European Smart Grids Task Force
Expert Group 1 – Standards and Interoperability

Interoperability of interfaces for the large scale roll out of smart metering systems in EU Member States

August 2016

Interoperability of the H1/H2 interfaces of the Flexible Demand Architecture applied in the large scale roll out of smart metering systems in EU Member States

Smart Grids Task Force

Expert Group 1 – Standards and Interoperability

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This report has been prepared by the Expert Group 1 (EG1, 'Standards and Interoperability for Smart Grids Deployment') of the European Smart Grids Task Force and is a product of intensive work and discussions during 2016 amongst EG1 stakeholders and program managers of the roll-out of smart metering in Members States. Special thanks are due to all the experts (see Annex A), who contributed in the course of this work and especially to the Editorial Team.

Contents

1. Introduction

The Steering Committee of the Smart Grids Task Force decided in December 2014 to survey and assess the current and planned roll-out of smart metering systems in seventeen Member States (MS) with reference to their degree of interoperability with other components/operations of the energy system. An ad-hoc Expert Group (EG1) was set up in January 2015 to perform this work. Appendix A of this report shows the EG1 membership.

The detailed results from a survey questionnaire to MS were covered in the EG1 final report published at the end of 2015 [see Ref 1 at the end of this document]. The EG1 report gave a snapshot of current developments and useful information to those that are still at the planning stage.

In order to further assist MS and other stakeholders involved within a MS, the EG1 was requested by the Steering Committee of the Smart Grids Task Force at the end of 2015 to provide additional guidance on interoperability required for the provision of energy services and Demand Side Flexibility (DSF) and to provide regulatory recommendations. This report is the response to this request and includes a description of the interoperability process and of the inputs required.

2. Scope of this report

The purpose of the report is to set out more precisely the process by which MS may ensure interoperability required for the provision of energy services to consumers (including but not limited to functionalities a, b, & f in the common minimum functionalities recommended by the European Commission) and to enable DSF. Functionalities a, b, & f can be found in 2012/148/EU: Commission Recommendation on preparations for the roll out of smart metering systems [Ref 2].

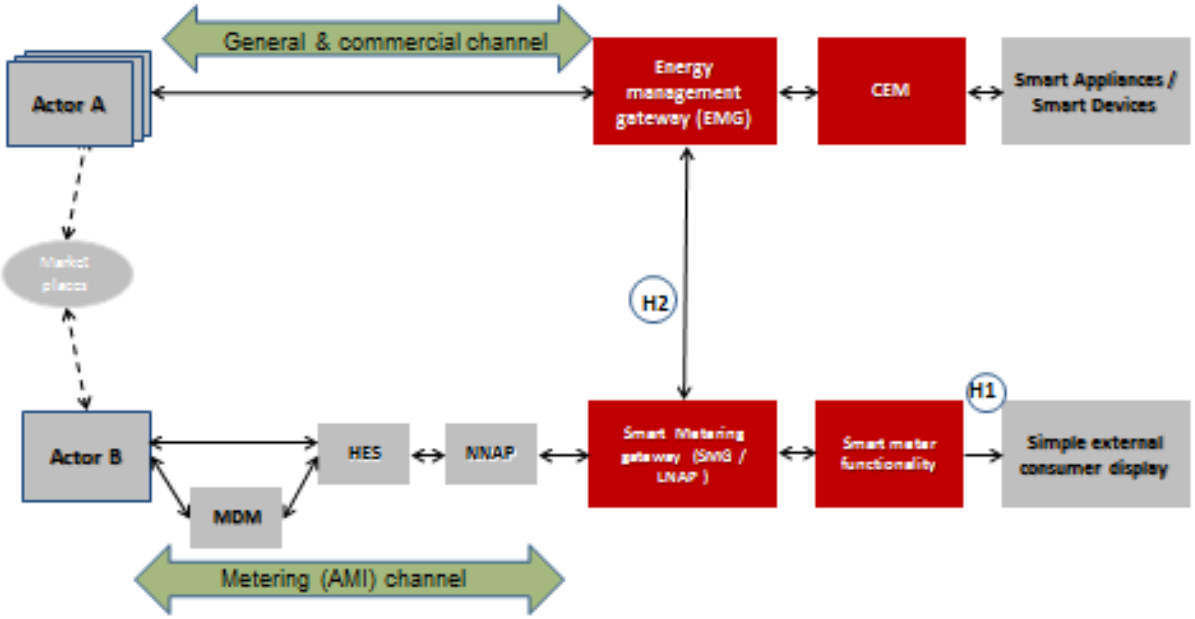
An overview of the process to ensure interoperability is given in section 3 below, with detailed information included in Appendix B – E. Section 4 includes regulatory recommendations in this area.

