PD IEC/TR 62939-1:2014

BSI Standards Publication

Smart grid user interface

Part 1: Interface overview and country perspectives

National foreword

This Published Document is the UK implementation of IEC/TR 62939-1:2014.

The UK participation in its preparation was entrusted to Technical Committee L/13, Smart Grid policy.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2014

ISBN 978 0 580 87037 8

ICS 33.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 December 2014.

Amendments/corrigenda issued since publication

Date	Text affected

IEC TR 62939-1

Edition 1.0 2014-11

TECHNICAL REPORT

colour inside

Smart grid user interface –
Part 1: Interface overview and country perspectives

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE XF

ICS 33.200

ISBN 978-2-8322-1913-3

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

SMART GRID USER INTERFACE –

Part 1: Interface overview and country perspectives

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62939-1, which is a technical report, has been prepared by IEC project committee 118: Smart grid user interface.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
118/40/DTR	118/42/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62939 series, published under the general title *Smart grid user interface*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

0 Introduction

0.1 High-level definition of Smart Grid user interface (SGUI)

The Smart Grid user interface (SGUI) is a logical, abstract cross-domain interface that supports appropriately secure communications of information between an entity within the customer domain (e.g., home or building energy management system, electrical load, energy storage system or generation source) and an external service provider (e.g., utility, aggregator, market or customer energy service provider). Devices and applications will implement the SGUI between grid-side entities and customers for the purpose of facilitating machine-to-machine communications. The SGUI needs to meet the needs of today's grid interactions (e.g., demand response, grid-aware energy management, electric vehicle (EV) charging equipment interactions) and those of the future (e.g., retail market transactions).

In practice, the SGUI will potentially be one interface between multiple aggregation points, both inside and outside of the customer facility. Implementations will have variations arising from complex system inter-relationships: diverse customer business and usage models with different types of equipment in different types of customer facilities controlled by a range of energy management systems.

0.2 PC 118 history

In 2010, China proposed three new work proposals for IEC standards for Smart Grid user interface. There was a long process (refer to Annex A for details of the history of the establishment of Project Committee 118) of SMB and Strategy Group 3 (SG3) discussions and interaction with different TCs who each were working on some standards efforts related to the customer interface. Because many TCs have some connection to the SGUI, the Project Committee approach was chosen with the goal of coordinating between TCs to move forward toward effective standards. China was appointed secretary of PC 118 and the two Chinese work proposals became two working groups within PC 118, each tasked to produce a standard that would become deliverables of this temporary PC.

PC 118 members first met in Tianjin, China, in February 2012. At that meeting, representatives from different TCs and NCs each presented standards work related to the SGUI. Also at this meeting PC 118 members agreed to prepare a technical report covering the definition of the SGUI, the national requirements for SGUI communications (use cases), and an analysis of standards gaps between requirements and available standards. The end result would be acknowledgement of available international standards, recommendations for advancement of national standards and/or development of new standards to fill gaps.

PC 118 members recognized that standards exist for interactions between the traditional grid domain and the customer domain. There are international and national standards covering different parts of the interface. IEC TC 57 had just established a new working group (WG 21, Interfaces and protocol profiles relevant to systems connected to the electrical grid) and other TCs and WGs address meter interactions, industrial plant interactions, EV communications, market information models, etc. PC 118 adopted the approach of preparing this technical report, welcoming member countries and other IEC TCs to participate.

One may ask where Smart Grid stakeholders derive value. The industry will be best served by rapid progress which in turn is enabled by use of established technologies which meet Smart Grid user interface functional and quality requirements. This technical report presents the work of PC 118 members to gather and report the requirements for the customer interface, available standards, and identified standards gaps. Some national standards are recommended for advancement in IEC.

0.3 Relation of IEC PC 118 to other IEC technical committees

According to the PC 118 Strategic Business Plan (SBP) (SMB/4823/R, June 2012), the scope of PC 118 is to look at information exchange between the customer and the power grid from the user's point of view. PC 118 draws on the input of other IEC TCs to have a coherent IEC perspective on the customer interface, developing a set of standards (or mapping to existing standards) to ensure that IEC standards meet the needs of customer Smart Grid interactions. In order to do this, PC 118 works with IEC TCs developing standards for the power grid and within the customer domain.

IEC TC 57 is the manager of the IEC Common Information Model (CIM) and 61850 standards that serve as the information models for power grid domain communications. TC 57/WG 21 is specifically focused on the customer interface from the power grid point of view. IEC TC 13 developed the standards of the IEC 62056 Device Language Message Specification (DLMS)/ Companion Specification for Energy Metering (COSEM) suite [1] [1] for the purposes of electricity metering.[2] The PC 118 SBP scope is, "Standardization in the field of information exchange for demand response and in connecting demand side equipment and/or systems into the Smart Grid." Also, "PC 118 will develop a harmonized and consistent suite of standards for the users." PC 118 will work with existing IEC, ISO standards and examine existing national standards in order to identify the collection of standards that together meet the needs of the Customer Smart Grid interface.

The PC 118 SBP specifically states, "Smart Grid user interface related standards prepared by other technical committees of the IEC (including IEC/ISO JTC1) shall be used where applicable. PC 118 shall apply analytical approach and Use Cases developed by IEC TC 8 for Smart Grid requirements. PC 118 shall use IEC CIM and IEC 61850, and will develop new information models in view of demand side needs and characteristics. PC 118 shall consider IEC TC 57, TC 13, TC 59, TC 69, TC 72, TC 100, IEC/ISO JTC1 SC 25, TC 56, TC 65, etc., related architectures and standards. PC 118 should also consider Smart Grid user interface related standards prepared by other organizations such as ISO and ITU."

0.4 Report overview

Clause 2 introduces the customer (the Smart Grid user) interface—an interface between separate and historically independent domains. Subclause 2.3 presents a high-level conceptual model for demand response interactions from loosely coupled market interactions down to direct load control interactions. Subclause 2.4 organizes the functional requirements that have been discussed in PC 118. The remainder of Clause 2 examines the SGUI architecture, actors, and quality requirements.

Clause 3 begins with an overview of PC 118 member country perspectives on SGUI and an overview of contributed use cases (details in Annex C). Subclause 3.4 presents an analysis of use cases organized according to the functional requirements in 2.4. Subclause 3.5 looks at the relationship of SGUI to advanced metering infrastructure (AMI) and electric vehicles.

Clause 4 examines existing standards relevant to the use case classes to identify standards that meet the needs of the SGUI, or alternatively to identify gaps in IEC standards. This in turn informs Clause 5 recommendations for IEC SGUI standards development work.

0.5 Key recommendations and findings

PC 118 has identified some gaps in international standards for each of the use case classes presented in 4.4. Several existing national standards are recommended for advancement in IEC. Discussion of recommendations can be found in 4.5 and Clause 5.

1 Numbers in square brackets refer to the Bibliography.

2 The COSEM data model is also used by other Technical Committees responsible for non-electricity metering.

SMART GRID USER INTERFACE –

Part 1: Interface overview and country perspectives

1 Scope

This part of IEC 62939, which is a technical report, presents an international consensus perspective on the vision for a Smart Grid user interface (SGUI) including: SGUI requirements distilled from use cases for communications across the customer interface (the SGUI); an analysis of existing IEC and other international standards that relate to the SGUI; and an identification of standards gaps that need to be filled and might become potential work items for IEC Project Committee 118.

The PC 118 scope is, *"Standardization in the field of information exchange for demand response and in connecting demand side equipment and/or systems into the Smart Grid"*. This report presents the information exchange and interface requirements leading to standards to support effective integration of consumer systems and devices into the Smart Grid.

2 Smart Grid user interface overview

2.1 SGUI – Consensus perspective

The title and scope of IEC PC 118 refers to a "user interface." This term can have multiple meanings and interpretations. In the context of the work of PC 118 a "user" is some entity (actor) that consumes electricity supplied by the electric grid, or some distributed energy resource, such as storage or local generation that might produce energy. A user can be considered as a home, a vehicle, a commercial building, an industrial plant, or some system/device within a customer facility [3]. A "user interface" is a means to exchange information between the electric grid service provider and the user.

This Smart Grid user interface (SGUI) is not designed to be a human-machine interface, but may supply information to aid such an interface. It does not presume any particular communication or control technology that might be deployed by the user within a facility to react or respond to the information exchanged, and does not presume a single communication mechanism between actors on the grid and facility sides. It provides a basis for information exchange between the energy service provider or other grid-side entity and the customer-side entity, and nothing more. A high-level view of the SGUI is shown in Figure 1. In this simple figure, "Grid operations" also includes markets and energy service providers (see also 2.4 for SGUI functional requirements, 2.5 for SGUI architecture and 2.6 for example of actors within grid operations and customer facility management and control).

