interface for these functionalities.
4.2 Request confirmation to start if the available power (in the home) is not sufficient to run a Smart Appliance	The system may require explicit confirmation from the customer if the use of a Smart Appliance may lead to power overload. The system checks if the total available power in the home is sufficient to run the Smart Appliance, depending on its power profile estimation, on other Smart Appliances estimated power profile and on the current total consumption. The customer is notified that there is not enough available power to run the Smart Appliance and the customer can make the final decision what to do.	***Coordinated management:*** The Home Gateway hosts the application that allows the customer to coordinate the Smart Appliances according to the available power and has knowledge of the activity schedules of other Smart Appliances in the HAN (e.g. due to pre-programming).

7.5 Use Case 5: Optimize energy cost

In this scenario the system performs actions in order to reduce and optimize the energy cost. The optimization of energy cost applies in the case of a multi-tariff contract. Configuration of a monthly cost limit is also supported

Title	Description	Home Gateway
5.1 Multi-tariff energy use optimization in the case of both smart and non-smart appliances	The system provides an optimization of appliance 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 or dishwasher. The most important exception is the fridge, which operates continuously. ***Coordinated management:*** The customer can define/modify the house rules for energy cost optimization in the case of single or multiple appliances. For any appliance, 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 the operational time interval for non-smart appliances (e.g. a boiler). In order to simplify the process, default configurations could be considered.	***Coordinated management:*** The Home Gateway can host the application that allows the Customer to optimize the energy use or communicate with a 3rd party server to get instructions. The macro functionalities could be: • Allow the Customer to define for each time interval the appliance priority list (e.g.. from 19:00 to 23:00 give priority to the washing machine) • Allow the user to associate a Smart Plug with a non-smart appliance • Receive Smart Appliance information about the estimated appliance power profile for the program activated by the Customer. • Control the appliances in order to optimize energy costs and/or provide the required customer quality of life The Home Gateway can also provide a web customer interface for these functionalities.
5.2 Automatic time shifting of some phases or functions of the Smart Appliance for favourable economic conditions	This Use Case foresees Smart Appliances' capability to delay some of their specific functions (either activated by the customer or automatically within the cycle) according to current tariff and energy cost. ***Coordinated management:*** The coordination between the different entities in the house and their needs in terms of power consumption will allow consideration of the overall power consumption forecast and thus better optimize the energy costs and prevent overloads.	***Coordinated management:*** The Home Gateway can host the application that allows the user to optimize the energy cost.
5.3 Configure cost limit	Users may configure their HEM system to limit monthly cost. The system offers a simple way to	The Home Gateway hosts the application that allows the user to optimize the energy cost.

	configure these limits with a clear and intuitive interface. The HEM system can suggest the recommended consumption of each application to achieve the configured cost limit. This would need to be in user friendly terms, e.g. number of washing machine usages.	

7.6 Use Case 6: Demand response

This scenario takes into account requirements related to the future interaction between clients and the electricity market. The customer could be presented with daily (or even hourly) offers coming from the current energy supplier or possibly alternative suppliers which aim to modify clients' behaviour. Such offers could be via by a new player in the energy market called the Aggregator, who has the business objective of aggregating many small customers and to offer this aggregated set to the energy market. The Aggregator could offer the following capabilities to an energy supplier:

- Power limiting within a given geographical region and temporal slot
- Peak clipping
- Peak shifting

To encourage end-users to use such services, the Aggregator could provide them with offers, for example providing a rebate for power reduction within the required time slots. There needs to be a mechanism to provide the clients with the offer details (temporal slot, needed reduction, remuneration mechanism, etc.), which are generally indicated as price/volume signals. For example the Aggregator could require its clients to limit the power below 2 kWh between 14.00 and 16.00. It is also possible that the energy retailer himself could act as the aggregator.

To help clients' acceptance of demand/response policies, price/volume signals have to contain information for the coming hours to allow the appliance planning to take into account the client's needs and the appliances' cycle characteristics. Price/volume information would need to be linked to the daily energy market. Very short-term variations (only a few minutes notice) would have the greatest potential impact on customer experience and so should be limited to unexpected conditions like critical grid Peak Demand conditions.

From the system point of view, price/volume signals could be collected by the Home Gateway and used as inputs for the cost-evaluation algorithms.

Title	Description	Home Gateway
6.1 Demand response management	The Aggregator, in order to perform power limiting within a given geographical region and temporal slot, peak clipping or peak shifting, provides price/volume signals to the HEM function of the Home Gateway which can control devices on the HAN Some HAN devices may be able to use such price/volume signals directly.	The Home Gateway may host the application that analyses price/volume signals and controls HAN devices accordingly.

