Ecodesign Preparatory study on Smart Appliances

Discussion note on Interoperability and Standardisation

In preparation of the Stakeholder meeting of 10 March 2015

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CHAPTER 1 SCOPE OF THE STUDY

1.1. INTRODUCTION

We have prepared this discussion note as part of the Ecodesign preparatory study on Smart Appliances carried out for the European Commission – DG Energy.

The note focuses on the interoperability and standardisation needs, which are essential topics for the market up-take of smart appliances, and which will be one of main topics at the first stakeholder meeting.

The study was launched in September 2014 and is scheduled to be finalised end of September 2016. The preparatory study is the first step in the Ecodesign/Energy Labelling process. It is foreseen to have three stakeholder meetings in the course of the study. Once the study has come to an end, the regulatory process will startoff on the basis of the findings of the Ecodesign Consultation Forum.

More information on the study can be found on www.eco-smartappliances.eu, where it is possible to register as stakeholder and receive notifications by e-mail regarding website updates, meetings and availability of documents for download.

1.2. OBJECTIVES

The objective of the ecodesign preparatory study is to analyse the technical, economic, market and societal aspects with a view to a broad introduction of smart appliances and to develop adequate policy approaches. The study should respect the MEErP methodology, where it is relevant and possible in relation to the type of appliances and technologies in scope of this study.

1.3. SCOPE

The scope of the study is smart appliances and, for some aspects, smart meters. As a starting point, the study will consider the range of communication-enabled appliances but will for many aspects focus on demand response ("DR") enabled appliances. Features that support energy efficient user behaviour will also be given special attention. Finally, features that do not have a direct relation with demand response and energy efficiency (e.g. safety) will be taken into account as far as consumer acceptability, market shares and energy consumption of these additional functionalities is concerned. The analysis will primarily target at appliances for the residential/commercial sector.

Only products within the scope of the Ecodesign and Energy Labelling Framework Directives (2009/25/EC and 2010/30/EU) are in the scope of the smart appliance study, because these directives form the legal background for the study and policy measures to be implemented after the study. E.g. means of transport for persons or goods including electric vehicles are not in scope of the ecodesign framework directive and consquently not in scope of the present study.

1.4. SMART GRID AND SMART APPLIANCES

The overall idea of a smart grid with smart appliances is to achieve a better balancing of energy supply and energy demand while accommodating more renewable energy and reducing peak load power generation. Flexibility of the energy demand is obtained through smart appliances for which the energy consumption load patterns can be shifted with acceptable user impact. Benefits for the energy system should be awarded both to the demand and the generation side.

The load shifting can take place when needed – typically at power peaks and times with renewable energy power surplus – and in accordance with the agreements with the consumers. It may be infrequent activations, as part of emergency reserves, e.g. manual frequency restoration reserve, or as part of continuous control, while participating in intra-day imbalance markets.

Shifting of the energy consumption load patterns take typically place through:

- control signals from the power system as direct appliance control (start, stop, modulate load etc.) after an agreement with the consumer.
- price signals that the appliance can react on according to consumer settings.
- appliances with internal voltage and/or frequency measurement and control, where the appliances switch on/off or modulate the consumption in function of those measurements and according to consumer settings.

In any case, consumer agreement and/or consumer enabling of the shifting functionality is needed for the appliances to be regulated by the power supply system and to achieve this, some sort of incentives – typically financial through tariffs or a capacity payment – should be offered to the consumers.

1.5. USE CASES

We present in the following a few examples of use cases serving the purpose of an overall understanding of the scope and of the functionalities that appliances may support and to illustrate the connection between the supply side system and the demand side i.e. the appliances.

The use cases are intented to be representative rather than exhaustive. Variations of the examples given may emerge, both regarding variety and complexity of control objectives, as regarding variety or number of appliances. However the aim is to illustrate the typical modes of operation from the point of view of the smart appliance.

In these examples, the focal point is demand response control of individual appliances.

1.5.1. USE CASE EXAMPLE 1: LOAD SHIFTING OF HEAT PUMP SUPPLIED HOUSES

The use case is based on the assumption that an agreement exists between the consumer and an aggregator or similar intermediate organisation.

Suppose that a peak load is foreseen the next day at 18h, which would have required starting up power generating units at higher costs and/or higher environmental impacts. Instead, the BRP sends a signal to the aggregator requesting a reduction of 50 MW during 1 hour from 18h onwards. The aggregator sends signals to the heat pumps and/or the Home Energy Gateways in 50,000 houses requesting these are not switched on during the mentioned period, resulting in an average 1 kW load per house reduced.

The local heat pump or Home Energy Gateway secures that there is sufficient heat stored in the building components and the warm water tank to limit the impact on the user. The heat pump owner may be remunerated for his/her flexibility, e.g. by means of a yearly capacity fee.

1.5.2. Use Case Example 2: variable pricing support by a washing machine

In this use case, the user has an electricity contract based on variable prices, e.g., prices based on the day ahead energy market,
Those prices are directly downloaded to the washing machine, which has a communication interface that supports the used pricing scheme and which is equipped with dynamic pricing scheduling logic.

When the user configures the machine, he/she sets a deadline when the laundry should be finished the latest, and the washing machine then automatically starts the washing program such, that the total energy price for the program is cheapest, while the laundry is still finished in time. The washing machine may also give indications via its user interface to the user on when the cheapest and/or highest prices occur, such that the user can take this into account during configuration.

1.5.3. Use Case example 3: Appliance-based System Frequency Control (AbSFC) of freezers

Suppose that an emergency situation occurs in the power system, resulting in a reduction in voltage and frequency at the consumers' level in a local area. Suppose that 1,000 households with AbSFC freezers switch off, resulting in a total load reduction of 100 kW, sufficient to stabilize the grid.

The freezers dispose of built-in control, securing a maximum of half a degree raise of temperature during maximum 1 hour. The household owners could be remunerated for the flexibility.
This type of DR is based on internal measurements and control: The appliance is equipped with power measurements (e.g., frequency and voltage) and it switches or modulates its electricity consumption in function of those measurements. This type of control requires no communication to or from the appliance.

1.5.4. Use Case example 4: User information feedback system

A third use case example regards user information functionality, aimed at reducing energy consumption at the end-user level. This is supplementary to demand responsefunctionalities.

Suppose a family has a 10 year old fridge and often forgets to close the fridge door and to defrost the fridge. The family subscribes to an energy consumption surveillance service at a service provided, thereby accepting a transfer of privacy data. Based on the energy consumption pattern combined with basic household information and technical data, the service indicates that the fridge's energy consumption is 50 % above average. Adapted behaviour (e.g. closing the door)would save 10 % energy and switching to the most energy efficient fridges on the market would save 60 %.