3 A "facility" is used in this report to refer to homes, buildings and industrial plants.

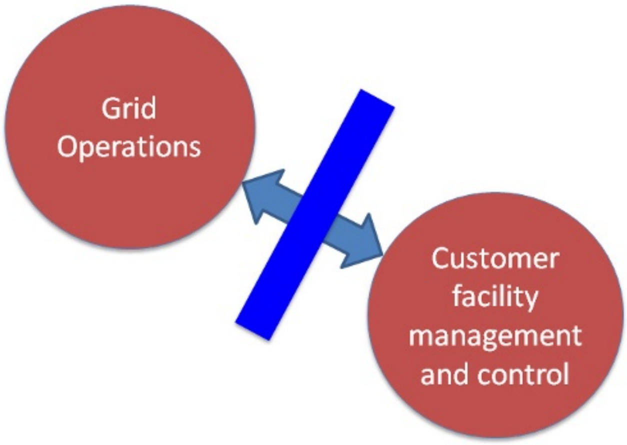


Figure 1 – High-level view of the SGUI architecture as interface (blue line) between different domains

The SGUI serves as an interface between two different domains that exist and evolve independently, and have developed over time with different information models and communication protocols. The SGUI serves to connect these domains: the “grid” domain (all those entities directly involved in the operation of the traditional electric grid) and the “customer facility” domain. The SGUI “user” is a more abstract term for the customer facility, since the “user” can be the same as the customer facility, or some system/device within the domain, or even an aggregation of systems.

The information communicated across the interface may include: demand response signals, price signals, load parameters (e.g., demand, forecast demand, storage availability), market transactions, energy usage (meter data), emergency signals broadcast by system operators, and other energy-related parameters such as power quality [2]. No single interface is required to communicate all of these things. For example, a simple residential gateway may possibly receive only price, or a meter may possibly report only energy usage information[4].

The SGUI may on the one hand be a high-level interface passing data such as price and DR event signals or meter usage data to be interpreted by the customer facility, or it may on the other hand be a low-level device interface which commands device operation based on the grid-side operational needs. In the first case, the interface is more abstract, with information communicated to enable any user devices, systems, or sub-systems within home or building to take actions. In the second case the interface is at the system or device level and may expose specific controls[5]. The kind of interface is determined by the specific requirements. In order to promote customer choice, scalability, flexibility and security, it is better in general to have a higher-level interaction.

In practice, the SGUI will be one interface within a hierarchy consisting of potentially multiple interfaces which may include aggregation, both inside and outside of the customer facility. Implementations will have variations arising from complex system inter-relationships: diverse customer business and usage models with different types of equipment in different types of customer facilities controlled by a range of energy management systems.

---

4 The ISO/IEC 15045 series [3] specifies options for gateway features that extend beyond communications protocol translation between a wide area network and a local area network.

5 ISO/IEC 15067-3 [4] specifies these levels of interaction including the “abstract” level where price or event data are sent to a local Energy Management Agent that interacts with local devices.

2.2 Inter-domain interoperability

2.2.1 General

The Smart Grid is composed of multiple domains, each with systems that together coordinate between all the actors of the electrical power system to provide reliable power to customers. SGUI includes the standards that connect actors in the grid domain (service providers, operations, markets) to customer systems (the Smart Grid "user"). Each domain has existing information models with invested equipment using existing communication protocols. The challenge is to bridge the different domains to accomplish SGUI functions (meeting SGUI use case requirements). Subclause 2.2 reviews some key principles of cross-domain interoperation. SGUI standards shall adhere to these principles.

Interoperation across domains typically involves components that are managed by different organizations. Organizations maintain autonomy while collaborating and sharing their resources. These relationships are governed by a set of principles described in the GridWise Interoperability Context-Setting Framework [5], which clearly establish rules for interoperation as shown below.

2.2.2 Agreement at the interface – a contract

As in any business engagement, the associated parties establish the ground rules and capture them in a contract or an agreement. Each party exchanges goods and services as an independent entity. The terms and conditions describe how goods and services flow between parties, the price, the scope, the schedule, and the quality of the deliverable. They also describe the consequences for failure to perform. They rarely state how the good or service is created or obtained.

Similarly, we presume that agreements between components concentrate at the place where the boundaries of each component meet – their interface. By establishing an interface agreement, each component preserves its integrity. It can change internally and react to various pressures independent of other components as long as it meets its interface agreements.

2.2.3 Boundary of authority

In the electric system, resources are aggregated in a hierarchical fashion, for example, from the demand side (customer facility), to the distribution feeder, transmission substation and network control. Each component of such a system plays a role with appropriate authority to do its job. Constraints, rules, or regulations may be specified to which interface agreements shall conform. How such authority is bestowed is a regulatory, political, and business policy decision.

The boundary of authority includes addressing rights of privacy and disclosure and run-time expectations. To the greatest extent possible, any constraint or restriction should be reflected in the interface agreement between interacting entities so that internal decisions for how a constraint or restriction is met remain within the boundary of authority of each interacting party.

2.2.4 Decision making in very large networks

As systems grow, common approaches are to federate systems with similar scope. The Smart Grid is a system of systems, where each system has its own models, rules, and implementations. System federation addresses issues of customer, grid, bridging, and diverse management approaches, and enables working together across individual organizations, subsystems, and persons acting in their own best interests while setting up information mechanisms to influence decisions that benefit all participants [6][7].

2.2.5 The role of standards

Standards are extremely important tools to improve interoperability. For a standards specification to have impact, however, it needs to be available to its potential users. Proprietary standards may only be available to a community that purchases a specific product. Open standards can encourage a competitive, multi-supplier environment. Allowing multiple solution suppliers to compete encourages innovation in features and performance. Openness implies that there is adequate information to ensure equal opportunities to produce compliant components from independent suppliers. The European Information and Communications Technology Industry Association offers the following criteria for openness [8]:

- Control: The evolution of the specification is set in a transparent process open to all interested contributors.
- Completeness: The specification is complete (within its scope) to ensure interoperability.
- Compliance: There is a substantial standard-compliant offering promoted by proponents of the standard.
- Cost: Fair, reasonable, and non-discriminatory access is provided to intellectual property unavoidably used in implementation of the standard.

2.3 Smart Grid user applications

2.3.1 General

Subclause 2.3 covers possible applications involving the Smart Grid user interface. One key application for SGUI is demand response (DR), as defined below. Demand response (and other SGUI applications) may include customer use of storage and generation resources behind the meter to reduce energy usage measured at the meter. Customers may respond to price signals, DR event signals, or control signals, to provide flexibility [9] to the grid.

2.3.2 Demand response

2.3.2.1 General

Demand response refers to changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

2.3.2.2 Levels of demand response interactions

2.3.2.2.1 General

The electric industry and customers have implemented various methods of demand response. ISO/IEC 15067-3 [4] divides these methods into direct and indirect load control that may convey control and price signals. We can categorize these methods into four distinct hierarchical levels of interactions as shown in Figure 2.

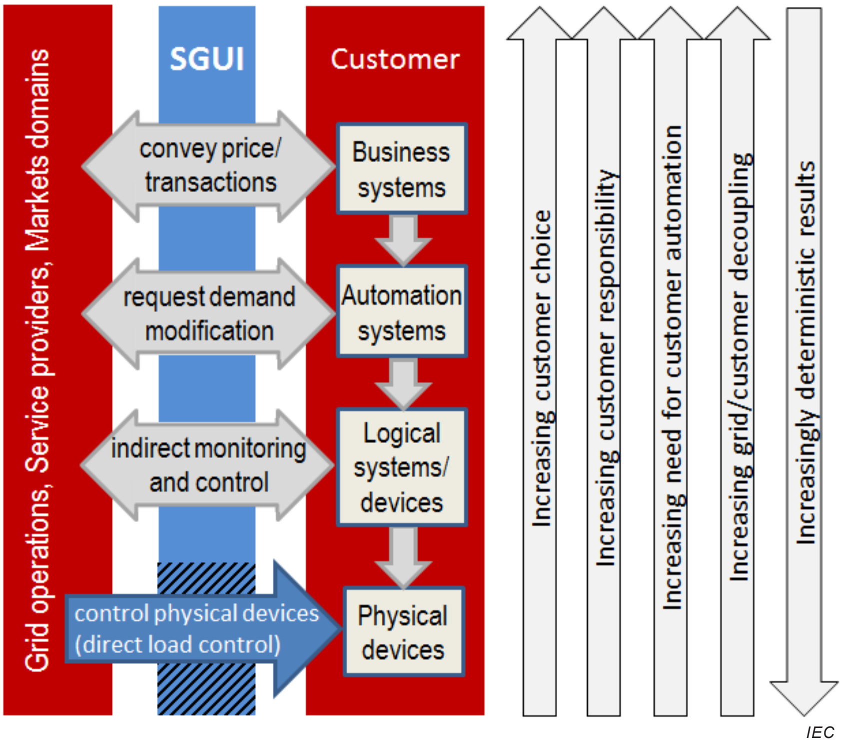


Figure 2 – Levels of demand response interactions

DR signals are passed from a DR service provider (left side of Figure 2) to a customer (DR resource), and there may be feedback. The four levels of DR interactions are shown in the arrows crossing the SGUI in Figure 2, and are discussed below. The levels represent the different kinds of signals (information and purpose) sent to different customer systems/devices with varying level of benefits to the customers and service providers. The long vertical arrows on the right show the changes in the nature of the interaction across the SGUI at different levels. The level of DR interaction determines the kind of signals communicated, the amount of automation required in the customer facility, the amount of customer control over response versus DR provider control, and the degree to which device action is deterministic. Each approach has its advantages and disadvantages as discussed below.