This report focuses on the interfaces in and with the metering infrastructure from the Head End System to the Smart Meter and on the provision of profiles for the following interfaces:

- H1 is the interface between the smart meter and a simple external display device (where applicable) via one-way communication.
- H2 is the interface used for smart grid communications (including Demand Side Flexibility) exchanging information between the advanced metering infrastructure (AMI) and DSF applications. H2 connects the smart metering gateway (LNAP) and the energy management gateway. H2 enables two-way communication for home automation end devices (which may include advanced consumer displays).
  Note: H3 refers to a similar link between the NNAP and the energy management gateway. The MS survey carried out by EG1 in 2015 [Ref 1] established that the H3 interface was not planned to be used.

The H1 and H2 interfaces are depicted in Figure 1 below.

Figure 1: Standardisation of the Demand Side Flexibility communications architecture (M/441 and M/490)



Key:

This diagram is a functional representation of the DSF communications architecture. In physical deployments, functions and interfaces can be combined.

The General & Commercial channel (the horizontal line at the top of this diagram) will be mainly used for consumer-focused energy services and operations (including demand response), typically via the internet. Regulated smart grid communications/operations typically use the Metering channel, shown in the lower half of the diagram. In most MS the metering channel is operated by the Distribution System Operator.

Actor A can be any party (suppliers, aggregators and other energy services companies) using the General & commercial channel to access the Energy Management gateway. Actor B is the DSO in MS where the AMI is operated by the Distribution System Operator.

MDM = Meter Data Management system that manages the configuration of the meters and stores the collected data of the connected meters.

HES = Head End System that collects meter data end sends information to the connected meters

LNAP = Local Network Access Point that connects to in-home meters and smart devices (mostly referred to as "Smart Meter gateway")

NNAP = Neighborhood Network Access Point that connects to multiple houses and aggregates data (mostly referred to as "Data Concentrator")

CEM = Consumer Energy Management System that manages local demand and generation

3. Process for reaching full interoperability

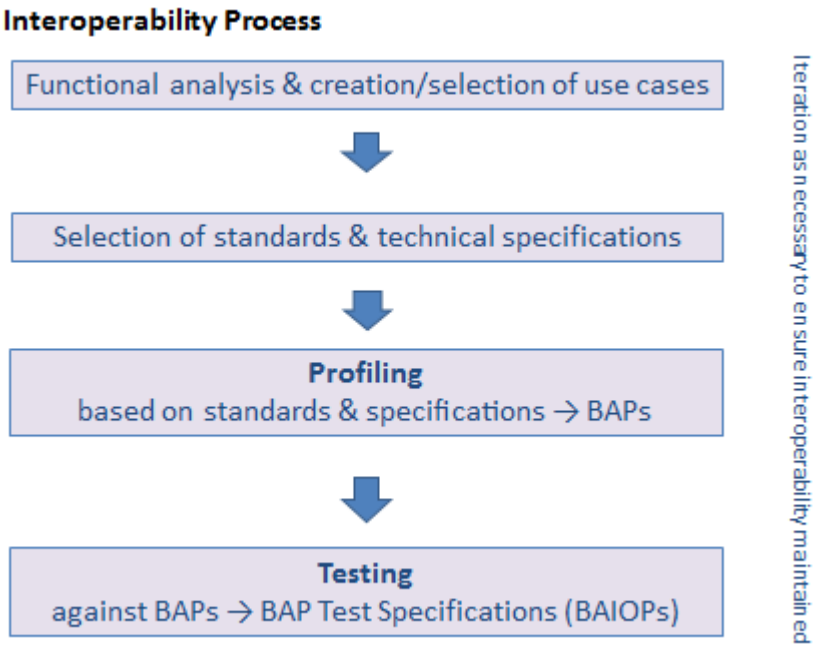
At the end of 2014, the WG Interoperability (WGI) of the Smart Grid Co-ordination Group published their final report on methodologies and definitions to facilitate smart grid interoperability, as a deliverable under M/490 [Ref 3]. Their final report recognised that simply selecting communication standards is not sufficient to guarantee interoperability. The study performed by EG1 in 2015 showed that various MS had not taken the extra measures needed to reach full interoperability and revealed several potential areas of risk from the viewpoint of interoperability, in particular:

- Some current smart meter/smart grid standards were not available when a deployment was planned
- In their responses, MS did not always provide specific information about standards or technical specifications to be used
- Additional specifications (use cases, data definitions, companion standards) are not defined in the majority of MS.