7.7 Use Case 7: End User Control

The aim of the following use case is to provide the customers with the ability to control all appliances within their Home Network.

Title	Description	Home Gateway
7.1 Appliance configuration	The system will provide the end user with an easy way to access the appliance configuration web page. When the end user opens the remote page general options to control an appliance are available (stop and start), and other more specific ones for various appliance (e.g. for a washing machine skip the spin cycle or use a lower temperature). The user will be informed of the current consumption and the impact of any configuration change.	The Home Gateway hosts a web application that enables appliance configuration.
7.2 Start/Stop appliances	The system will provide the end user with an easy way to cancel actions taken by the system. For instance, if the user chooses an evening “Smart Energy” start time, but then decides in the morning that the washing machine should start immediately, then he should be able to override the Smart Energy start time. The system should also provide the end user with an easy way to control every home appliance and electrical device.	The Home Gateway hosts the application that allows device control.
7.3 Override of HEMS recommendation by user	The HEMS decides when a certain household appliance will be powered on. However this schedule is not convenient to the user who decides to override it. The HEMS establishes (either by itself or by communicating with the Advanced Metering Infrastructure of the utility company) that its recommendation can be overridden. It then computes the financial penalty associated with the override and displays this information to the user. The user can decide whether or not to accept the financial penalty.	The Home Gateway hosts the application that allows limited user over-ride of the HEMS recommendation.
7.4 Unsuccessful override of HEMS recommendation by user	The HEMS decides when a certain household appliance will be powered on. This schedule is not convenient to the user and the user decides to override it. The HEMS establishes (either by itself or by communicating with the Advanced Metering Infrastructure of the utility company) that its recommendation cannot be overridden. This should only be done for contractual or safety reasons.	The Home Gateway hosts the application that helps to decide whether or not the HEMS recommendation can be overridden.

7.8 Use Case 8: Consumer/Prosumer tariff simulator

The aim of the following use case is to provide customers with the ability to optimize their tariff. The customer can choose the best tariff from each provider, simulate the consumption with that tariff and then change tariff if they wish. It is necessary to introduce the prosumer concept where the user also generates energy; "prosumer" is the union of two words: "producer" and "consumer". This new word indicates that a user can *consume* energy but also *produce* it. With this electricity generation, users can help to reduce consumption peaks from the external grid in their homes, neighbourhood and the network as a whole.

Title	Description	Home Gateway
8.1 Compare provider tariffs and simulation of the user consumption with a new tariff.	The consumer can compare their current tariff with the cost in Euro of their total consumption using other available tariffs. The system also suggests the lowest tariff from each provider for the user's consumption pattern.	The Home Gateway allows external applications to retrieve the stored data e.g. consumption data in order to enable those applications to calculate the user bill with different tariffs
8.2 Compare provider tariffs and simulation of a new prosumer tariff.	The consumer may visualize his current "prosumer" tariff and the amount in Euro that he is earning. The system also suggests the most beneficial tariff from each provider for the user's generation pattern, and allows a comparison with the tariffs of other companies.	The Home Gateway allows external applications to retrieve the stored data.

8 Annex A - Glossary

The following glossary is based on terminology produced by the project Energy@home, but a few additional terms have been defined.

Term	Description
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 other information which could be used for load shifting or shedding.
Customer Interface	An appliance or Smart Info User Interface extension. The goal is to have a remote, more verbose, portable, user friendly, configurable device interface This could be on a standalone physical device or, more commonly, a logical component, which can be displayed on a PDA, PC or Smart Phone. Typical implementations are through Web pages or custom software written for each of these device types.
Demand Side Management	Demand Side Management (DSM) entails actions that influence the quantity or pattern (load profile) of energy consumed by end users, so as to reduce peak demand during periods when supply is limited. Example DSM techniques are load shifting and load shedding.
DSO	In the electrical power business a Distribution System Operator carries and delivers electricity to the consumer from the TSO's distribution lines.
Energy Cost Algorithm	Algorithm to determine 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 could be quite complex, and will be different for each Energy Retailer. The Energy Cost Algorithm takes as inputs a Power Profile, either actual or estimated, and meter data.
Energy Gateway	A function that can be instantiated in various devices, ranging from the smart meter itself, to a dedicated device with specific connectivity or the home gateway, and which implement Home Energy Management.
Energy Regulation Algorithm	An Energy Regulation algorithm is a procedure designed to coordinate Smart Appliance behaviour, in order to optimize energy consumption or cost. Inputs to this algorithm include total energy consumption, cost, appliance Power Profile and current status. The related control techniques are load shifting and shedding.
Energy Retailer	A company that participates in the retail energy market providing a service (energy) to the end user and managing the retail aspects of the business scenario.
HAN	A home area/automation network is a residential local area network, usually characterized by low