The question was raised in PC 118 as to the definition of direct load control and whether it belongs in the SGUI functional requirements. Direct load control (DLC) is defined below in the discussion of level 1. Its place in PC 118 is discussed in the use case analysis (3.4).

2.3.2.2.2 Control physical devices (level 1)

At the lowest layer of DR interaction, the energy service provider directly controls devices and the power to the load. An example of this is the use of a radio frequency signal to trigger relays on air conditioning units.

The term “direct load control” is often used to refer to a DR service provider (e.g., utility) switching on or off customer systems, devices, or appliances. For example, signals from a utility or a third-party service provider may directly control home air conditioners and hot water heaters. DLC is widely used with residential customers and ISO/IEC 15067-3 defines DLC in the residential context as “remote control of one or more appliances by a utility or third-party service provider”.

Advantages/disadvantages:

- The energy service provider needs to understand how the load operates as well as the device type in order to turn power on and off directly and how this affects safety, reliability, environment, comfort, etc.
- Low-level physical control is often the lowest cost in the absence of existing automation equipment.
- The customer has no risk or control for whether the load is actually controlled as directed by the energy service provider.

2.3.2.2.3 Indirect monitoring and control (level 2)

At the next level of DR interaction, the utility uses the customer's automation equipment (thermostat, building management system, etc.) to send device-specific (or sub-system-specific) signals to change the load.

At this layer, there is control logic between the utility and the load. The utility requests an action to occur on a logical device or system. For example, an energy service provider might send a signal to a thermostat to increase/decrease temperature set points. Higher priority requirements in the control logic may override the signal from the utility, e.g. safety overrides or equipment reliability considerations.

Advantages/disadvantages:

- Energy Service Providers do not require full knowledge of the devices in the customer domain, because the automation system ensures that appropriate facility and equipment constraints are maintained.
- The customer requires a minimum level of automation capability depending upon what devices are being controlled. This may increase cost if new automation equipment is required, for reasons such as the ability to communicate with the Energy Service Provider.
- Energy Service Providers wishing to come in at this level may need to interface with automation and control protocols used by existing systems.
- Security and privacy concerns may require additional costs in order to address the associated risks.
- Changes in the customer’s automation equipment can impact the Energy Service Provider.
- The customer is only responsible for doing what was requested and not for whether what was asked is sufficient to achieve the needed demand reduction.

2.3.2.2.4 Request demand modifications (level 3)

At the next level of DR interaction, the DR Service Provider specifies the desired results and the user decides how to achieve those results, e.g. "Reduce/Increase your load by 10 kW."

At this level the user or the user’s automation systems decide on the optimum course of action, based on an analysis of the trade-offs, to achieve the desired results with the minimum impact on the user.

Advantages/disadvantages:

- The customer is fully responsible for achieving the agreed upon reduction in demand.
- The Energy Service Provider is not impacted by customer-side equipment changes or automation strategy changes.
- The customer has a choice on what it will curtail in order to achieve the requested results.

- The Energy Service Provider does not require knowledge of the exact details of how the user will respond internally, only the overall result.

2.3.2.2.5 Convey prices / transactions (level 4)

At the highest level of DR interaction, the DR service provider conveys a price or a price is negotiated and the user decides what to do. At this level, the user or the user's pre-programmed automation systems decide on the optimum course of action to achieve the best results consistent with the user's business goals.

Advantages/disadvantages:

- The customer determines price risk and potential savings.
- The customer has a choice on how, or whether, to respond to the price signals.
- Advanced automation strategies may be required to take advantage of dynamic prices while minimizing risk.

2.3.2.2.6 Interactive DR versus DLC

Figure 3 may be helpful in understanding the distinction between indirect or "interactive DR" (levels 2 to 4) and DLC (level 1) and the customer role. DLC is equivalent to circumventing any local customer control over a customer device; a DR service provider directly controls the power to the customer device. On the other hand, interactive DR includes some measure of customer control in varying degrees. Interactive DR may also imply customer feedback (bidirectional communications), which is required for certain DR use cases.

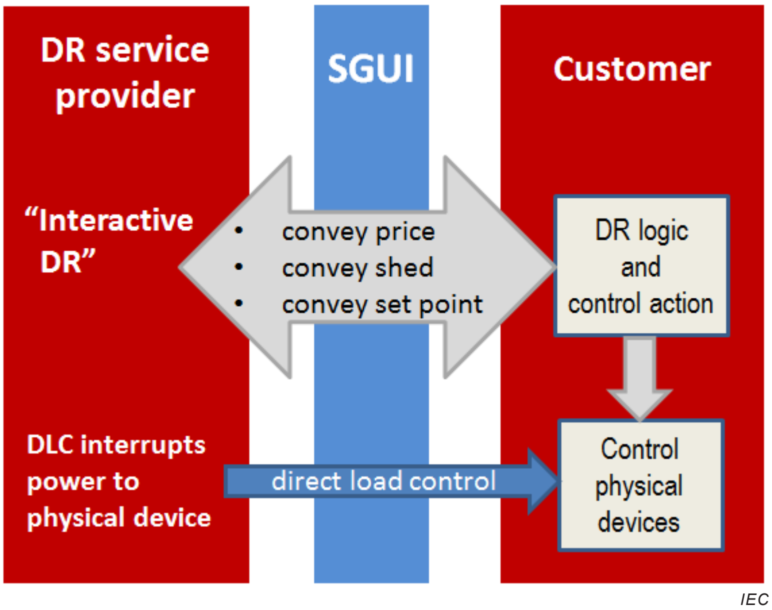


Figure 3 – Interactive demand response versus DLC

2.3.2.3 Characteristics of moving to higher levels of DR interaction

2.3.2.3.1 General

There are several characteristics that tend to emerge as demand response solutions move to higher levels of demand response interaction. These are shown as vertical arrows on the right side of Figure 2.

2.3.2.3.2 Increasing customer choice (characteristic 1)

At lower levels of demand response interaction, the user may have no control over when the DR service provider curtails their loads. This may cause problems with customer satisfaction and willingness to participate in demand response programs. It can also affect equipment reliability. At higher levels of demand response interaction, customers can decide how to achieve the desired demand reduction or whether financial or other considerations override the request from the Energy Service Provider. This can increase customer satisfaction and willingness to participate in demand response programs.

2.3.2.3.3 Increasing user responsibility (characteristic 2)

At lower levels of demand response interaction, the DR Service Provider is responsible for installation and maintenance of all equipment and connections used to control the response to the demand response event. The DR Service Provider is also responsible for all demand reductions which are achieved or not achieved as a result of system problems. At higher levels of demand response interaction, responsibility for installation and maintenance of facility equipment that is used to control the response to the demand response event shifts to the customer. The financial benefits and risks of participating in the demand response program also shift to the customer.

2.3.2.3.4 Increasing need for user automation (characteristic 3)

At lower levels of demand response interaction, the user is not required to have any automation equipment since the DR Service Provider directly controls whether power is allowed to flow to the load. The need for automation increases as demand response shifts to higher levels of interaction. At the level just above direct load control, this may be as simple as a thermostat. Higher levels of interaction may require a building management system, energy management system, or even some type of enterprise level system that considers trade-offs between energy prices and other business considerations.

2.3.2.3.5 Increasing grid/user decoupling (characteristic 4)

Users often have a significant investment in automation equipment for their facilities. They will not automatically replace existing automation equipment to communicate with the Smart Grid. Instead, they will evolve their existing systems to include this functionality.

Facilities do not need to have as complete of an understanding of the grid as grid domain participants require. The grid operator does not need to have as complete of an understanding of all facilities as operators of these facilities require. The SGUI can serve as a decoupling mechanism that allows these two domains to interoperate without being too closely tied together.

A stable interface promotes decoupling and enables changes to occur on either side of the interface. This minimizes the impact of these changes on the other side of the interface. Stability does not automatically require a static interface, but it does require that changes to the interface shall be made in a way that does not break existing, deployed systems.

2.3.2.3.6 Decreasingly deterministic results (characteristic 5)

At lower levels of demand response interaction, the resulting demand reduction can be very deterministic since the energy service provider is directly disconnecting the power to the load. At the higher levels of demand response interaction, the resulting demand reduction is more indeterminate unless aggregation of numerous demand response resources is included. Aggregation converts a collection of indeterminate resources into a determinate resource for the grid.

2.3.3 Other SGUI applications

SGUI applications include but are not limited to demand response. While demand response and related functions discussed above relative to Figure 2 are key functions of the SGUI, other use case functions have been identified, as seen in 2.4. These functions include: information communication such as meter reading (energy usage information), equipment energy efficiency management, power quality monitoring, and notices of imminent power failure. Also, ancillary services are not traditionally considered demand response.

2.4 SGUI functional requirements

Subclause 2.4 presents a summary of the requirements based on use cases that are reviewed in 3.3, and based on discussions in PC 118 that have focused the SGUI perspective down to a cross-domain interface as shown in Figure 1. There are some requirements expressed in use cases reviewed that seem to be more like edge cases for the SGUI, and which may or may not be clearly captured in the following functional requirements classifications. These edge cases are not being completely dismissed, but may be of lower priority, or may be re-examined.