The report therefore encouraged the use of additional or companion specifications, here referred to as Basic Application Profiles (BAPs). A BAP is a document that describes how standards or technical specifications are applied to support the requirements of a particular (national) infrastructure. In addition the report considers Basic Application Interoperability test Profiles (BAIOPs), which are used to check that the individual technical requirements of the selected profile are met. BAIOPs can be also be referred to as BAP Test Specifications.

The following flow-chart depicts the main steps in the process how to reach full interoperability.

Figure 2:



The process starts with identifying the functions of information transfer, analysing what data will be exchanged and how. These functions can be captured in standard use cases (see also Appendix D and the use cases defined by the SM-CG [Ref 4]).

Based on the functions and architecture designed, standards and technical specifications can then be selected from the overviews provided by the SEG-CG and SM-CG [Ref 5 and 6].

Profiling in this report fixes the way standards/specifications are used: it determines the part of the standard used and how options are used in order to achieve interoperability between products of several manufacturers in the most economical way.

The key elements of a BAP are:

- An introduction incl. purpose of the BAP
- Scope
- Terms, definitions & abbreviations
- Referenced documents, e.g. to other companion documents
- System architecture
- Use case definitions for different interoperability layers, starting with the functional layer, including standards and implementation details i.e.
    - functional layer incl.
        - use cases to be covered, which should be described in such detail that the test cases can be derived from it.
        - a list of standards used to support the use cases
    - information layer
    - communication layer
    - component layer
- Security

Appendix B of this report gives further detail on each of the stages noted in Figure 2. It should be recognised that use cases, devices and standards will evolve over time, and that a maintenance process for companion documents should be put in place to ensure the required levels of interoperability are maintained.

Appendix C & Appendix D describe in greater detail the content of a BAP, with Appendix D giving detailed consideration of interoperability layers.

Interoperability testing is an important aspect. It confirms that implementations are compliant with the standards/specifications (conformance testing) and exchange information according to the predefined use cases (interoperability testing) and has the goal of ensuring interoperability with other infrastructure components. Testing processes therefore have to be specified to enable a check that the individual technical requirements of the selected profile are met.

A typical BAP Test Specification (BAIOP) may comprise:

- An introduction incl. purpose of the BAIOP
- Scope
- Terms, definitions & abbreviations
- Referenced documents e.g. to the related BAP and any other companion documents
- Description of the test procedure and test architecture (incl. requirements for conformance testing)
- List of test cases
    - for Test case N
        - identify section in BAP which is tested
        - specify purpose of the test
        - specify pre-conditions for the test
        - describe the test
        - specify expected results and requirements for passing the test
- Security
- Documentation of testing

Appendix E considers interoperability testing in greater detail.

4. Conclusions and regulatory recommendations

Conclusions

The focus of this report by Smart Grids Task Force Expert Group 1 in June 2016 is interoperability across interfaces 'H1' and 'H2' in the large scale roll out of smart metering systems.

Companion documents - referred to in this report as Basic Application Profiles (BAPs) and BAP Test Specifications (BAIOPs) describe how standards or technical specifications are deployed and how compliance with the BAP is to be assessed.

In addition to identifying the standards/specification to be used, the BAP will show how these are utilised in combination, defining the data to be exchanged and the functionality of this exchange through use cases. The BAP Test Specification describes the process of testing conformity to the BAP and interoperability within the smart metering system.

BAPs and Test Specifications are essential to ensuring and maintaining interoperability

The descriptions of BAPs and BAP Test Specifications in this report are presented as templates to assist Member States and other stakeholders involved in the development of such companion documents, and in particular the provision of Demand Side Flexibility and the interoperability of the interfaces involved. To this end, templates are included in the Appendices based on a number of existing Member State examples.

Regulatory recommendations

It is recommended that smart meter/smart grid planning by Member States and other stakeholders within a MS include the development of companion documents, dealing with the interfaces in and with the metering infrastructure from the Head End System to the Smart Meter and in particular the profiles for the interfaces H1 and H2.

These documents should sufficiently describe the data exchange over the H1/H2 interfaces used in the provision of information to consumers or parties designated by consumers. They should describe the data to be exchanged, the functionality of such exchange (e.g. by use cases), the standards (including data formats) to be used and the way these standards are used.

A recommended description of the process for reaching and maintaining interoperability and the content of the necessary companion documentation (namely Basic Application Profiles and BAP Test Specifications) is provided in this document.