1.6. APPLIANCES

Based on the study scope we have analysed the following categories of appliance types:

- Household appliances:
    - Periodical appliances: Dishwashers, washing machines, tumble dryers and washer dryers
    - Permanent appliances: Refrigerators, freezers and water heaters
    - Behavioural appliances: Electrical hobs, ovens, hoods and vacuum cleaners
- Heating, ventilation and air conditioning (HVAC):
    - Electric heating: Electric radiators, electric boilers, electric and hybrid heat pumps and boiler circulators
    - Ventilation: Local and central extraction fans and local and central heat recovery ventilation units and central extractors and air handling units
    - Air conditioning: Residential and non-residential air conditioners
- Chargers (low power): Multimedia devices, power tools etc.
- Battery storage systems: Backup systems like UPS and battery energy storage systems
- Lighting systems: Lighting in residential and commercial indoor areas and street lighting.

The analyses include the shifting or capacity modulating possibility - the nature of it, shifting or reducing from which periods to which (working days, weekends, seasons etc.). Furthermore, we are estimating the shifting or capacity modulating potential in GW and in GWh.

We are also analysing the comfort and user impact and gaps and pre-conditions for the realising the potential (technical maturity, redesign needed, availability, other). Finally, we are looking at functionalities that support energy efficiency of the equipment and the use.

For the preliminary conclusions we have divided the appliances into 3 categories of potentials:

- High flexibility potential with few comfort impacts: Dishwashers, washing machines, washer dryers, water heaters, radiators, boilers, heat pumps, circulators, residential and non-residential air conditioners and battery storage systems

- Smaller flexibility potential and/or larger comfort/health impacts: Tumble dryers, refrigerators, freezers, extraction fans, heat recovery ventilation and air handlings units and chargers (low power)

- Only emergency flexiblity potential: Electrical hobs, ovens, hoods, vacuum cleaners and lighting

Further product development including the products' control system may move more products to the high flexibility potential category. E.g. refrigerators and freezers may have more cooling capacity built in and may store more cool before the planned shifting period in order that the temperature variation would be minor.

CHAPTER 2 STANDARDIZATION ACTIVITIES AT EU LEVEL

The scope of standardization in the field of smart appliances is strongly related to information exchange for demand response and for connecting demand-side consumer equipment and/or systems into the smart grid.

We describe in the following a selection of the current most relevant architecture activities, focusing on activities at EU level.

2.1. CEN-CENELEC-ETSI: SMART GRID COORDINATION GROUP (SG-CG)

On 1 March 2011 the European Commission issued Mandate 490 - Standardization Mandate[1] to European Standardisation Organisations (ESOs) to support European Smart Grid deployment. To accomplish this task, CEN-CENELEC-ETSI established the Smart Grid Coordination Group (SG-CG), now succeeded by the Smart Energy Grid Coordination Group (SEG-CG) to coordinate standardization activities in Smart Energy (e.g. electricity, heat, gas) Grid(s). SEG-CG includes interactions between energy systems and interaction with end-users.

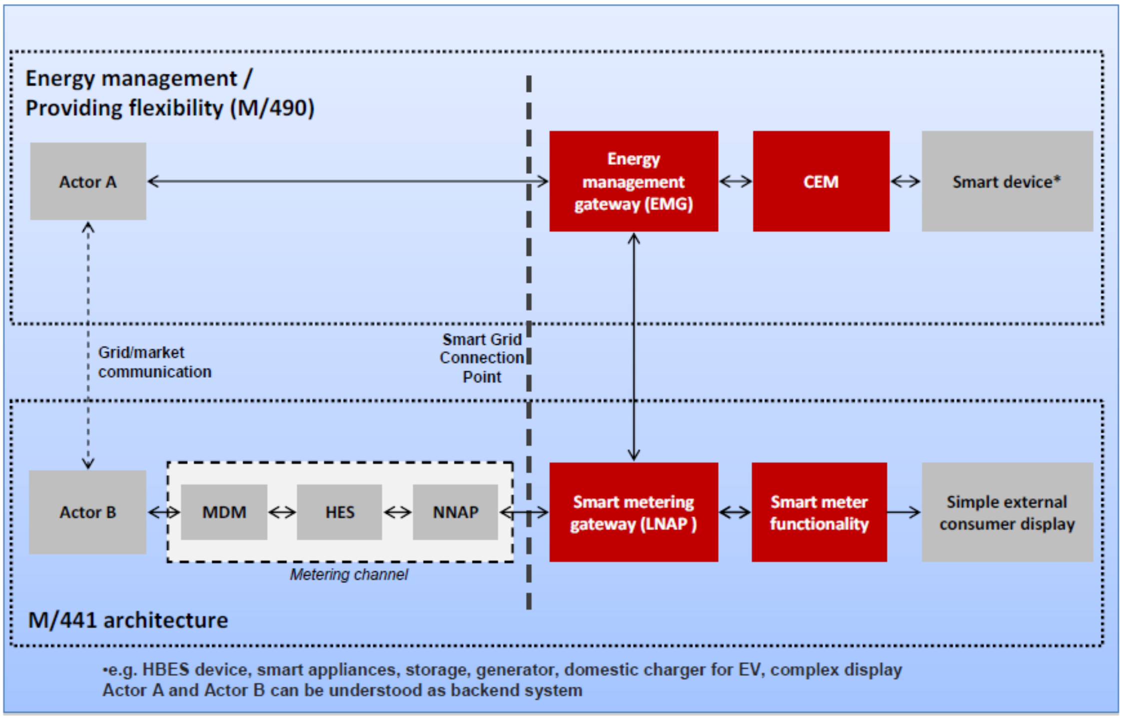


Figure 1: Flexibility functional architecture[2]

[1] http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2011_03_01_mandate_m490_en.pdf

[2] ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Methodology_FlexibilityManagement.pdf

The flexibility functional architecture model in the above Figure has been developed by the SG-CG. In this architecture the Customer Energy Manager (CEM) provides the flexibility of connected smart devices, through the energy management gateway, while the smart meter and the simple external consumer display provide a number of functionalities that are described more detailed in work of the Smart Meters Coordination Group (SM-CG). The energy management gateway communicates with the metering channel and the smart metering through the Smart Metering Gateway. The gateways in this architecture split different networks (Wide Area Network, Neighborhood Area Network and Local Area Network) and may be integrated with other functional entities. The actors in this architecture are functional / logical entities, which means that some of them may be part of the same physical device.