Functional requirements are derived from business use cases and define the system functions—what the system should do. Quality requirements (2.7) address the performance requirements including SGUI testing requirements based on the use cases. The architecture (2.5) defines the structure of the system to meet the requirements.

Use cases can be summed up in terms of the following information exchanges (functional requirements list below). Not all users (e.g. residential devices versus large facility energy management systems) need to support all of these functions since the programs and the capabilities of systems can vary greatly.

This technical report, guided by the submitted use cases, addresses the important present areas of: demand response, price-based interoperation, and direct load control. In addition, monitoring, confirmation of delivery and demand, and other reporting capabilities are important. In 3.4 we present a detailed analysis of the use cases; the following functional requirements are in the same form and order as the use case classes of Clause 3.

Functional requirements for the smart grid user interface include the following:

1. Interact with markets: This requirement implies the communication of market prices and product descriptions, and the ability to respond to price information. Market transactions between the grid and the user are used to buy or sell electricity under terms that can be negotiated using the interface. Market transactions require a client that knows its forecast demand or generation in order to place bids and offers into a market.
2. Convey price and product description[6]: This includes fixed, scheduled, or real-time varying prices for electricity provided by the grid and consumed by the user, or vice versa. Prices may address a diverse range of electricity market products which will continue to evolve. Price information shall include product description. In some cases prices may be determined through a negotiation process that needs to be part of the interface.
3. Convey ancillary services and operator signals: This includes voltage regulation and real-time dispatch.
4. Convey demand response and distributed energy resource (DER) requests and notifications: This involves asking the user to shape electricity demand on a temporary basis and may be done through price changes or by invoking a previously agreed upon

6 As described in the NIST Smart Grid Framework and Roadmap [10], price without product definition (to which the price applies) is insufficient.

response to a DR event signal[7]. Here we refer to an abstract interface where the energy provider does not control the load and relies upon the user to respond in an appropriate way (per contract) to the information provided. DR requests include those for emergency DR.

5. Convey indications of impending power failure or grid instability: This does not include communication of natural disaster or weather related events, but does include notifications of impending power failure or grid instability that may result from natural disasters, weather, or other events.
6. Convey directed interaction requests: This includes direct load control actions applying to users who do not have the ability to respond to price signals or demand response requests but have entered into an agreement to permit the energy supplier to directly modify or shut off individual loads. Related areas include directed management of energy storage resource; such requests may be expressed in terms of either power, energy or charge state of the resource.
7. Convey historical or real-time energy usage (meter measurements): This involves providing a way for a user to supply aggregated, whole building, systems, or sub-system energy usage information to the energy provider, which can be used to meet DR program participation requirements and assist in measurement and verification of the participating user. The same software mechanisms can convey forward power usage projections, providing a way for a user to supply forecast information to the energy provider that can be used to manage grid resources, and be useful for evaluating and measuring energy efficiency and for facility commissioning and green building/LEED continuous commissioning. The energy provider may also provide validated energy usage data to the user. Demand is more specific and is included in the next class.
8. Convey monitoring information: Monitoring is key to demand response and distributed energy resource management and verification, as well as energy efficiency information with respect to the Smart Grid user. Information that may be monitored includes storage and generation availability, status, present and forecasted demand and capacity, and other forecast information to enable effective management of the grid. Usage forecasts are addressed in item g). Measurement of energy usage at a transfer boundary is important for monitoring and verification. Power quality may be monitored, although perhaps by other interfaces. Compared to item g) above, monitoring suggests more extensive data collection and interaction than simple usage (historical, present, and future projections).

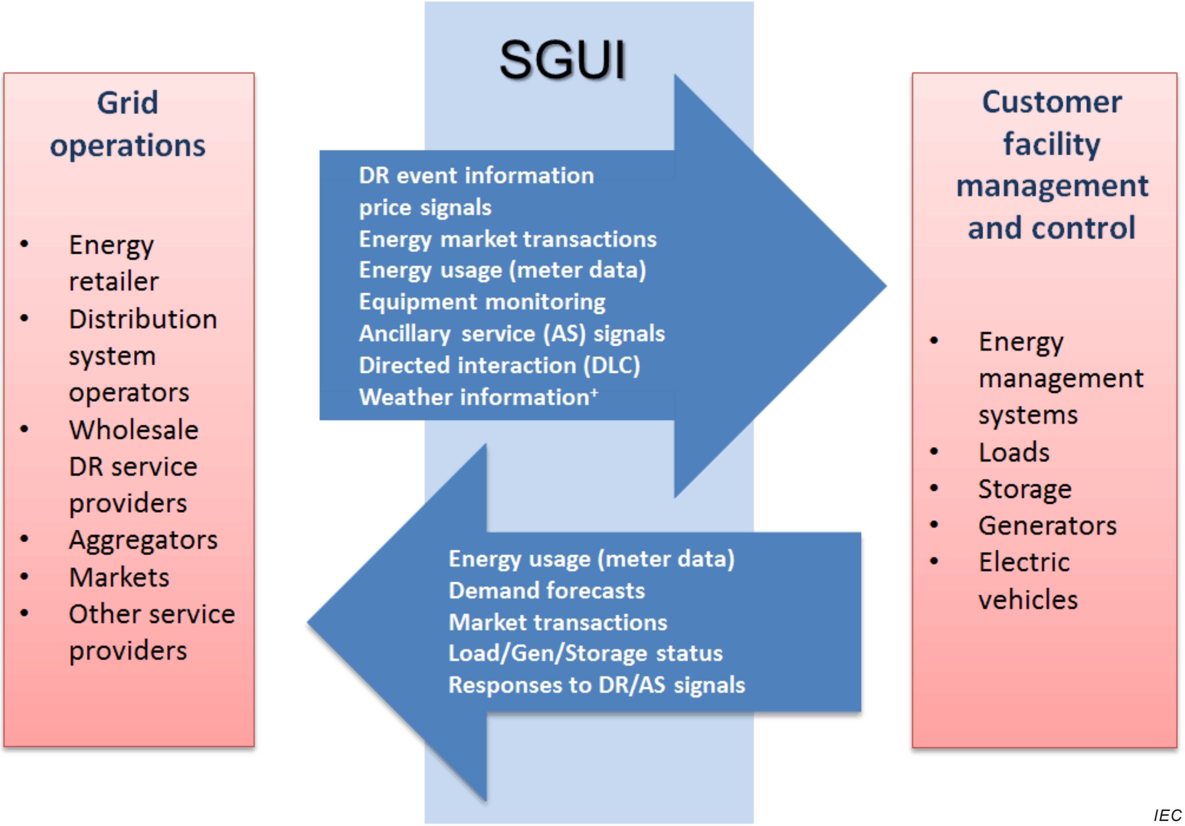
In addition, some submitted use cases present functionality that provides remote facility management for systems internal to the customer/Smart Grid user, such as remote health monitoring, which seems specific to facilities and their implementations, and subject to future independent evolution.

DR and DER events, as well as ancillary services and market interactions require supporting services and information. This might include: registration, enrollment, communicating the availability of resources, opt-in or opt-out responses to DR event signals, status of load response, and appropriate baseline data.

The following figure (Figure 4) shows the information flowing across the SGUI and some actors on either side. The information is represented in the blue arrows. The architecture of the SGUI will be discussed more in 2.5. Actors are discussed in more detail in 2.6.

---

7 This agrees with the more simple definition of DR given in IEC 60050-617-04-16 [11], “action resulting from management of the electricity demand in response to supply conditions.”



NOTE Weather information is important for Smart Grid, but is not listed as an SGUI functional requirement in 2.4. International standards (e.g. WXXM in WMO) cover this, and weather services already provide weather data.

Figure 4 – Information exchange through the SGUI between the grid (external service providers) and users in the Customer Facility domain

2.5 Architecture

The goal of 2.5 is to understand how the SGUI fits into a Smart Grid architecture, by discussing the goals of the architecture and a conceptual reference model.

The SGUI shall be suitable for interaction with many different kinds of users with varying abilities and constraints. The control and automation technology used to respond to the grid communication will vary with the type of user (residential, commercial, industrial). The Smart Grid user interface shall work with all of them. It is important that changes in the control technologies found in the user's facility do not "break" the interface. These control technologies will evolve on independent time schedules. This means that the architecture for the interface shall be based on specific communication exchanges that do not depend on the details of how the user implements a response. The interface serves to abstract the details behind the interface in order to promote scalability, extensibility, and flexibility. The proper level of abstraction provided by the interface will vary based on the business and application requirements.

Because of the possibility of aggregation of users, a single entity (e.g., an aggregator) may look like a user to an energy service provider but at the same time look like an energy service provider to one of the aggregated users. The architecture shall accommodate this type of hierarchical structure.