Appendix A – Expert Group 1 – Interoperability Group

List of participants

Name	Organisation
Manuel Sánchez (EG1 chair)	European Commission- DG ENER
Constantina Filiou	
Kai Tullius	
Henrik Dam	
Ulrike Nuscheler	
Patricia Arsene	European Commission – DG CNECT
Daniel Hanekuyk	European Commission DG GROW
Neil Avery John Ketchell (alternate)	ANEC
Peter Hermans	Stedin for CEDEC
Dirk Costrop	Eandis for EDSO
Manuel Jesus de Tellechea	ENDESA for Eurelectric
Willem Strabbing (ET)	ESMIG
Enrique García	Iberdrola for EUTC
Jos Dehaeseleer	ORES for MARCOGAZ
Aitor Amezua	Ormazabal for T&D Europe
Antonio Tortolero	Schneider Electric for Orgalime
Marylin Arndt	Orange for ETSI
Joerg Seiffert (ET)	E.ON/CENELEC
David Johnson (ET)	CEN
Thomas Willson	ECOS
Peter Claes	VP of IFIEC Europe

(ET): Editorial Team

Appendix B - Process for reaching full interoperability

The following describes the process steps noted in the flowchart in Figure 2 towards the creation of smart metering system interoperability profiles, which can be categorised generically as

- the Basic Application Profile (BAP) and
- the BAP Test Specification, also known as a Basic Application Interoperability Profile (BAIOP)

a) Functional analysis and use case creation

Interoperability starts with defining the functionality of information exchange - in other words: what data will be exchanged and how. Use cases describe the information exchange in terms of the interactions between actors and components of the metering system.

The interfaces between different components in the smart metering infrastructure can therefore be identified and the layer(s) on which interoperability is required (functional, information, communication, component). The Smart Grid Co-ordination Group has defined example use cases for DSF and the Smart Meters Co-ordination Group (SM-CG) has defined example use cases for the metering part (see Ref 4).

To support the definition of use cases in a standardised way, the methodology according to IEC 62559-2 can be used.

b) Selection of standards and technical specifications

Once the relevant use cases are defined, appropriate (open) standards and technical specifications can be selected.

The selection of appropriate standards for any layers and individual interfaces (including for H1 and H2) can be supported by the SM-CG overview of standards as described in TR 50572 [Ref 5], the Smart Grid Set of Standards report [Ref 6] and the "IOP Tool" of the SG-CG [Ref 7].

The M/441 reference architecture has been refined within SG-CG by the development of a DSF architecture, showing the interfaces between the components of the smart grid system (see Figure 1 above). This (functional) reference architecture will need to be adapted to reflect the specifics and physics of particular deployments.

c) Profiling

A profile describes how standards or specifications are deployed to support the requirements of a particular application or function. This means that on top of the selection (in step b) of a communication standard such as EN 62056, an additional specification has to be developed which describes the way a standard will be used, and fixes the options. These additional definitions are called BAPs (Basic Application Profiles). BAPs are identifications of relevant parts of the applicable standards and specifications and are intended to be used as building blocks for interoperable specifications, e.g. by specifying the requirements according to the different layers described in step a)

- Identifying the relevant standards and by considering all options allowed by the standard

- Identifying the way the standards will be used: definition data to be exchanged and of use cases for this data exchange

BAPs should be created under consideration of the following general rules:

- Only existing standards shall be referenced
- A BAP should not contain any conflict to the referenced standards (i.e. a device passing the BAP testing shall also pass the conformance test of the referenced standard)
- A BAP should only contain statements which are testable at the accessible interfaces
- Specifications should be precise enough that its implementation can be tested with a unique verdict: “passed” or “not passed”
- Options should be avoided (the options chosen in theses sections must be identified and specified in detail, but the standard should not be modified). All selected criteria are mandatory to achieve interoperability
- Where available, formal language should be used for the specifications
- The sections of the standard used have to be identified - no new options should be introduced into the standard.

d) Testing

In order to prove interoperability a BAP has to be extended to describe a testing process. Testing is one of the most important phases in reaching interoperability. A BAP Test Specification or BAIOP (Basic Application Interoperability Profile) specifies the detailed setup to test the individual technical requirements of a BAP.

Although many types of tests exist, the two main types of testing to demonstrate interoperability are conformance testing and interoperability testing.

Conformance testing verifies the correct implementation of the standards and technical specifications: the system/component concerned is tested against a test tool or reference implementation of the standard. The test also verifies what part of the standard is implemented if it is not a full scope implementation. Conformance testing is a prerequisite for interoperability testing.

Interoperability testing is performed to verify that devices within a system are interoperable, i.e. they are able to exchange information according to the final defined functionalities (Use Cases). During interoperability testing, devices are tested in their final configuration together with other components of the total architecture known to be correct (according to BAIOP). This is necessary because it is possible for two devices that individually comply with a standard (resulting is a positive conformance test) to be still unable to interoperate, for example when devices have implemented different or conflicting options or cover a different part of the standard(s). The interoperability test is therefore based on the BAP that describes the way the standards are used.