Note that the communication path between the smart metering gateway and energy management gateway is optional (as are all communication pathways in this architecture). In the aforementioned case, the information exchange between the metering channel and energy management channel will take place between Actor A and Actor B. The external actors A and B, identified in this functional architecture represent (a bundle of) roles that communicate through the Smart Grid Connection Point. Examples of these roles are a meter data collector, meter operator, aggregator/flexibility operator, supplier etc.

2.2. STATUS OF STANDARDISATION

2.2.1. SMART METER INTERFACE

The following Figure gives an overview of the standardisation activities related to the smart meter interface, mapped onto the flexibility functional architecture.

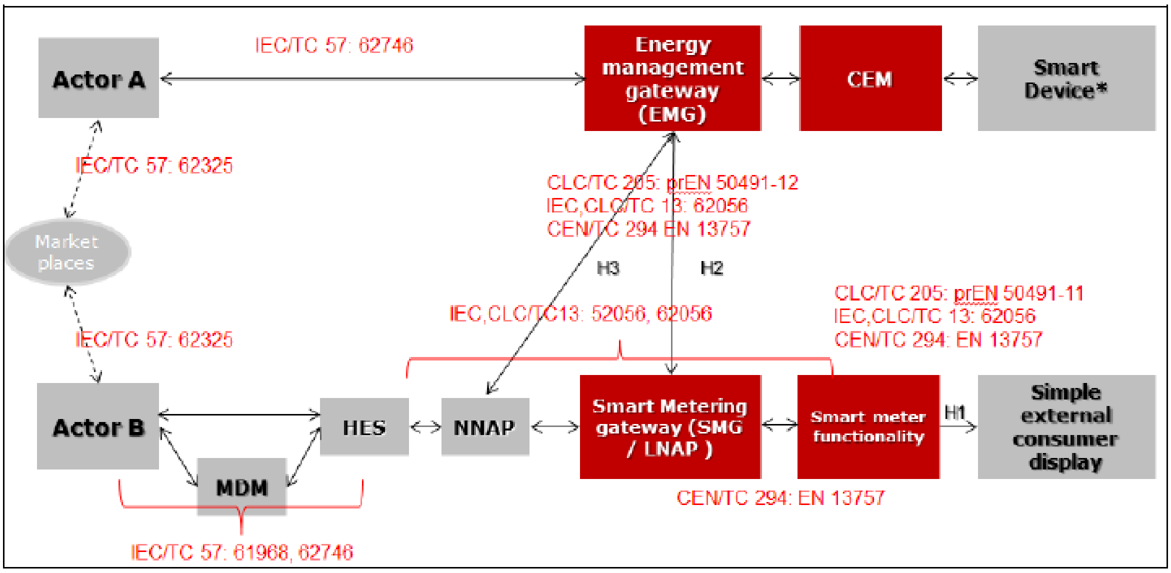


Figure 2: Standardisation activities mapped onto flexibility functional architecture[3]

[3] ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/Reference_Architecture_final.pdf

Within the SG-CG, a dedicated Task Force looked at the ‘possible need for further standardisation work order to include in the AMI an open interface to provide energy management services beyond the utilities, focusing on consumers’ needs’. In this context, the Task Force performed a technical analysis which focused on the following aspects:

- interfaces 'H2' and 'H3' and the blocks 'EMG', 'CEM', 'LNAP', and 'Smart meter functionality'
- consider functionalities (a) and (b) of the Recommendation 2012/148/EU, and investigate how these are involved in the flexibility architecture.

These aspects are currently covered by the activities of IEC/TC 13 ‘Equipment for electrical energy measurement and load control’, CEN/TC294 ‘Communication systems for meters and remote reading of meters’, CLC/TC 205 ‘Home and Building Electronic Systems (HBES)’ and IEC/TC 57 ‘Power systems management and associated information exchange’.
According to the Task Force, there is no need for additional standardization initiatives (e.g. further standardization mandate) in order to include in the AMI an open interface to provide energy management services beyond the utilities, focusing on consumers' needs (further development is happening in the work of IEC/TC 57 WG 21).

a. IEC/CLC/TC 13 “Electrical energy measurement and control” WG14 (Electricity Metering data exchange)
Working Group 14 of IEC/TC 13 has developed the standards for the exchange of information through the AMI from the Head End System (HES) to the meter: IEC 62056 series. In the first place, these standards are able to transfer consumption information that is registered in the electricity meter. Additional information related to DR that can be transferred concerns for example tariff information, power limitation, connect/disconnect and prepayment settings. Standards developed by IEC/TC 13 are voted in parallel at European level (CLC/TC 13). Working Group 14 has recently developed a new international standard for the (uni-directional) provision of metering data from a meter to an external device, such as an In Home Display: IEC 62056-7-5. This relates to the H1 interface. The status of this standard is currently CD (Committee Draft), which implies it should normally be available in 2015.

b. CEN/TC 294 “Communication systems for meters and remote reading of meters”
The work performed in this TC is similar to the work in IEC/CLC/TC 13, but is focussed on the exchange of information to non-electricity (Gas/Water/Heat and beyond) meters and other supporting equipment: EN 13757 series. Standards related to consumption and DR related information transfer are available or under finalization.

c. CLC/TC 205 Home and Building Electronic Systems WG 18 (Smart Grids) and WG 16 (Display)
CLC/TC 205 current work is centred on two aspects for home & building electronic systems: firstly home displays and the H1 interface in the smart meter reference architecture (prEN 50491-11) and secondly the interface and framework for customers (prEN 50491-12), which concerns the H2/H3 interface. The work of TC 205 envisages the need for sufficiently frequent information updates for the customer (every 15 minutes). It also anticipates advanced tariff structures, time-of-use registers and remote tariff control, with automatic transfer of information about advanced tariff options to final customers via the interfaces H2/H3. The standards developed by TC205 concerns the definition of data models that can be used on top of the communication profiles identified e.g. by IEC/TC 13 and CEN/TC 294. IEC TC13 requested that the data models proposed by CLC/TC 205 are linked to the existing data models of the IEC 62056 series.

The status of the work is as follows:

- prEN 50491-11 is the responsibility of TC 205 WG16. This work item is expected to be completed by the end of 2014 and expected to be available in 2015.
- prEN 50491-12 is the responsibility of TC 205 WG 18. It is focused on data modelling and is expected to be available mid-2015, beginning of 2016.