	throughput, low power and low cost. 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. Command and Control Power Line Communication).
HG	Home Gateway: 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 the Internet (usually via a standard xDSL connection). Moreover, the Gateway is able to collect energy data, from the Smart Info and from the user's appliances, and publish them on the HN and WAN.
Home Domain	The Home Domain consists of the wired/wireless communication system (HAN and HN), covering Smart Appliances, Customer Interfaces, Smart Info and Home Gateway. This domain is normally limited to the customer's home.
Home Domain Overload	Condition which takes place when the aggregate home load exceeds a given power limit. The power limit can be determined by different factors and may depend on the regulatory environment. For example, in South European countries, domestic connections are subject to a maximum contractual power (e.g. 3kW). Note that the maximum contractual power limitation process is managed by the Meter, which is the only entity entitled to sense exceeding the threshold. It can also perform actions such as opening the circuit breaker immediately, and without emitting any alarm. In other countries, the limitation is imposed by the limits of the home equipment and appropriate safety devices are installed to prevent overload.
Home Energy Monitor	A Home Energy Monitor is a device providing the consumer with prompt and convenient feedback on energy use. These devices may also display cost of energy, estimates of greenhouse gas emissions and near real time consumption of some electrical loads inside the house. Its display is usually portable and remote from the measurement point , communicating with the sensor/Home Electricity Meter using a wired (e.g. power line communications) or wireless connection.
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, such as personal computers, printers, gateways and set-top boxes. The home network can be wireless (e.g. Wi-Fi) or wired (e.g. Ethernet, PLC).
Load Profile	Load profile is the variation in electrical load with

	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 is a rolling blackout, 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 by temporarily reducing their power consumption: load shedding could be performed by the appliance control logic itself. This action requires information from the Utility through the Smart Grid to the Smart Appliance in order to signal the need for shedding; there may also be an associated severity level. The Smart appliance's performance should not be noticeably affected by the load shedding operation. Load shedding is a Demand Side Management technique.
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 is a Demand Side Management technique. 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 those single loads, in order to achieve the needed performance of the machine).
NAN	Originally a NAN (Neighborhood Area Network) consisted of one or more persons putting up an 802.11 access point (AP), to cover a small geographic area. With Smart Grid, NAN now refers to a small neighborhood powerline or ZigBee network managed by a utility (DSO) and includes the meter and possibly a concentrator.
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 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 with time. It will vary according to customer type (typical examples include residential, commercial and industrial), temperature and holiday seasons.

	In the Smart Appliance context, the more specific concept of Appliance Power Profile is used.
Simplified Tariff Profile	This 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 period of time (e.g. the next 24 hours) and the corresponding price (in euro per kWh) for each time slot. The entity that provides the Simplified Tariff Profile must take into account all the relevant factors that influence the tariff, such as current time or differences between working and holiday days.
Smart Appliance	This is an appliance connected to the HAN and equipped with some intelligence to cooperate with the other home devices in order to provide new services to the consumer, like for instance energy consumption awareness, demand response, etc. The Smart Appliance plays an active role in the home system complying with the system policies, satisfying the user wishes and always assuring its best performance. Most of these technologies imply some information transfer from the Smart Grid to the Smart Appliance and thus need a communication channel within the HAN and outside the Home Domain, and additional control and supervision logic (inside and/or outside the appliance).
Smart Meter	A smart meter is an advanced meter (usually an electrical meter) that records consumption in intervals and communicates that information via some communications network back to the utility for monitoring and billing purposes (telemetering). Smart meters enable two-way communication between the meter and the central system.
Smart Plug	Device provided with a HAN interface (e.g. ZigBee or powerline) that typically has a power meter able to calculate the power/Energy consumption of the connected load and provide a Relay that can be used to switch the load on and off.
SN-C	Sensor Network Center: this manages, together with the Home Gateway, the HAN devices and provides service oriented interfaces for the development of third-party applications.
TSO	Transmission System Operator. In the electrical power business, a transmission system operator (TSO) transmits electrical power from generation plants to regional or local electricity distribution operators (DSO).
WAN	Wide Area Network: this is a communication network that covers a large area (i.e. any network whose communications links cross metropolitan boundaries)