BAP Test Specifications (BAIOPs) should be created under consideration of the following general rules:

- The verdict of the test must be “passed” or “failed” (i.e. not “passed but …”)
- The tests must be reproducible in time (the same device tested several times must result in the same verdict)

- It must be possible to perform the tests without the support of the manufacturer of the device under test
- for Conformance testing
    - the test cases should follow the applicable standards/specification (what is specified is tested; what is not specified is not tested)
    - the tests should be as far as possible automated with minimal human interference.
- for Interoperability testing:
    - the test cases should follow the use cases defined in the BAP
    - the tests should be as far as possible automated with minimal human interference
- the test cases should be described to such detail that a programmer can write a program performing these tests.

Remark:

A contact point has been established by the Smart Meters Coordination Group (SmartMetersSTD@cencenelec.eu) that can be used to raise issues or questions regarding the interoperability of smart metering systems.

Appendix C - Content of a Basic Application Profile (BAP) for the H1/H2 interfaces

Member States have considered a number of communication standards/profiles for use in the H1 and H2 interfaces. This report draws attention to the importance of deployments specifying how these are to be used in the context of demand response i.e. via a BAP. In order to illustrate the nature of a BAP and to identify the most common elements of a BAP for these interfaces, this report has considered four Member State examples of companion documents:

(1) P1 Companion Standard, Version 4.0 (2011-01-31) - Dutch Smart Meter Requirements
(2) French Linky PLC profile functional specifications, Version 1.0
(3) Smart Metering Implementation Programme; Great Britain Companion Specification (GBCS); Version 0.8.1 (2014-11-28)
(4) BSI TR-03109-1 „Anforderungen an die Interoperabilität der Kommunikationseinheit eines intelligenten Messsystems“ Version 1.0 (18.03.2013)

Based on this analysis, the following elements have been identified as comprising a typical BAP:

a) an introduction
b) scope
c) referenced documents
d) system architecture
e) terms, definitions & abbreviations
f) interoperability layers
- functional layer
- information layer
- communication layer
- component layer

g) security
- security
- user access
- device security

a) <u>Introduction</u>

The introduction to a BAP may include

- Addressees of the BAP
- General guidance for application of the BAP
- Overview and relevance of smart metering systems in a very general description
- Responsible editors of the BAP and contacts for comments and recommendations
- Structure of the BAP and further explanatory links to other related documents
- Versioning

b) Scope

A description of the scope of a BAP may include

- Application scope referring to specific communication technologies
- Specific interfaces which are covered
- Limitations or restrictions for application (e.g. what is already covered in other/related profiles)
- Description of what is out of scope (e.g. consumer devices)
- Specific description of separate chapters, annexes, tables and pictures

c) Referenced documents

Reference to other documents may include

- International and national standards and technical specifications (e.g. normative reference to EN and IEC)
- Further companion documents (e.g. related BAPs and BAIOPs)
- Explanation on versions, dated and undated references, e.g.:
    - For dated references, only the edition cited applies
    - For undated references, the latest edition of the referenced document (including any amendments) applies
- presentation as flat list or with mapping to layers

d) System architecture

A system architecture description may include

- Identification of the communication environment(s), for which the communication profile is specified
- Architecture model of the complete system
- Entities and interfaces of the smart metering system based on the European reference model with respect to H1 and H2 Interfaces (e.g. H1 communication interface built in the meter)
- Roles that interact with the metering infrastructure

e) Terms, definitions and abbreviations

This may include

- Specification of the terms, definitions and abbreviations that are used in the BAP
- Distinction of normative and informative requirements by definition of key words such as SHALL, MUST, SHOULD, MAY and NOT
- Procedures in case of differences between the definitions in the BAP glossary and those contained in referenced documents (e.g. in referred product or system standards)

f) Interoperability (IOP) layers

See Appendix D below

g) Security

System security

Related to smart metering system security, the following should be at least considered for specification in a BAP:

- Definition of applicable security functions, covering standard and legacy modes
- Certificate based authorization and connection
- Security provisions that are common across messages (e.g. cryptographic protections and signature of objects)
- Key/certificate management
- Security for remote party messages
- Encryption of attributes in remote party messages
- Securing all communication above transport layer with TLS and handshake between TLS and security modules
- Specific requirements for uni- and bi-directional communication
- Related to communication with (authorized) remote parties, a Common encryption and decryption approach