2.2.2. SMART GRID – SMART APPLIANCE INTERFACE

The following Figure provides a situational overview of some relevant standardization documents related to Smart Appliances and Smart Home interoperability[4]:

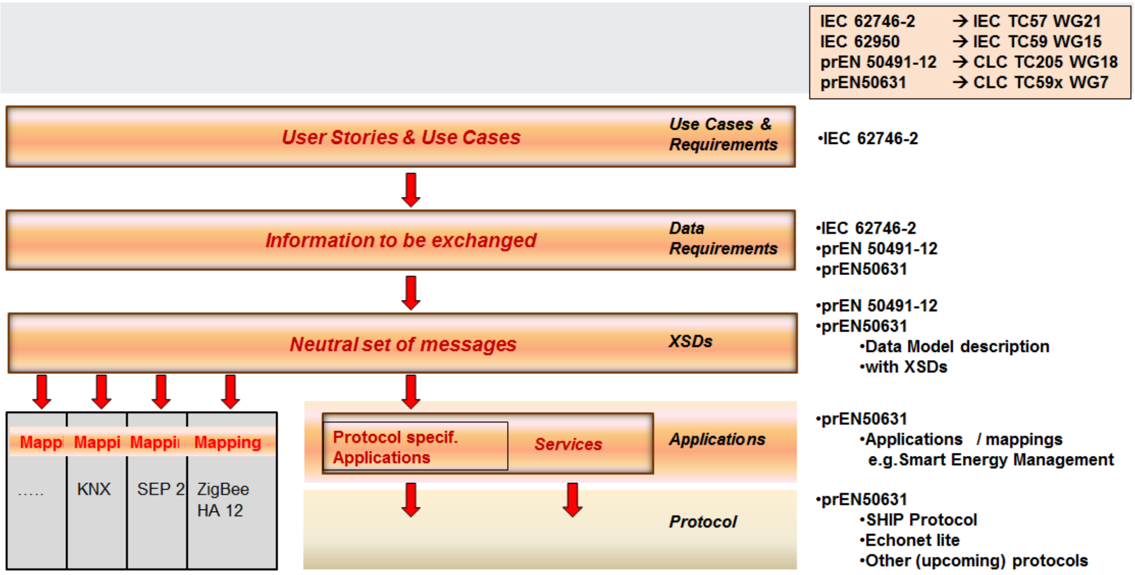


Figure 3: Excerpt of relevant documents related to Smart Appliances & Smart Home interoperability

a. IEC/TC 57 WG21 "Interfaces and protocol profiles relevant to systems connected to the electrical grid"

IEC/TC 57 addresses the market aspect as well as the grid operation. WG21 of IEC/TC 57 is focusing on the functionalities (Use Cases) and data definitions for DR in its Technical Report IEC TR 62746. These functionalities and data definitions are used by CLC/TC 205 to have a reference for the data and transactions to be supported.

A joint working group of IEC/TC 57 WG21, CLC/TC 205 and CLC/TC 59X has been collecting Use Cases and requirements for Smart Grid/Smart Home. The Use Cases cover for example: providing energy consumption information, controlling smart appliances, EV charging, power limitation, consumer offering flexibility, manage DER, battery management, etc. These Use Cases and requirements are listed in IEC TR 62746-2. The architecture document IEC 62746-3 is currently distributed as Committee Draft to the national committees.

In order to solve the interoperability issue, TC 57 and PC 118 'smart grid user interface' have agreed to continue the development of IEC 62746 towards a CIM-compatible DR standard, by first defining an openADR <-> CIM adaptor, followed by a purely CIM-based version of OpenADR. WG21 is

[4] Communication from Josef Baumeister, IEC & CLC Smart Home Standardization

managing the connections with WG16 (energy market information exchange), WG 15 (Cyber Security) and WG17 (DER) of IEC/TC 57. In parallel with the work on functionalities, new work will commence to consider the technologies that should be supported to transfer the data.

b. IEC/TC59 "Performance of household and similar electrical appliances" WG15 "Connection of household appliances to smart grids and appliances interaction"

IEC/TC 59 WG15 is establishing a set of common terms, concepts and criteria, to assist the TC 59 and its Subcommittees in addressing the technical aspects of interaction between household appliances and the smart grid.

IEC/TS 62950 'Household and similar electrical appliances - Specifying and testing smart capabilities of smart appliances - General aspects' (work version) is intended to develop the common architecture which applies widely to different use cases and appliance types, and the principles of measuring smart performance within the context of the common architecture. The use cases considered initially (see previous paragraph) are based on the energy/electricity aspects pf performance, but future revision of this Technical Specification may not be limited to these aspects.

c. CLC/TC59x "Performance of household and similar electrical appliances" WG7 "Smart household appliances"

CLC/TC59x WG7 performs standardization work to enable domestic appliances to improve functionality through the use of network communication. Examples of network communication include smart grid, smart home and home network. The working group is working on prEN 50631 "Home network and smart grid connectivity ", a first readable draft version is expected soon.

2.2.3. ETSI M2M

The European Telecommunications Standards Institute (ETSI) has created a dedicated Technical Committee with the mission to develop standards for "Machine to Machine" Communications, ETSI M2M[5]. The group will provide an end-to-end view of Machine to Machine standardization. Besides standards at the architecture level, ETSI also works on test specifications to demonstrate end-to-end interoperability.

In ETSI, smart appliances standards are being handled by the **SmartM2M technical committee** and by the **oneM2M** partnership project. In 2013, much of the work of ETSI's M2M committee, including the development of the core M2M specifications, was transferred to the new oneM2M Partnership Project. The committee's new focus is now services and applications, especially aspects of the Internet-of-Things and smart cities, and it has adopted a new name, the Smart Machine-to-Machine Communications Technical Committee (TC SmartM2M), to reflect this new work. TC SmartM2M will also support relevant European policy and regulatory requirements, and handle the conversion of oneM2M specifications into European Standards.

In 2013 collaboration was initiated with the EC specifically related to the interface between service and application layers. ETSI began work on smart appliances – products such as white goods, heating, ventilation and air conditioning (HVAC) systems, storage systems and micro renewables, which are able to communicate with facility management systems, energy management systems, so-called 'Energy Boxes' and other systems using a common language and semantic. In November 2013, TC SmartM2M began to plan its activities for 2014 to support the creation of a standard for smart appliance communication. The plan was expected to include a common data model (see also next chapter on the common ontology for M2M) and identification of a communication architecture and

[5] http://www.etsi.org/technologies-clusters/technologies/m2m

the related protocols. A clear roadmap and milestones were introduced by TC SmartM2M and the first ETSI specifications are planned to be published during 2015.