9 Annex B - Main sources for use cases

9.1 Energy@home Consortium

Energy@home is a collaborative project between Electrolux, Enel, Indesit and Telecom Italia. The aim of the project is to develop a communications infrastructure that enables provision of Value Added Services based upon information exchange related to energy usage, energy consumption and energy tariffs in the Home Area Network (HAN). The project envisions a protocol that will be used to build an integrated platform to allow cooperation between the main devices involved in residential energy management/consumption in particular:

- The Electronic Meter, responsible for providing certified metering data. The meter will be interfaced via a new device called Smart Info to enable communication with the telco infrastructure and the household appliances;
- Smart Appliances, which are able to cooperate in order to adjust power consumption by modifying their behaviour, while preserving the quality of service and user experience;
- Smart Plugs, which are able to collect metering data and to implement simple on/off control on non Smart Appliances;
- The Home Gateway, which can act as the central coordinator of the home. It allows data exchange between the devices operating in the Home Network, the Home Area Network, and the Internet;
- Customer Interfaces, i.e. the devices used by the customer to monitor and configure their energy consumption.

These are the main categories of device in the Home Domain, but a given device may implement functionality from more than one category. As an example, an advanced Smart Appliance, provided with a sophisticated user interface, could also implement advanced Customer Interface functionality.

Energy@home envisages a system that can provide users with information on their household consumption directly on a display on the appliance itself, on their smart phone, or on a computer. It is expected that through easy access to such consumption information and the availability of energy related applications, consumers will use their appliances in a “smarter” way thereby improving the energy efficiency of the whole house. For instance, Smart Appliances can start functioning at non-peak (and therefore less expensive) times of day and they can cooperate to avoid overloads by automatically balancing consumption.

The project is a step towards the development of the so-called "smart grid" that in the future, will allow continuous real-time two-way information exchange between utilities and appliances in the houses to enable each customer to manage their own energy consumption depending on available supply and price.

Energy@home aims to leverage existing standards, in particular ZigBee wireless technology, and the Smart Energy and Home Automation ZigBee Application Profiles. If needed, these profiles will be extended and customized in order to fulfil the requirements of the project. The resulting protocol will be open to any stakeholder who will be free to define their own services and supporting business models, while being confident that the common communication platform will ensure interoperability between different vendors’ equipment. Although the definition of services and business models is explicitly outside the scope of the project, partners have decided to perform a first assessment of the different categories of services that should be supported by the communication platform in order to ensure full support of a wide range of energy applications.

The first deliverable of the project is the “Energy@home Use Cases” document, where the system architecture is presented together with reference application scenarios. In this document, different types of services are defined, taking into account incremental levels of interoperability in order to provide clients with different levels of service, starting from simple awareness, up to a fully integrated Energy Management system. The first release of the Use Cases took into account the experience of the partners involved in the project and defined the initial set of functionalities that will be addressed by Energy@home.

Further versions of the document are envisaged where partners can identify supplementary categories of services taking into account their initial experience.

The final phase of this project includes a pilot market trial which will involve selected customers throughout Italy.

Telecom Italia, HGI member since its foundation, represents the telco world in the consortium. Other partners are:

- Enel: Italy's largest power company, and Europe's second listed utility by installed capacity. It is an integrated player that produces, distributes and sells electricity and gas. Further to the acquisition of the Spanish utility Endesa, Enel has now a presence in 23 countries with over 95,000 MW of net installed capacity and sells power and gas to around 61 million customers. Enel was the first utility in the world to replace its 32 million customers' traditional electromechanical meters with modern electronic devices that make it possible to take meter readings in real time and manage contractual relationships remotely. This innovation has enabled Enel to implement time of use electricity charges, which offer customer savings for evening and weekend electricity use, an initiative that has attracted interest from many utilities around the world, especially in Spain where Enel's subsidiary Endesa is about to install 13 million electronic meters.
- Electrolux is a global leader in household appliances and appliances for professional use, selling more than 40 million products to customers in more than 150 markets every year. With a culture of passion for innovation, customer obsession and drive for results, the company uses thoughtful design and extensive consumer insight to meet the real needs of consumers and professionals. Electrolux products include refrigerators, dishwashers, washing machines, vacuum cleaners and cookers sold under esteemed brands such as Electrolux, AEG-Electrolux, Eureka and Frigidaire.
- Indesit Company is one of the European leading manufacturers and distributors of major domestic appliances (washing machines, dryers, dishwashers, fridges, freezers, cookers, hoods, ovens and hobs). It is the undisputed leader in major markets such as Italy, the UK and Russia. Founded in 1975 and listed on the Milan stock exchange since 1987, the Group posted sales of €2.6 billion in 2009. Indesit Company has 16 production facilities (in Italy, Poland, the UK, Russia and Turkey) and 16,000 employees. The Group's main brands are Indesit, Hotpoint-Ariston and Scholtès.