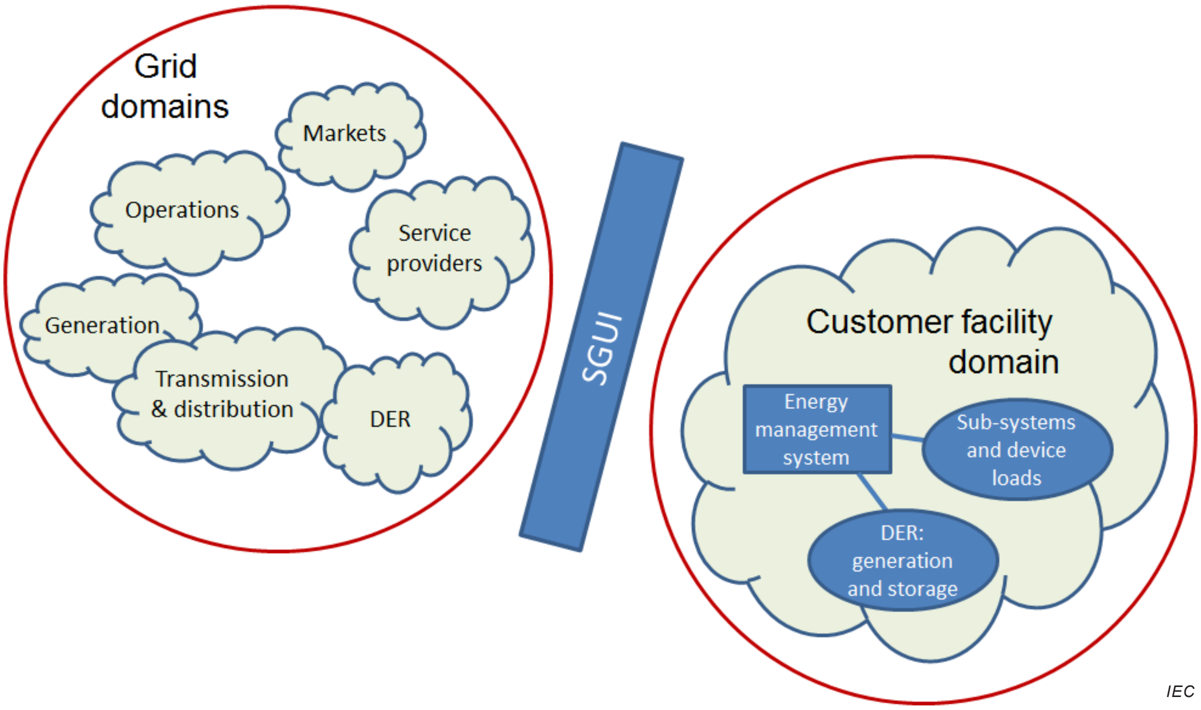


Figure 5 – High-level generic Smart Grid user interface architecture

Figure 5 shows a conceptual diagram of the different Smart Grid domains and the interactions with the customer facility domain. The customer facility domain is seen to interact directly with service providers (and other grid-side domains) via the SGUI. All communications to the customer domain pass through an SGUI, whether that interface is used for communications to an energy management system (EMS), or to a specific piece of equipment (direct load control). The SGUI functions can be hosted by a dedicated device such as a residential gateway or added as a functional component inside an existing device such as a smart meter. In particular, a smart meter may be used to support a subset of SGUI functions in order to ease deployment of services without needing to deploy new hardware components inside the premises. An example architecture for residential applications with direct interactions through the meter is provided in 3.2.4 based on French implementation.

The ISO/IEC 15045 [3] series of standards specifies a gateway as a logical demarcation between the public and private domains. The SGUI may be included in the gateway, in an EMS (energy management agent, specified in ISO/IEC 15067-3 [4]), or at end-devices within the premises. The choice depends on implementation design, complexity, and market factors such as product configuration and cost.

In Figure 4 we see that there are two sides to an SGUI: the “grid” side and the “customer facility” side. The grid side is exposed to the energy service provider (or an aggregator), while the facility side is exposed to customer systems. The SGUI represents a logical demarcation point of ownership or an operations support boundary. A clear demarcation encourages market developments of competitive devices, equipment and appliances that facilitate demand response, energy efficiency and energy management.

An SGUI may be owned and operated by either an energy service provider or a customer. The physical location is of minimal importance. The number and structure (hierarchy) of SGUIs will vary as determined by service providers and customers.

2.6 Actors

2.6.1 Overview

An actor is a device, computer system, software program, or the individual or organization that participates in the Smart Grid. Actors may take on various roles. Actors have the capability to make decisions and to exchange information with other actors. Organizations may have actors in more than one domain. The grid service providers and customer facility users illustrated in Figure 4 are representative examples but are by no means all of the actors relevant to the Smart Grid user interface. Each actor may exist in several different varieties and may actually contain other actors within them.

2.6.2 Customer domain characteristics

The customer facility domain has varying degrees of complexity—the residential home is relatively simple while large commercial and industrial facilities can be very complex. Each sub-domain (residential, commercial, industrial) has multiple actors and applications. The communication technologies and standards used by devices in the different sub-domains vary significantly.

The diverse energy assets within the customer domain can be characterized by: electrical capacity, operational characteristics, economic impact on customer, operational flexibility of customer, operational impact on the electric system, system complexity of customer, level of customer automation, customer sustainability needs, and energy assurance needs.

2.6.3 Grid-side, customer-side, and SGUI actors

2.6.3.1 General

We divide actors into three categories:

- grid-side
- customer-side
- SGUI (at the boundary between the grid and customer sides)

Some actors are at the boundary, specifically, metering and gateway functions. The purpose of 2.6.3.2 to 2.6.3.4 is to show example assignments of actors; this is neither exhaustive nor prescriptive.

Metrology and metering are listed as grid-side actors, but also as actors in the customer-side; we include them in both lists as well as the SGUI list, as metering flows between the grid- and customer-side are an SGUI function.

2.6.3.2 Grid-side actor examples

Grid-side actors include markets, utilities, systems and transmission operators, energy services companies (ESCOs), energy management providers, aggregators, etc. The lists below are not meant to be exhaustive.

Market domain actors include:

- Retailer/wholesaler—Wholesaler or retailer purchasing energy in the market and selling it.
- Aggregator—Service provider aggregating small-scale participants (supplier, consumer, load shedding/reduction) and performing transactions for them in the electricity market.
- Energy market clearinghouse—Market operator or system deciding the electricity market price based on the bids of consumers and suppliers in the electricity market and the collected information on the electricity system operation, and calculating the charges for the services supplied by the market participants

Operation domain actors include:

- EMS—Comprehensive energy management system that monitors and controls the operation of the electricity system in real time, produces electricity in an economical way, and supplies electricity in a stable manner.
- DMS—Distribution management system that analyses the operation of the distribution system and operates it efficiently.
- MDMS—Meter data management system that stores and manages the energy use data or events measured by AMI/AMR.
- DRMS—Demand response management system that manages the amount of energy used by customers according to the demand/supply state.
- OMS—Outage management system that assists in the restoration of power to the customers.
- GIS—Geographic information system that captures, stores, manipulates, analyzes, manages, and presents all types of geographical data including the customer locations.
- TCM—Trouble call management system that offers better customer service by reducing interruption time.

Service provider domain actors include:

- Retail energy provider—Energy service provider (retailer) with its own customer information system and billing system.
- Home/building manager—Energy manager who manages and installs Smart Grid interacting equipment in homes or buildings.
- Aggregator—Service provider aggregating small-scale participants (supplier, consumer, load shedding/reduction) and performing transactions for them in the electricity market.

Generation and DER domain actors include:

- Generators—Generation equipment and distributed energy resource equipment may participate in markets and receive dispatch signals from grid operators.

Transmission and distribution domain actors include:

- TSO—The transmission system operator manages transmission of electrical power from generation plants over the electrical grid to regional or local electricity distribution operators.
- DMS—The distribution management system monitors and controls the distribution network to improve reliability and quality of service by reducing outages and outage time, and maintaining acceptable frequency and voltage.

2.6.3.3 User-side actor examples

User side actors might include devices, smart appliances, transactive parties, EMS, buildings, microgrids, etc.

DER domain actor examples:

- DER-EMS—Comprehensive energy management system that monitors and controls the distributed energy resource equipment and distributed energy storage system to produce and supply electricity in an economical, stable manner.
- Distributed generation—Distributed energy resource equipment.
- Energy storage systems—Distributed energy storage system.
- Microgrids—A self-managed sub domain with resources and loads.

Transportation domain actor examples:

- Electric vehicle—Plug-in hybrid/electric vehicle that consumes, stores, and supplies energy.
- Electric vehicle supply equipment (EVSE)—Charging station for EV.

Customer domain actor examples:

NOTE Gateway and metering functions are considered to exist between the grid and customer side; they are listed here and separately in the SGUI actors.

- Residential gateway—Customer side device or application that functions as the communication gateway between the customer devices and actors outside the customer facility domain. A residential gateway may provide gateway functions for energy management. If the gateway provides no other services, such as TV or Internet access, it is equivalent to an energy management gateway. Some electric utilities use the term energy services interface for an energy management gateway (ISO/IEC 15067-3:2012, 3.1.11).
- Meter—Smart meter in the consumer domain; measures the amount of electricity used and possibly generated and may play the role of a communication gateway.
- Customer subscriber equipment—Subscriber's equipment provided by the service provider and connected with the network; (e.g., terminal, set top box, and cable modem).
- Appliances—Home appliances such as air conditioners, heaters, refrigerators, and clothes washers.
- Thermostat—Automatic temperature regulator.
- Customer EMS—Energy management system of home, building, plant, etc. that may monitor and control the operation of electricity distribution, production, and storage within a home or building possibly in real time to achieve the goals of the occupants. These goals may be based on costs, desires for specific device operation (heating, cooking, lighting, etc), or agreements with an energy service provider. Residential EMS types and functions are specified in ISO/IEC 15067-3.
- Customer substation—Substation installed in the consumer's facility.