CHAPTER 3 INTEROPERABILITY

3.1. Scope of interoperability

For the purpose of this report interoperability is understood as the link between the individual appliance and the supply side (Balancing Responsible Party, aggregator, energy efficiency service provider etc.), making it possible to achieve a better balancing of energy generation and energy consumption within the grid.

In the context of the smart home and smart appliances cross-platform, interoperability is an essential requirement to guarantee flexibility and security of possible investment for the customer. An end-customer, who is faced with the choice in case of a smart home set-up, is initially motivated by its intended application goals, such as increasing the living comfort or the saving of energy. When comparing the available technical solutions, the extensibility of the system, the compatibility with other systems (of different manufactures and brands), the long-term availability of spare parts and operation security are important criteria, which influence this decision. In addition, it will be in the interest of the consumers that the operation of the system is manageable even without expert knowledge, ideally in the sense of a "plug and play"-solution, and this via an intuitively usable, integrated user interface. These system objectives require that the subsystems involved are syntactically and semantically interoperable, so the data is correctly exchanged, information and commands understood and correctly interpreted. The interchangeability of the subsystems requires the use of a technology neutral and standardized language, which is implemented through the relevant communication protocols.

In this chapter we assess the interoperability issues and gaps while in the next chapter we consider ways of reducing the gaps. We focus on the first link, i.e. from - and inside - the appliance itself to the first component of the DR control infrastructure.

The basic principle behind the connection of the demand side with the supply side is that the appliances on the demand side can communicate with the supply side; can send communication signals on the state, power consumption etc. and can react on needs on the supply side regarding decrease or increase of power loads. E.g. an aggregator should be able to send stop signals and delayed start signals to 100,000 heat pumps in a given Member State. The heat pumps may be connected to the system in different ways and may communicate via different protocols, but the signal should be understandable for all heat pumps. This requires interoperability between all links in the chain connecting appliances and the power system.

The below figure 1 illustrates the communication between the power system (here the BRP) and the appliance. The power system sends control signals to and recieves data from the appliance in a common language i.e. with data about identification of the specific appliance, what it should do, the state it is in, etc.

The signals are transferred over the internet and to the home and the appliances, which can be either through a Home Energy Gateway (HEG) or directly in connection with the appliances. Encoding modules translate the information content from the BRP to specific protocol dependant signals (e.g. 3G/4G, HEG and Wi-Fi).

From the HEG, protocol specific signals will be distributed in the home (e.g. Bluetooth, Wi-Fi, Ethernet and ZigBee). The signals are understood by the appliance, which reacts on the signal.

The appliance electricity consumption is measured for each quarter of an hour of the day and the data is transferred to the electricity retailer. The consumer pays for the electricity used with the relevant time-of-usetariff or a flat rate. Consumer flexibility remuneration can happen through the tariff or a capacity and/or activation fee.

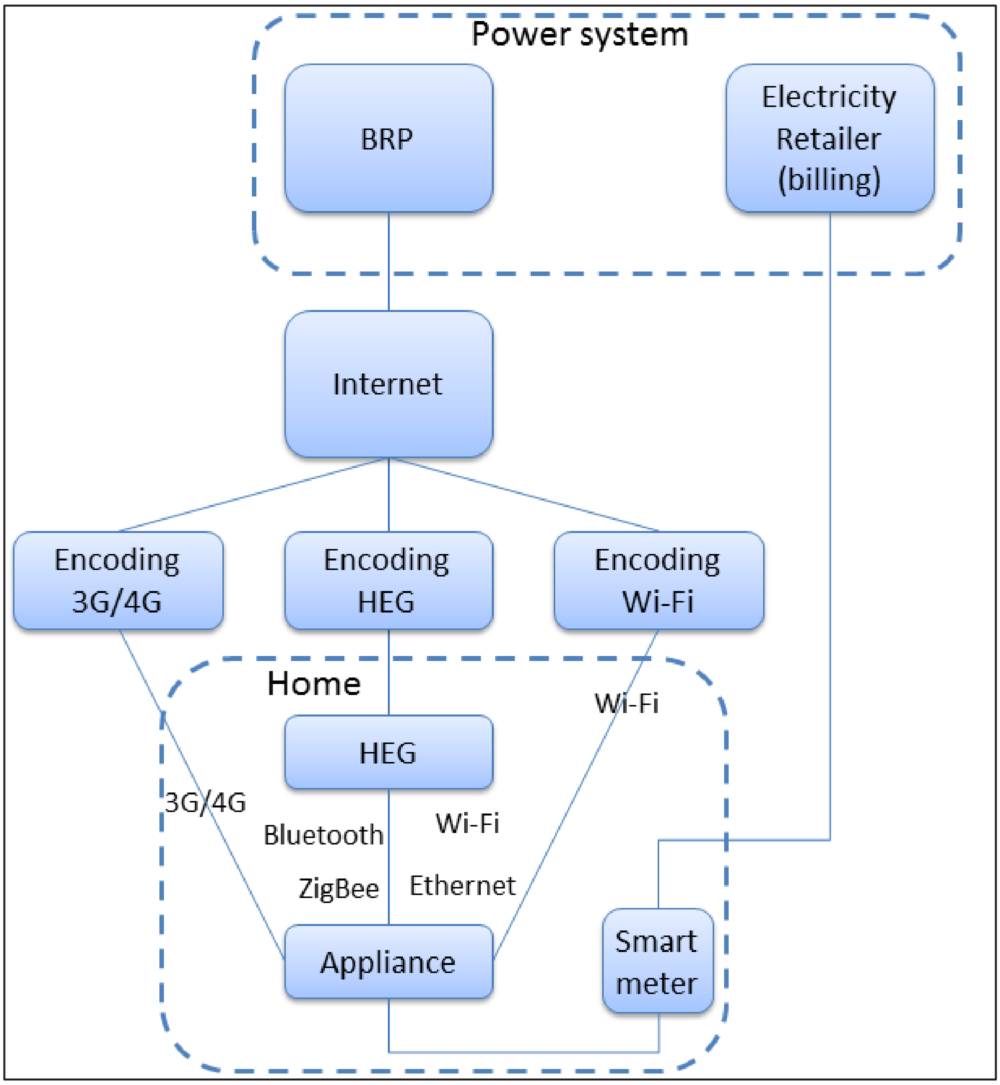


Figure 4: Principle of communication transfers between supply and demand side

Figure 2 details the communication transfers. The 2 upper parts of the illustration show the 2 basic models, the Home Energy Gateway model and the Cloud model, respectively. The bottom part of the illustration explains the 3 layers.