9.2 BeyWatch project

Targeting environmental sustainability, energy efficiency and new power distribution/production business models, the BeyWatch project aims to design, develop and evaluate an innovative, energy-aware and user-centric solution, able to provide intelligent energy monitoring/control and power demand balancing at home/building and neighbourhood level. The system will interconnect legacy professional/consumer electronic devices with a new generation of energy-aware white-goods, where multilevel hierarchical metering, control, and scheduling will be applied based on users' personal preferences, power demand and network conditions. Moreover, via a Combined Photovoltaic/Solar system (CPS), the BeyWatch system will be able to produce both hot water and electricity, which will be either used within the home or fed to the electricity network, depending on the end-user preferences, tariffs etc. The proposed system will function in a two layer hierarchy:

- **Micro-management level**: based on the outdoor temperature, the power consumption demand, the power supply network conditions and the user's preferences, all the devices in the home will be set under local interactive monitoring and intelligent control, in order to achieve a better load management through peak suppression and delayed energy consumption. The BeyWatch key element will also be the CPS system, which will provide for active energy production (both thermal and electrical energy), especially during daytime.
- **Medium-management level**: the local control elements will be included in a hierarchical system that will cover larger geographic regions (e.g. building blocks or neighbourhoods) to provide statistical data and enable medium-level control and coordination of energy resources. The effect of energy and CO_2

savings at the home level can therefore be estimated in larger geographical regions, by considering the benefits over the whole energy value chain (production, transportation and distribution).

The BeyWatch solution combines the efforts of designers of home electrical devices with service providers and energy suppliers in a unique way in order to tackle five main objectives:

a) design ultra-low energy-consumption white-goods
b) implement methods, techniques and technologies to reduce the power consumption in smart/green homes/blocks/neighbourhoods by intelligent monitoring and control of electrical devices
c) generate hot water and electricity from Renewable Energy Sources at the building level, leading to further energy savings
d) elaborate business plans and Business Support System (BSS) applications that will help users and energy providers to sign win-win energy contracts
e) enhance user awareness, towards less energy consumption and CO_2 emissions over the whole energy value chain (production, transportation and distribution).

9.3 AIM project

The European Project AIM (A novel architecture for modelling, virtualising and managing the energy consumption of household appliances, http://www.ict-aim.eu/) did not contribute directly to this document, but various HGI members belonging to AIM introduced some of its concepts.

AIM's main objective has been to foster a harmonised technology for profiling and managing the energy consumption of appliances at home. AIM introduced energy monitoring and management mechanisms in the home network, and provided a proper service creation environment to serve virtualisation of energy consumption, to offer users a number of standalone and operator services.

AIM defined an architecture based on 3 main components/functions:

1. the AIM gateway serving as the access to home appliance, includes device discovery and management, local home automation interfaces like Zigbee and PLC, exposes an API under the form of web-services for device control & monitoring (called MtM API). The AIM gateway would connect to the HG via Ethernet;
2. a Device Virtualisation Engine offering the energy efficiency logic, for the purposes of the project, this is run on a separate device supplying the intelligence, that is similar to the energy gateway function defined in HGI and could potentially be hosted in the HGI gateway;
3. a service platform in the network for business logic.

Three different setups of network connections between AIM Gateway and Utility Provider were identified:

1. Full telco integration: Connection between telco operator and utility: all data for the AIM Gateway is transferred via the telco provider. Telco operator processes information.
2. Telco distributor/proxy: Connection between telco operator and utility: all data for the AIM Gateway is transferred via the telco provider. Telco operator acts as a distributor/proxy for the data transferred to the Device Virtualisation Engine. This was selected in AIM.
3. Direct communication: Connection between Device Virtualisation Engine and utility and telco operator and utility. Utility and Device Virtualisation Engine communicate informations directly

The AIM project introduced the Energy Management Device to bridge the gap between existing "no-smart" appliances and future smart appliances. This could be considered by HGI.

The project also defined a profile (low cost, green, or comfort) for appliances. Optimization of consumption is managed according to this profile.

10 References

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