2.6.3.4 SGUI actor examples

The SGUI in Figure 1 is between the grid-side and customer-side; in 2.6.3.4 we list actors relevant to the SGUI. Logically, these are between the grid and customer, and are essential to carrying out functions related to the SGUI, and can be for example:

- Energy Services Interface—Device or application that functions as the communication gateway between the customer-side actors and the grid-side actors. Some gateways may extend beyond energy, e.g. for telecommunications, cable television, and the like. Some electric utilities use the term energy services interface for an energy management gateway (ISO/IEC 15067-3:2012, 3.1.11).
- Meter—Smart meter in the consumer domain; measures the amount of electricity used and supplied.

NOTE Another vision of these actors considered as functional components is described in the French COSEI Architecture provided in 3.2.4.

2.7 Quality requirements

2.7.1 General

Subclause 2.7 presents the quality requirement topics that shall be considered for any given implementation of an SGUI, in order to meet use case requirements. Application quality requirements include security, reliability, scalability, performance and maintainability. These directly impact system architecture and design.

2.7.2 Security and privacy

Cyber security is critical due to the potential for adverse impact on both the customer and the power system. Signals sent to or from large numbers of customers represent an attack surface that has the potential to disrupt the bulk power system. Invalid signals from the grid-side sent to the SGUI can interrupt and compromise commercial and industrial operations and may result in harm to equipment and personnel. Invalid signals sent from customers to service providers may cause misinformation and result in potentially harmful actions.

Security enables protected interaction and is fundamentally concerned with managing risk. Security measures shall address application vulnerabilities and exposures, as evaluated by domain experts at the time application requirements are developed. Security in the marketplace requires transactional transparency to ensure auditable and traceable transactions.

Security measures should be tailored to the application. A single security regime does not apply everywhere. The security equipment and operational costs should be appropriate for the environment, threat, and potential consequences. Some data, such as published electric rates, may not need to be encrypted. Rather, customers need to be assured that the data are authentic, meaning the sender is the energy services provider. Such authentication is widely used in Internet commerce.

The six areas of security that need to be addressed by applications are: authentication, authorization, confidentiality, integrity, non-repudiation and auditing. Authentication refers to validating the identity of a user or code. Authorization refers to validating the authority of a user or application to perform actions. Confidentiality is the ability to encrypt data in order to prevent its access and integrity is the ability to detect data tampering. Non-repudiation is the ability to ensure that messages are sent and received by those that claim to have sent and received.

In order to maintain system-wide security and integrity, the above security principles and techniques shall be applied in such a way that if the security of a single SGUI interaction is compromised it does not affect the security of other SGUI interactions. Furthermore to ensure proper operations and accountability, the SGUI shall support means to audit and monitor interactions through the SGUI. This includes the ability to log transactions and exchange status information.

Consumer privacy shall also be considered, with interface design permitting minimal information transfer. Privacy protection uses some security tools such as encryption and authentication, but establishing security does not ensure the privacy of customer data. Customers should be informed of and should be in agreement with plans for collecting personally-identifiable data, uses of these data, the length of data retention, data anonymization, and data obliteration when the data are no longer needed [12].

Security is typically composed with an interoperation specification for a specific deployment; a single security profile does not address all possible implementations. In addition, security requirements and functionality generally evolve more quickly than interface specifications. Different parties involved in interactions require different choices for security, privacy, and reliability. Details of security requirements for particular interactions across the SGUI are too specific for inclusion in this technical report.

2.7.3 Scalability and performance

The SGUI needs to be designed to scale in multiple dimensions. It shall scale across different types of customers: residential, commercial, and industrial. It shall scale across a single customer, since a facility may have one or more SGUIs and a customer may have one or more facilities. It also shall scale across multiple customers, since a single service provider may interface to hundreds of thousands of separate SGUIs. A single SGUI may also connect to multiple grid-side service providers.

The SGUI is a component in a large-scale, fast-responding energy system with wide geographical distribution. Business and economic requirements from business cases are often tied to the ability of service providers to reach large numbers of customers within rigid time constraints. Scalability can be characterized in terms of the quantity of actors involved and the performance required in terms of data throughput (i.e., messages per second) and data delays or latency (i.e., milliseconds). These may vary from thousands of large customers to millions of homes, and from hours-ahead DR signals to sub-second response times. The architecture chosen will determine the ability to meet application performance requirements. Technology that meets performance requirements in the context of relatively small numbers of actors may not meet performance requirements when a large number of actors are involved.

2.7.4 Maintainability

To ensure the continuing evolution of the customer centric applications on the Smart Grid, the SGUI design needs to ensure maintainability. It should be understood that the SGUI will evolve over time and methods should be included to ensure backwards compatibility and ability to evolve standards. The methods should also extend to identify, communicate and diagnose exceptions and errors at SGUI.

3 Country actions and perspective on Smart Grid user interface

3.1 General

Subclause 3.2 starts with member country perspectives on SGUI, followed (3.3) by a summary of use cases submitted by each country (with use cases details provided in Annex C), and then (3.4) an analysis of the use cases to derive common classes of use cases (e.g. communicating DR events, price signals, etc.). Subclause 3.5 calls out some specific issues that need attention, including use cases of member countries that do not fit well with the consensus SGUI perspective presented in Clause 2.

3.2 Overview of country experiences

3.2.1 China perspective

3.2.1.1 China’s research and practice in Smart Grid user domain

China has made great efforts in promoting energy savings and emissions reduction in the whole society, and has valued it as a part of accelerating the transformation of their economic development mode, with the vision to benefit the power grid enterprise, third parties such as service providers, and customers through the deployment of demand response, energy efficiency evaluation, renewable energy integration, and interactive services in the Smart Grid. A practical way to realize the vision is to make good use of business resources on the grid side, to fully explore the dispatchable loads on the user side, and to develop standards and specifications on the Smart Grid user domain. Standardization on information exchange between grid and user interface will promote the information exchange and business integration between the grid side and the user side, facilitate innovation on the business mode for Smart Grid, lower the R&D cost and implementation cost for the service provider and the manufacturer, enhance the safety and service of the grid enterprise, and satisfy the diversified requirements of customers, such as energy conservation and efficiency improvement.

Since China launched the Strong and Smart Grid Construction program in 2009, the State Grid Corporation of China (SGCC) has carried out significant research and practice in the customer domain. By the end of 2011, SGCC finished construction of EV charge/switch facilities covering 26 provinces, installed and applied 51,62 million smart meters, constructed 28 smart communities and buildings, provided energy management service for 35 000 households; finished the main station construction for the power consumption information collecting system in all provincial electric power companies, realized information collection, load management, auto-metering and billing service for 76,45 million households including industrial and residential customers. SGCC also achieved certain accomplishments in integration of roof solar and wind, pre-pay billing system, interactive service platform of smart power consumption, and other areas. In 2012, SGCC and Honeywell together launched a project to study the demonstration and feasibility of DR in Smart Grid. The project deployed auto–DR systems and devices in the district administration office, commercial buildings, office buildings and industrial users, which received significant effect in reducing peak load.

3.2.1.2 China's efforts on system construction of Smart Grid standards

In March 2009, SGCC launched the research project on Smart Grid standards system. A research team consisting of experts of various domains from China EPRI was assigned to this project. Through a year's effort, and considering comments and opinions from interested parties, and after several revisions, the team came up with the *SGCC Framework and Roadmap for Strong and Smart Grid Standards*, covering 8 domains, 26 technical areas and 92 standards series.

In order to boost China's Smart Grid construction, the Bureau of Energy of the National Development and Reform Commission (NDRC) and Standardization Administration of China (SAC) set up a working group on the national level to promote the standardization of the Smart Grid. Currently, the group is working on the draft of *Smart Grid Technical Standards System of China* with nationwide support of domain experts. In the customer domain of China's standards system, the following areas are given priority:

- Advanced metering infrastructure
- Demand response
- Customer energy management
- Power energy efficiency
- Electric vehicle charging
- Electric storage
- Distributed energy resource
- Electric energy management service (interactive service platform)

3.2.1.3 Latest developments of the Smart Grid standardization in China

According to the arrangement of the National Development and Reform Commission (NDRC) and the SAC, the following national standards are under development:

- Effect monitoring and comprehensive evaluation of demand response
- General specification of electric power efficiency assessment
- Metering and certification specification of power conservation through demand response
- Guidelines for energy efficiency evaluation in low-mid voltage distribution grids
- Series standards of public service platform for user side management
- Series standards of electric energy efficiency monitoring system
- Technical standards of aggregating and acquisition device for energy efficiency

3.2.2 U.S. perspective

The United States (U.S.) has made significant advancements on developing a standards infrastructure to enable a future Smart Grid. The U.S effort is led by the National Institute of Standards and Technology (www.nist.gov/smartgrid). NIST is mandated by U.S. law (the Energy Independence and Security Act of 2007) to assume primary responsibility for coordinating the development of a standards framework to achieve interoperability of Smart Grid devices and systems. The U.S. plan for Smart Grids is described in the *NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 2.0*:

http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf.