The information layer contains the same information content from the aggregator to the appliance. The communication layer contains the specific protocols transmitting the information. Each protocol has its own encoding (also called mapping) of the information content. The component layer contains the hardware component varying for each part of the communication system.

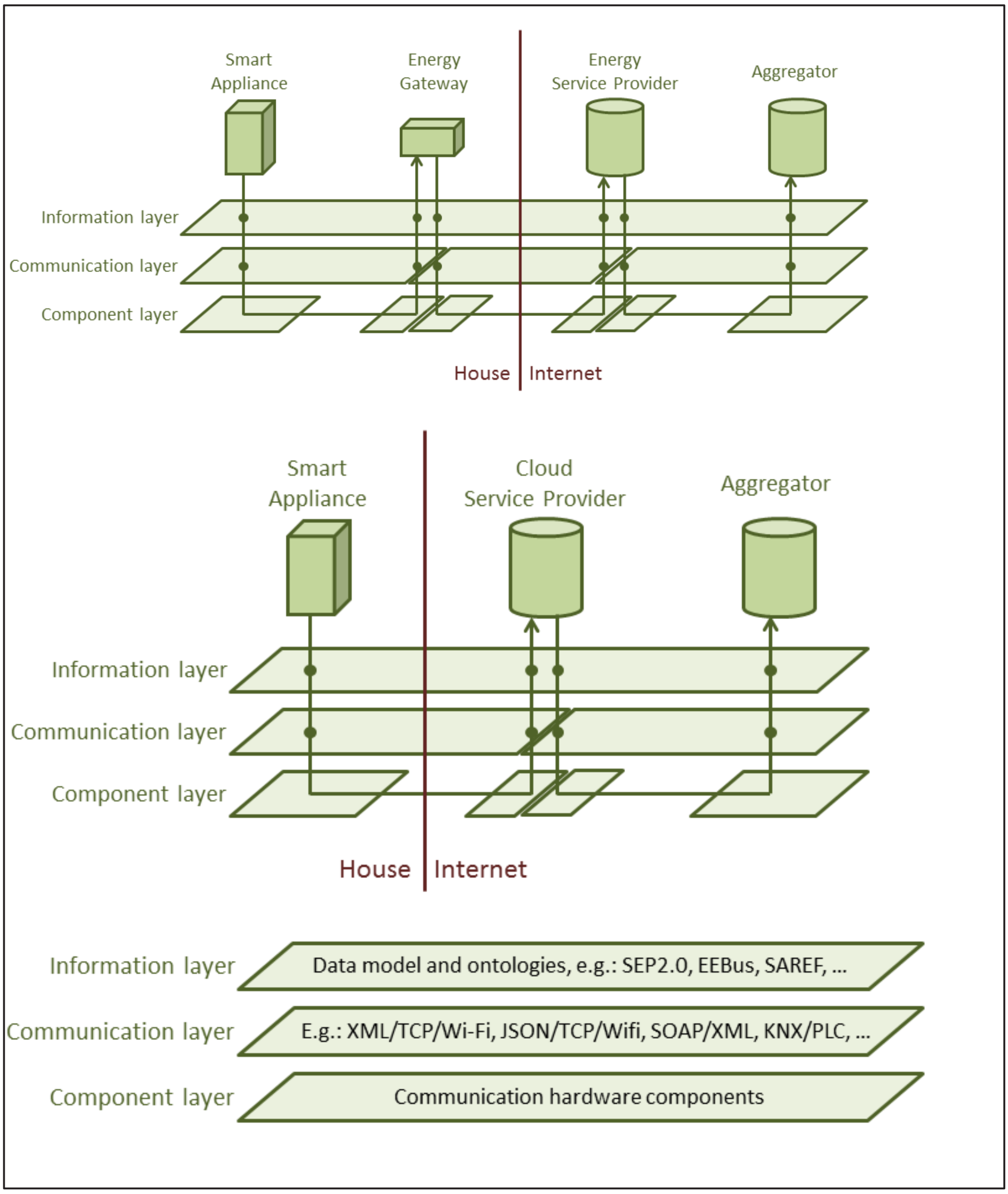


Figure 5: Details of communication transfers, with BRP split up in service provider and aggregator

Examples of information content include:

- Unique identification of the appliance, which again is related to the consumer
- Control signals from the grid to the appliance: e.g. stop now, stop within xx [time period], do not start, reduce load to xx percent, stop if [condition], use own storage etc.
- Information signals from the grid to the appliance: price information
- Control/status related signals from the appliance to the grid: consumption information, state of the product, time to finish a cycle etc.
- Information signals from the appliance to the grid: data related to information required to reduce energy consumption or increase appliance energy efficiency, and intended to other purpose, e.g. safety / comfort / maintenance functionalities.

3.2. INTEROPERABILITY GAPS

3.2.1. COMMUNICATION ARCHITECTURES

For the purpose of the study, an architecture is defined as the control and communication connection from the DR and communication enabled appliance to a hub in the smart grid such as a central building management system, Home Energy Gateway, an aggregator or BRP / DSO / TSO. The communication submitted could be price signals that the appliances react on and control signals for direct control of the appliances.

In this section we are not assessing the appliance-based system frequency control because it is based on internal measurements and control and does not need have a more extended communication architcture.

There are a large number of initiatives investigating smart grid architectures. Most of the architecture activities have a broader scope than the scope for this study being the DR and communication enabling. From the point of view of the appliance, there are two ways for appliances to interfere with the energy system:

- The central energy manager model: The application communicates locally to a central energy manager (the Home Energy Gateway, or Building Control Unit). In this case, the interoperability gap is situated at the level of the communication interface between appliance and central energy manager. Note that the smart meter could also take up this role, provided it supports sufficiently timely and reliable backend communications, which today is often not yet the case.