User Access

Related to the user access to the smart metering system, the following access requirements should be at least considered for specification in a BAP:

- Access requirements shall be based on use cases and role model of the system
- No readout of secret keys shall be possible
- Only access for specific purposes shall be granted
- Specific access scenarios for admins, service staff, end users, external market participants

Device Security

Related to smart metering device security, the following should be at least considered for specification in a BAP:

- Management (provision and update) of security credentials on devices in terms of the relevant commands, responses and alerts
- Pair-wise authorization of devices (covered by various use cases)
- Device log, backup and restoration

Appendix D - Interoperability (IOP) layers

IOP definitions should be available on all required technical layers, namely:

a) **Functional layer outlined by use cases**
b) **Information layer**
c) **Communication layer**
d) **Component layer**

This should include layer-specific reference to applicable standards and specifications and their implementation in order to support the specified use cases

a) <u>Functional Layer</u>

Use cases are an integral part of any BAP.

The SM-CG use cases report [Ref 4] and TR 50572 [Ref 5] contain a set of standardised use cases that have been identified to support the following functionalities considered under Mandate M/441.

- Remote reading of metrological registers and provision of these values to designated market organizations
- Two-way communication between the metering system and designated market organisation(s)
- Support advanced tariffing and payment systems
- Allow remote disablement and enablement of supply, and flow / power limitation
- Provide secure communication enabling the smart meter to export metrological data for display and potential analysis to the end consumer or a third party designated by the end consumer
- Provide information via web portal/gateway to an in-home/building display or auxiliary equipment

Another framework which may be useful for use cases are the 10 common minimum functionalities recommended by the European Commission [Ref 2].

Functionalities can be broken down to a lower level. Where appropriate use cases should be developed for:

- Meter reading (on demand, scheduled and for export)
- New meter identification
- Tamper and Fraud detection
- Diagnostics for electronic system components
- Remote configuration or parameters used by the meter/metering system
- Clock synchronization
- Software and firmware updates
- Manage contractual parameters
- Receive messages from designated market organization (e.g. on price changes)
- Multiple rate tariffs (incl. credit and prepayment)
- Remote connection/disconnection of meters
- Remote flow / power limitation

- Information on energy consumption or on gross electricity generated from micro-generation device(s)
- Interfacing with home communications systems / home area network

Tariffs

Related to advanced tariffing and payment systems, the following should be at least considered for specification in a BAP:

- Data structure covering different tariffs, e.g. depending on data volume (e.g. monthly
- transfer), time of use, grid load, consumption, event-driven, prepaid or credit
- Management (provision and update) of tariffs
- Parameters for processing and accounting of tariffs, e.g. measuring point ID, measurement period, accounting period, role who is allowed to access data, access rights, transfer data, period of validity, tariff clusters, load clusters, etc.

Demand side flexibility

To support DSF in smart metering systems, the following functionalities should be at least considered for specification in a BAP:

- Monitoring of current feed-in parameters of demand-site generation assets and provision of data to external authorized parties (e.g. with certificates and signatures)
- Control of interruptible consumers and producers by mapping of specific tariffs and control signals to prosumers with time stamps

Push / pull operation

Related to push and pull of data, the following should be at least considered and specified in a BAP:

- Consumer Information Push (CIP) using push operation, e.g. Client - Server structure for the optional CIP client, HDLC and IP based protocol stack
- Overview on the interconnection of the different interface classes contributing to the push operation
- Object and associated attribute values
- Frequency of push values

Supervision and Management

Related to supervision and management functions, the following requirements should be at least considered for specification in a BAP:

- The communication is managed considering the rules of the different communication specific layers
- Methodology how events and alerts are handled
- Types and construction of alerts
- Communication scenarios e.g. for
    - Management
    - Admin-services
    - Info report
    - Wake-up service

- Remote party access rights to attributes and methods
- Remote party usage rights linked to use cases

Processing of measurement values

Related to the processing of measurement values, the following requirements should be at least considered for specification in a BAP:

- Receiving of measurement values according to OBIS groups
- Processing of measurement values according to internal registers (tariffs, time stamps…) with mapping to specific end customers
- Processing and mapping of meter status information
- Configuration of profiles in XML format

Detailed provisions for each of the use cases shall be further outlined in the technical layers without options to ensure interoperability. Where appropriate, use cases could also be mapped to specific types of network, e.g.