To carry out its mandate, NIST established a public-private partnership called the Smart Grid Interoperability Panel (SGIP). The SGIP engages national and international stakeholders from the entire Smart Grid community in a participatory process to identify applicable standards, gaps in currently available standards, and priorities for new standardization activities for the evolving Smart Grid. The SGIP has over 700 member organizations representing 22 interest categories. Over 100 of the member organizations are from outside the U.S. The work of the SGIP has already had significant impact resulting in several new or revised U.S. and international standards.

SGIP is focusing on standards in the following areas to encourage interoperability among the components of smart grids:

- Demand response and consumer energy efficiency
- Wide area situational awareness
- Electric storage
- Electric transportation
- Advanced metering infrastructure
- Distribution grid management
- Network communications
- Cyber security

Specific standard gaps are identified and addressed in the SGIP process through the creation of priority action plans (PAPs). A PAP is both documentation of a specific need with targeted deliverables and a collection of experts from the SGIP community who work to produce the deliverables. A PAP typically develops use cases and other preliminary work that is offered to a standards development organization to accelerate their standards development process. The PAP monitors the development of the standard and evaluates how well the resulting standard meets the identified industry need. Several PAPs and their associated standards have scopes that are relevant to PC 118.

Figure 6 shows a conceptual Smart Grid architecture model based on the seven domains defined in the NIST Framework. This architectural model was used to help identify existing national and international standards that are critical to achieving a Smart Grid and to identify gaps that need to be filled in order to achieve interoperability of products and systems. We believe that standards related to a “Smart Grid user interface” are most strongly associated with the interface points in Figure 6 where the solid black lines connect to the Customer domain (lower right).

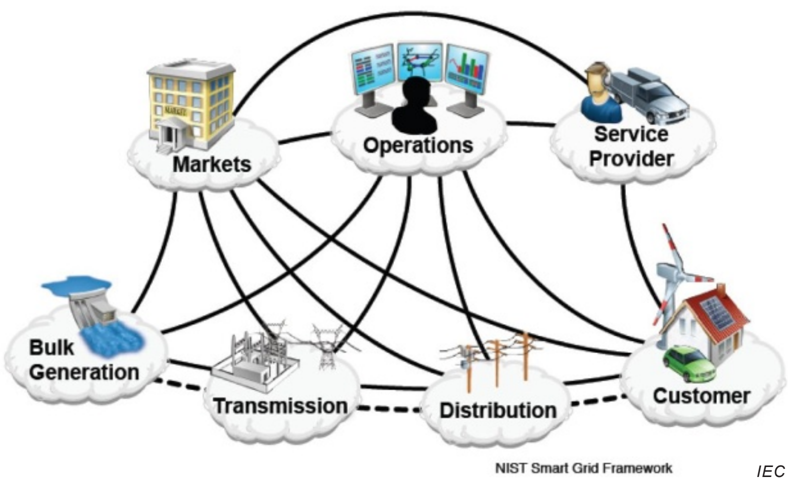


Figure 6 – NIST smart grid conceptual model (from NIST Framework 2.0)

3.2.3 European perspective

The Smart Grid standardization framework in Europe is pushed by two mandates of the EU: Smart Metering M441, and Smart Grid M490. The answer to these standardization mandates is jointly worked by CEN, CENELEC and ETSI. The standardization in the field of the so called “Home and Building Electronic System” (HBES) is handled by CENELEC (CLC) TC 205. For the Smart Grid related items CLC established a special working group – CLC TC 205 WG 18. IEC TC 57 WG 21 defines the data models and communication services delivered to residences as well as commercial and industrial facilities. In ETSI, the M2M Technical Committee has specified an M2M generic architecture and APIs to enable vertical applications such as smart metering or smart grid use cases to access capabilities commonly needed (security, access rights, device management, store and forward, etc.). These specifications (ETSI TS 102690 and TS 102921) were published at the end of 2013.

For the handling of Smart Grid and smart metering in Europe, a reference architecture was defined (see Clause B.2). The management of loads, e.g. switching on or off, in a building (or residence) can be controlled by the grid (in dependence of the electricity generation). For the execution of the management of loads in a building a home and building electronic system (HBES) is necessary. The HBES interacts with the Smart Grid architecture via the addition of a utility customer energy manager (CEM) interacting with the HBES via a Smart Grid energy management gateway. To enable the Smart Grid functions in the building the energy management gateway and the CEM play a key role. To assure the interworking of devices from different manufactures all units shall work on a standardized basis.

The resulting standardization structure has these standards bodies with the following responsibilities: TC 57 WG 21 for the grid side of the SG user interface, TC 205 for the SG connection to the HBES and TC 59 WG 7 for customer devices like washing machines, refrigerators, and so on.

In order to enable differentiation between various vendors of customer energy managers, its behaviour will not be standardized, but the framework and the data structures for the interface will be standardized. If interoperability and the independence of the customer energy manager are a requirement, then a customer energy manager framework (CEMF) is needed. The task of CENELEC TC 205 WG 18 is to describe this CEMF in a normative way. The result of this WG will be the EN 50491-12 standard. As in reality there is not only one type of HBES in the market it is necessary to define a solution that enables to have a unique standardization in the grid and at the CEM. The solution is one common framework with one neutral standardized interface for the connection (mapping) of any HBES.

The input of the framework is described in the IEC 62746 [13] series. The framework will be described in EN 50491-12 [14]. The mapping to the HBES / BACS is described in the specifications of the different systems (e.g. EN 50090 series). In detail the architecture of the gateway is as follows (see Figure 7):

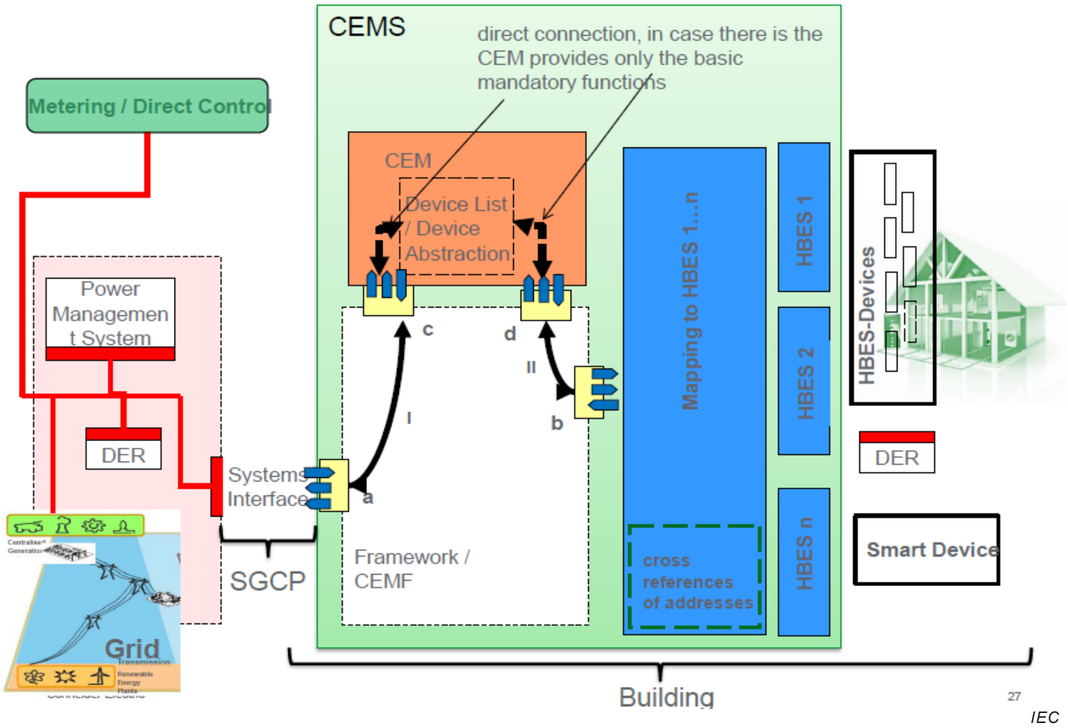


Figure 7 – Architectural details of the EN 50491-12 CEM framework

More details (with schematics of architecture) are presented in Clause B.2.

3.2.4 France perspective

France has already a long history and experience, recognized worldwide, in demand response, either through:

- Tariffs (supplier or utility): time of use, dynamic tariffs (critical peak pricing, fixed or variable, such as day/night tariffs or so-called "TEMPO" tariff).
- Incentive DR programs: direct load control and interruptible load (curtailment), proposed by utilities to cover internal needs, and potentially emergency programs.

France has launched Smart Grid initiatives at least in two major areas: the "Linky" smart metering program, and the "Smart Grid trials" program.