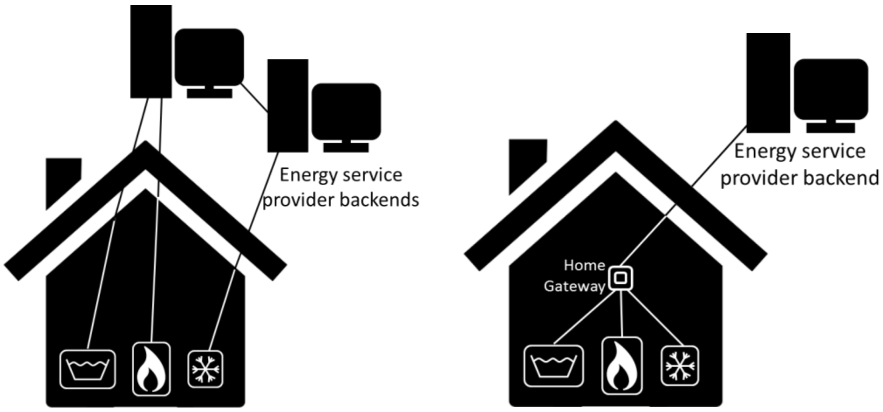
- The cloud model: The appliance connects directly to an appliance manager in the cloud, often through the internet via a wireless modem or similar. This appliance manager then communicates in turn with the energy service provider. If the appliance manager is the manufacturer, then the interoperability problem is located on the level of the interface made available at the manufacturer's backend to allow the energy service provider to control the appliance.

Both models each have their advantages and disadvantages. The gateway model requires the installation of extra hardware. However, the cloud model requires that each smart appliance (and measurement component) guarantees all onboard functionality to establish a stable and secure extra-house communication link (authentification, encryption, handling dynamic IP addresses, handling firewalls, etc.). The gateway model implies interoperable interfaces on the devices, whereas the cloud model shifts this interoperability problem up to the level of the communication between the servers.

An important reason why the cloud model emerged, is that appliance manufacturers are no longer dependent on a gateway provider to integrate their device and that it allows them to provide device specific functionality. However they should connect further to the aggregator for the DR functionalities.

In both cases, an in-home communication link must be established, which is discussed more in detail further.

The below figure illustrates the two types of interfaces.



We describe in the following a selection of the most relevant architecture activities.

→ **Common ontology for M2M**

As described in the previous chapter on standardization, the European Commission/DG Connect is collaborating with ETSI (European Telecommunications Standards Institute) on developing an ETSI M2M (Machine to Machine) architecture. DG Connect has launched a study carried out by TNO (the Netherlands) "Available semantics assets for the interoperability of smart appliances. Mapping into a common ontology as a M2M application layer semantics".

The study aims to provide the material needed to define the semantic tools and unified data models for specific devices to be used in the ETSI M2M architecture. The tools and data models can subsequently be applied by the industry to produce ETSI M2M compliant devices, or interoperability boxes to make existing, non-ETSI-M2M devices interwork with an ETSI M2M system. The tasks consist of taking stock of existing semantic assets and use case assets, performing a translation exercise of each model or use case to a common ontology language (called SAREF, Smart Appliances REFerence) and subsequently a mapping between these models and finally to propose a common ontology and document it into ETSI SmartM2M/oneM2M architecture.

The architecture defines various classes being e.g. building objects (door, window), devices (door switch, energy meter, sensor etc.), function (level control function, start stop function etc.), time (day of week) etc.

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The ontology specifies recurring core concepts in the smart appliances domain as given by the assets, the main relationships between these concepts, and axioms to constrain the usage of these concepts and relationships. SAREF is based on the fundamental principles of reuse and alignment of concepts and relationships that are defined in existing assets, modularity to allow separation and recombination of different parts of the ontology depending on specific needs, extensibility to allow further growth of the ontology, and maintainability to facilitate the process of identifying and correcting defects, accommodate new requirements, and cope with changes in (parts of) the SAREF ontology. The projected has found that there is a good correlation between the ETSI M2M Architecture and SAREF's function-related device categories.

This ontology work is broader than the scope of this study being appliances comprised by the ecodesign and energy labeling regulation, while the ontology also includes sensors, actuators etc.

The work is still in progress and is planned to be completed with a draft report in April 2015.

A draft version of Smart Appliances Reference ontology can be accessed here: http://ontology.tno.nl/saref/.

→ Common language for smart home

AGORA, Energy@Home and EEBus has recently agreed (published November 2014) to establish a common language for the European Smart Home. The organisations have developed a list of key functionalities based on agreed use-case scenarios serving as a common base. They have agreed in the context of cooperation to provide extensible functionality in order to adapt the system to future technical developments. These key functions were initially focused on energy management, and to add more specific functionalities of smart homes.

According to the initiatives interoperability will be ensured through an open and standard communication protocol that is technology neutral.

Their goal is to reach a simple plug and play solution, which enables consumers across Europe to connect their devices.

→ Communication architecture gaps

A main interoperability gap is lack of one data model and communication architecture standard applicable in all Member States for the appliances in scope of this study. The standards should be able to work on top of the various possible hardware carriers, and should carry commonly defined status and command data, such that all possible use cases are supported, e.g. variable tarrifs, balancing reserves, grid support, etc.

There are a large number of architecture initiatives aiming at achieving one data model and communication architecture standard. However, there is a risk that there are parallel activities taking place in some areas and lack of activities in other areas.

3.2.2. Control Architectures

From the point of view of the smart appliance, 3 approaches exist to establish control of the smart appliances in function of the demand response objective. Note that a smart appliance may be equipped with the functionality to be interoperable to multiple of these approaches.

→ **External control and external objectives**

The smart appliance is connected to an external control system via a generic flexibility interface. This interface allows the control system to read the flexibility status of the appliance, and allows the control system to switch or modulate the electricity consumption or production of the smart appliance. Comfort protection based settings by the smart appliance of those control signals may be possible. Use case 1 (load shifting of heat pump supplied houses) illustrates this scheme.

In this case, the information layer data model (see Figure 2) contains flexibility status information and control actions. It must be extended when smart appliances offer new types of flexible behaviour. This implies updates of the control systems, but not of the installed smart appliances. Different or new uses of flexibility in the energy markets require no data model updates nor smart appliances firmware updates.

As the smart appliance's interface is flexibility based, and not DR control objective based, the appliance can be used for any current or future DR scheme, provided the timing requirements of the control objective can be met by the DR communication and control infrastructure.

The control system can be either a home controller, or a cloud based systems.

→ **Internal control and external objectives**

The smart appliance is connected to an external control system via a DR objective based interface, e.g., a variable energy price interface. The DR objectives are sent to the smart appliance, and the smart appliance independently adapts its energy profile in function of the sent objectives and the user's configurations and settings. Optionally, the smart appliance may report it's actions back to the originator of the control objectives. Use case 2 (variable pricing support by a washing machine) illustrates this scheme.

In this case, the information layer data model contains DR control objective specific data. This implies that the smart appliance must support DR control objective specific functionality and that each smart appliance must support the control objectives it is potentially used for (variable pricing, frequency restoration reserves, emergency reserves, grid congestion reserves, …). New uses of flexibility in the energy markets require data model updates and firmware updates of all smart appliances that participate to this new scheme. These updates include the required optimization and control logic. When smart appliances offer new types of flexible behaviour, then only those appliances are impacted, but not the data model.