- Local Metrological Network (LMN)
- Wide Area Network (WAN)
- Home Area Network (HAN)

Use cases could be also accompanied in BAPs by sequence diagrams.

b) Information Layer

Referring to the information layer, a BAP shall

- Describe the information that is being used and exchanged between functions
- Contain information objects and the underlying canonical data models
- Specify the application of standards that are used

Examples of standards that are specifically suited for the interface between the AMI and Home Automation are:

- IEC 62056-7-5 “Local data transmission profiles for Local Networks”
- CEN 13757 “Communication systems for meters & remote reading of meters”
- FprEN 16836 “Communication Systems For Meters - Wireless Mesh Networking For Meter Data Exchange (based on Zigbee)”
- EN 50090 “Home and Building Electronic Systems (HBES)”
- EN 50491-11 “General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) -- Part 11: Smart metering - Application specification - Home display”
- EN 50491-12 “General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 12: Smart grid - Application specification - Interface and framework for customer”

c) Communication Layer

Referring to the communication layer, a BAP shall

- Describe mechanisms and protocols for the interoperable exchange of information between functions
- Be supported by a communication protocol stack, covering the 7 ISO/OSI layers of communication functions
- Make a decision for the protocol stack which of the 7 ISO/OSI layers are applicable for the H1/H2 interface

Within the defined communication protocol stack, the following should be at least considered for the ISO/OSI physical layer:

- Type of modulation used (e.g. S-FSK, OFDM or BPSK)
- Further services implementation (e.g. alarm signal during pause, repeater call algorithm)
- Modulation/demodulation description, with communication frequencies and network speed
- Physical synchronisation with the 50 Hz electrical network frequency
- Signal and noise level measurement/ requirements
- Optical interface
- Transmission of frames with 50 Hz signal
- Repetition of signals
- LPWAN technologies (Low power Wide Area Network)

Within the defined communication protocol stack, the following should be at least considered for the ISO/OSI link layer:

- Media specific profiles, e.g. according to IEC 62056-7-5 but not limited to these
- Description of MAC and LLC sublayer and structuring of into frames/bytes
- Repetition of frames

Within the defined communication protocol stack, the following should be at least considered for the ISO/OSI Network layer:

- IP or other network profiles

Within the defined communication protocol stack, also the ISO/OSI application layer should be selected. Examples are listed above under b).

- Specific considerations for the application services, e.g.
    - Application Association establishment and release (ACSE services)
    - Interface classes to configure the LDTI for standard and legacy mode
    - Restrictions for interfaces supporting Legacy operating modes
    - xDLMS services
    - Information security services
- Synchronization with concentrator

d) Component Layer

Referring to the component layer, a BAP shall describe all smart meter system elements with respect to the physical interfaces required for interoperability. This includes specification of e.g.

- Interface implementation as a fixed or modular part of an electricity meter

- Galvanic isolation via opto-coupler
- Physical connection and voltage (e.g. 5V with RJ11 or USB interface)
- Adaptors and hubs
- Pin allocation of signals and I/O signal levels

For a specific implementation of a use case the identified functions can be mapped onto components complementing the relationships between all layers.

Other non-functional requirements may include

- Sealing of devices to prevent local attacks
- Installation of devices

Appendix E - Content of a BAP Test Specification (BAIOP) for the H1/H2 interfaces

This appendix outlines the suggested content of a BAP Test Specification (also referred to as Basic Application Interoperability Profile – BAIOP) for the H1/H2 interfaces, based on the analysis of profiles mentioned in Appendix C and the common elements of a BAP as described there.

BAIOPs specify the detailed setup to test the individual technical requirements of a BAP. A typical BAIOP may comprise

a) **an introduction**
b) **scope**
c) **referenced documents**
d) **terms, definitions & abbreviations**
e) **testing process description**
f) **design of the test architecture**
g) **test cases for interoperability layers**
h) **test cases for security**
i) **documentation**

a) Introduction

The introduction to a BAIOP may include

- Addressees of the BAIOP
- General guidance for application of the BAIOP
- Structure of the profile and relation to corresponding BAIOP(s) for testing
- Responsible editors of the BAIOP and contacts for comments and recommendations
- Versioning

b) Scope

A description of the scope of a BAIOP may include

- Application scope referring to a specific BAP
- Specific interfaces which are covered
- Limitations or restrictions for application (e.g. what is already covered in other/related companion documents)
- Description of what is out of scope (e.g. consumer devices)
- Specific description of separate chapters, annexes, tables and pictures

c) Referenced documents

Reference to other documents may include

- International and national standards and specifications (e.g. normative reference to EN and IEC)
- Further companion documents (e.g. related BAIOPs)
- Explanation on versions, dated and undated references, e.g.:

    - for dated references, only the edition cited applies
    - for undated references, the latest edition of the referenced document (including any amendments) applies
- presentation as flat list or with mapping to layers

d) <u>Terms, definitions and abbreviations</u>

This may include

- Specification of the terms, definitions and abbreviations that are used in the BAIOP
- Distinction of normative and informative requirements by definition of key words such as SHALL, MUST, SHOULD, MAY and NOT
- Procedures in case of differences between the definitions in the BAIOP glossary and those contained in referenced documents (e.g. in referred product or system standards)

e) <u>Testing process description</u>

This shall describe the basic testing process and clarify overall testing requirements and may include

- Initial situation including description of the test object (e.g. SMGW with the H2 interface) and further breakdown into various manageable test elements which will be assigned to specific test cases
- Evaluation criteria for test elements, e.g.
    - are specific interoperability criteria defined in the related BAP for a test element?
    - are specific functionalities defined in the related BAP for a test element?
    - is the test element fully described by the related BAP, or are there further profiles to be considered?
    - are already tested components (e.g. network adaptor) integrated in the test element?
    - how many configurations exist for the test element?
    - is the test process appropriate to fully assess the interoperability requirements?
- Different types of tests, e.g.
    - static tests (code or documentation reviews)
    - dynamic tests (black box tests)
    - structural tests (white box tests)
- Initial criteria for the test object, e.g.
    - unambiguous identification to ensure that the test object is correct
    - product related safety requirements to avoid hazard during testing
    - further passed tests as precondition for the interoperability test
- Structure of a test case including consideration of
    - positive test cases with test conditions which are compliant to the test specification
    - negative test cases with test conditions which are outside of the test specification
- Limits of the tests (e.g. the interoperability tests do not cover EMC requirements which will be considered as initial criteria for the test object)

f) Design of the test architecture

This shall describe the overall testing environment and the required systems simulation which is used to execute the test cases, e.g.:

- Implementation Under Test (IUT) which is the test element
- System Under Test (SUT) which includes the IUT
- Any interfaces connecting the IUT (e.g. realised by Upper Tester and Lower Tester)
- Service access point to initiate the tests and to evaluate the behaviour

g) Test cases for interoperability layers

There shall be detailed test cases described following the abovementioned testing process, considering each of the interoperability layers as specified in the BAP:

- Test cases for the functional layer shall consider all defined use cases
- Test cases for the information layer shall consider all information that is being used and exchanged between functions
- Test cases for the communication layer shall consider the defined communication protocol stack and the specific communications-related functions
- Test cases for the component layer shall consider all smart meter system elements with respect to the physical interfaces required for interoperability; this will cover the non-functional requirements as well

h) Test cases for security

There shall be detailed test cases described following the abovementioned testing process, considering each of the security requirements on system and device level and user access as specified in the BAP.

i) Documentation

All test cases shall be appropriately documented in a comprehensive and traceable manner. The result of a test case shall unambiguously refer to passed or failed criteria in order to assess the conformance or nonconformance to the corresponding requirements of a BAP.

The test cases should be preferably documented by an automated process. Otherwise another appropriate documentation process shall be developed, including suitable forms and templates.

References

The following documents help explain the focus and background to this report and clarify the terminology used in the profiles:

1. SGTF EG1 report on Interoperability, Standards and Functionalities applied in the large scale roll out of smart metering
   https://ec.europa.eu/energy/sites/ener/files/documents/EG1_Final%20Report_SM%20Interop%20Standards%20Function.pdf

2. 2012/148/EU: Commission Recommendation on preparations for the roll out of smart metering systems
   http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=G0D3JTGb413ZDy0Xq3qfj4crJrk8m97yvJGTLSTqvZk3tfZj3ypY!537741541?uri=CELEX:32012H0148

3. Smart Grid Co-ordination Group report "Smart Grid Interoperability"
   ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Interoperability_Report.pdf

4. Smart Meters Co-ordination Group report - use cases
   http://collaborationclc.iec.ch/LotusQuickr/clc_cenclcetsi_smcg/PageLibraryC125772900753598.nsf/0/DAA0ACC7AB5CD4DCC1257AC90052507E/$file/SMCG_Sec0060_DC_UseCaseReport.pdf

   NB – not directly available except via the CEN/CENELEC Collaboration tool

5. Smart Grid Co-ordination Group report - Smart Grid Set of Standards Version 3.1
   ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Standards_Report.pdf

6. Smart Meters Co-ordination Group report TR 50572: " Functional reference architecture for communications in smart metering systems"
   ftp://ftp.cen.eu/cen/Sectors/List/Measurement/Smartmeters/CENCLCETSI_TR50572.pdf

7. Interoperability Tool (IOP-Tool) of CEN-CENELEC-ETSI WG Interoperability
   ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Interoperability_IOPtool.xlsx