Control objectives can be sent to the smart appliances both via the home energy gateway model or via the cloud model.

As the control decisions reside with the smart appliances, this architecture is mainly suited for open loop control DR, such as dynamic pricing. If the DR response scheme requires closed loop control, e.g., if an exact increase or decrease of the consumption is required, for instance, for intraday BRP portfolio management purposes, then this can only be achieved by iterative control algorithms (if the smart appliances report their actions), or by statistically modelling the response of the smart appliances.

→ **Internal control and internal objectives**

The smart appliance requires no communication links, but rather optimizes it's energy consumption profile based on locally measured parameters only. Use case 3 (appliance-based system frequency control (ABSFC) of freezers) illustrates this scheme.

The number of DR control objectives that can be realized using this scheme is limited, as there must be a correlation with, typically, the voltage and/or frequency as measured by the smart appliance.

New or future control objectives require firmware updates of the smart appliance, and possibly a hardware update, should the supported measurements not suffice.

As the control loop includes no external communications, very fast response is possible. Only open loop control is possible.

→ **Control architecture gaps**

Both the appliances and the data model must accommodate for the control architecture(s) selected, as each model requires different logic in the appliances and different data communicated. Furthermore, if the control is internalized, as for two of the models, then the use of the flexibility may be limited. Most standardisation efforts today partly support a mixture of the three models. E.g., SEP2 supports both variable prices sent to directly to the smart appliances and direct control.

If the external control and external objectives model is to be supported, additional work is required to define broadly applicable generic flexibility interfaces for the smart appliances.

If the internal control and external objectives model is to be supported, additional work is required to define what control a smart appliance should at least support and how the objectives for each control case are formatted.

If the internal control and internal objectives model is to be supported, additional work is required to define what control a smart appliance should at least support.

3.2.3. APPLIANCES

There are very few appliances with built-in smartness and it is necessary to redesign the appliances in minor or larger degree, depending on the level of smartness to build in and the type of appliances.

The redesigns should include:

- A communication module to communicate with the system, using wireless, wired and/or power line communication (PLC) technology (see Communication carriers). This module should have always on live connection.. Development of a universal appliance communication chip, which can handle the DR communication for all types of appliances could bring down the costs substantially.
- A control module for switching on, off, load modulation etc. of the relevant components of the appliance.
- Components separating the ones applicable for the load shifting from the ones not applicable. E.g. in the case of a fridge, the light should be always on when the door is open, even though the compressor has received a pause signal.

- Adjustment of the internal control unit, because in most cases it is not sufficient to completely switch off the appliance but rather only parts of the appliance and additionally the internal regulating of the appliance need to be adjusted. E.g. in the case of a fridge, a pause signal should be proceeded by an additional cooling signal (within some limits) and the ligth should always be on when the door is opened.
- Additional logic to safeguard the comfort should be added.

The redesigns will have a different nature depending on the type of appliance. For some appliances a redesign of the compete design platform is needed, while other appliances only need smaller redesigns.

The main interoperability gap is that the demand response functionality of the similar appliances of different manufacturers should provide the same functionality, or a subset of a commonly agreed upon set of functionalities, such that the demand control system do not need to differentiate between appliances of different brands. This also maximizes the guarantee for the end-consumer's that the available demand response systems support the appliance of choice.

→ **Appliance gaps**

There is a need for development for the individual manufacturers, however common architecture standards for the information and the communication layer, the gaps should be minor.

3.2.4. COMMUNICATION CARRIERS

The communication carriers from the end-user (home, office etc.) and office is mainly the internet. The connection can be through broadband (ADSL, VDSL, DOCSIS etc.), GSM, UMTS, LTE etc.

The level of internet access in households in EU 28 in 2014 is in average 81 %[6]. The range is from 57 % (Bulgaria) to 96 % (Luxembourg and the Netherlands). There are thus Member States where lack of internet access might be a barrier towards full use of the DR enabled appliances.

Within the end-users' premises, the communication carriers are more diversified. The communication between smart appliance and Energy or Internet gateway (in the case of the cloud model), include wired Ethernet, WiFi, Bluetooth, RF, Zigbee, Z-Wave etc. Which carrier is reliable or not depends on the layout of the home, the building style and the location of the smart appliances and energy/internet gateway. The main interoperability gap is that the user (or installer) should be able to use the most/a reliable carrier, based on the criteria mentioned before. Moreover, the communication carriers should support the communication signals transferred.

→ **Communication carrier gaps**

Lack of internet access should not be a main gap and further development to support the communication signals should neither be a gap once the common communication architectures have been developed.

[6] "Level of internet access – households" Eurostat.

3.2.5. SMART METERS

Smart meters are being rolled out in many EU Member States, however, in different speeds and with different functionalities.

The smart meters are assumed to continue to be important for the main metering and payment of the energy delivered, however, not for the transmission of the communication signals between the demand and the supply side.

→ **Smart meter gaps**

The smart meter roll-out is ongoing in most EU Member States, however, not always with the full set of necessary functionalities in place.

CHAPTER 4 OPTIONS TO REDUCE THE INTEROPERABILITY GAPS

4.1.1. INTRODUCTION

We present in the following discussion topics in relation to options to reduce the interoperability gaps.

4.1.2. DISCUSSION OF THE OPTIONS

→ Do you perceive missing interoperability as a problem for your specific area/product/system? Where do you locate the gap in interoperability? Would you be in favour of interoperable and open standard solutions?

→ What could be the basis for interoperability? This could be in the form of a common data model, and if so, is it possible and feasible to achieve such a common data model? What are further steps needed to achieve the common data model?

→ Which steps are needed for implementing the data model for the communication layer protocols and how broadly should the communication layer protocols be covered? E.g. which steps are further needed for the implementation at the communication layer (Bluetooth, ZigBee, Wi-Fi etc.)? Should all existing and future protocols be covered and how would it be possible?What would be the next steps to progress towards standardization? A large number of standardization initiatives exist. The standards should be able to work on top of the various possible hardware carriers, and carry commonly defined status and command data, such that all possible use cases are supported, e.g., variable tarrifs, balancing reserves, grid support, etc. Therefore, wouldn't it be preferable to limit the number of agreed upon communications standards?

→ What kind of support for interoperability is needed? E.g. incentivation, framework, policy measures, energy labeling, voluntary agreements, product information, packaging information etc.