As a guideline framework to these initiatives (see details below), the Smart Grids standardization working group within the French Committee for the Strategic Orientation of Eco-Industries (COSEI) has especially formalized three high-level functional architectures, suitable for those programs (see Figure 8). Having been validated by the French Ministry of Industry (DGCIS), this work reflects a consensus among the stakeholders (French equipment manufacturers of the power sector, telecommunications operators and Électricité de France (EDF) Group) that are members of the Smart Grids standardization working group within the French Committee for the Strategic Orientation of Eco-Industries (COSEI). These three high-level functional architectures are located downstream of the electricity meter (smart home in the Smart Grid context). The scope focuses on electricity-related residential services and includes neither security nor health care services nor electric vehicles.

The architectures enable the management of electric flexibility within a smart home environment as well as the related customization and information services. The electric flexibility of a smart home is its ability to increase or decrease its electricity consumption in response to signals intended to change its load curve.

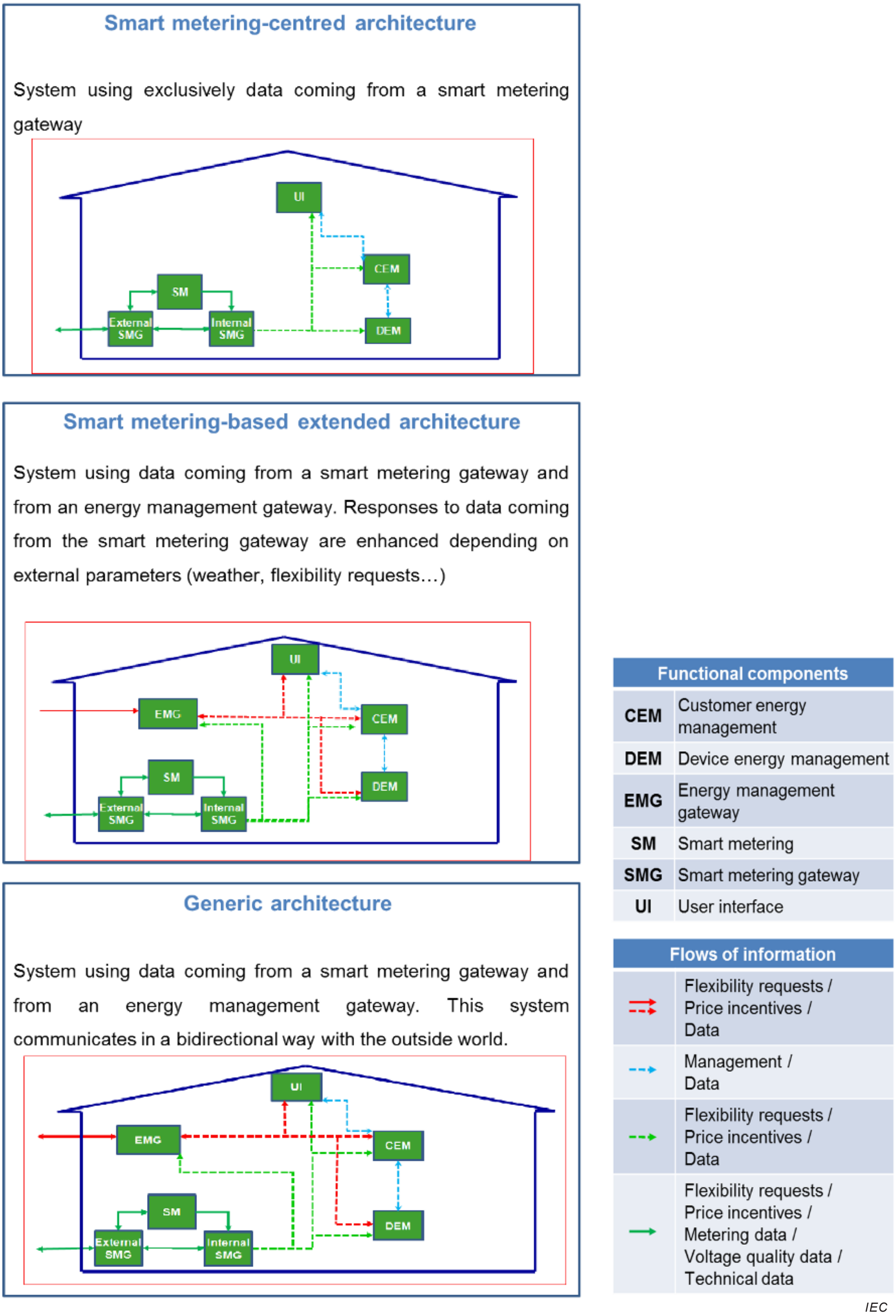


Figure 8 – Example COSEI architecture diagrams

In order to design these architectures, actor roles were identified, from which functional components of the smart home system were derived and the corresponding flows of exchanged information have been described through a use cases approach. These are shown in Figure 8. Indeed, a subset of the use cases that have been submitted to the IEC TC 8 WG 6 (called "Generic Smart Grid requirements") is the following:

- Manage the electric flexibility of a smart home depending on price incentives received through the smart meter.
- Manage the electric flexibility of a smart home depending on flexibility requests received through the smart meter or a WAN-HAN interface.
- Manage exceptions to automatic responses related to price incentives or flexibility requests.
- Customize automatic responses related to price incentives or flexibility requests.
- Process information likely to impact the smart home behavior (mobile peak period notifications, weather forecast, consumption estimates, etc.).

The functional components are defined as:

- Smart metering (SM) – Combination of the following meter-related functions from the Smart Metering reference architecture:
  - Metrology functions including conventional meter display (register or index) that are under legal metrological control. When under metrological control, these functions shall meet the essential requirements of the MID (Measuring Instruments Directive – 2004/22/CE);
  - One or more additional functions not covered by the MID. These may also make use of the display.
- Internal smart metering gateway (Internal SMG) – Meter communication functions between the smart meter and the smart home.
- External smart metering gateway (External SMG) – Meter communication functions between the area of grid and the smart meter.
- Energy management gateway (EMG) – Borderline between the WAN and the HAN.
- Device energy management (DEM) – Function adapting the operations of a given electrical device depending on the incoming orders, resident customization and potential exceptions that may be manually done locally.
- Customer energy management (CEM) – Function enabling the definition of energy management strategies of one or several related DEM depending on metering data, price incentives, flexibility requests, additional information coming from other channels such as the Internet, resident customization and potential resident dispensations. This function includes a processing ability notably in order to take resident customization and electrical data enhancement into account.
- User interface (UI) – User interface for the resident or the client. The UI can be connected to the smart home HAN or to the WAN.

Table 1 presents the correspondence between some examples of hardware components that can be found in a smart home environment and their potential integrated functional components. It is not intended to be exhaustive.

Table 1 – Correspondence between hardware components in smart homes and their potential integrated functional components

		Functional components						
		SM (Smart metering)	Internal SMG (Internal smart metering gateway)	External SMG (External smart metering gateway)	EMG (Energy mgmt gateway)	CEM (Customer energy mgmt)	DEM (Device energy mgmt)	UI (User interface)
Examples of hardware components	Smart meter	X	X	X				X
	Smart meter radio transmitter toward the smart home		X					X
	Interface between the HAN and the low-voltage grid			X				
	WAN-HAN interface				X			X
	Smart Home controller					X		X
	Appliances (connected home devices, that can receive orders; e.g., air conditioners, heaters,…)						X	X
	Smart appliances (connected home devices with embedded “intelligent” capabilities: clothes washer, heat pump, refrigerator)					X	X	X
	Display							X

The above generic architecture entirely reflects a consensus among the French stakeholders. In this architecture, as the system uses data coming from two sources, electric flexibility can be managed in a more complete way, covering more business cases.

Those reference architectures are suitable for the following programs:

a) “Linky” smart metering program

In conformance with the European directive, EDF has launched the Linky program in order to replace by 2020 the current metering system by an advanced metering infrastructure, potentially including 35 million meters.

As a first step, a trial comprising the deployment of 300 000 meters was done in 2012 in the areas of Lyon and Tours. After one year, the feedback and learnings are successful. The French government has validated the launch of the first step of the generalization. EDF Group launched in July 2013 a tender for the provision of 3 million of Linky smart meters that are to be deployed in 2015 and 2016.

This deployment of the Linky smart metering system will pave the way for the Smart Grids in France. In addition, the details for DR through smart meter infrastructure, including architecture diagrams, are presented in Clause B.3.

b) Smart grid trials program

The French Environment and Energy Management Agency, ADEME, has launched an important Smart Grid program through several calls for tenders for Smart Grid trials projects, co-founded by the partners of the projects and by the ADEME.

These trials projects are focused on some or all of the five main Smart Grid targets:

- integration of renewable energy, at the grid level and/or at the end customer location;
- integration of energy storage (thermal, battery, other) at the grid level and/or at the end customer location;
- demand response (generator/storage/load – tariff & direct control);
- network management and control;
- energy services (information to customers, control of equipment to optimize the response, etc.).

In addition, the integration of electrical vehicles was also considered in a new trial project launched in 2013.

These targets are closely bound to each other, and the demand response or demand side management may be considered as central and embedded in almost all the projects.

As an example, the three following projects can be seen as the most remarkable projects:

- Smart Electric Lyon, in the area of Lyon, is targeting smart grid compliant equipment in the home that is able to adapt to the demand response signals sent through the Linky smart metering infrastructure, with trials in 25 000 households.
- Nice Grid, in the area of Nice, is targeting grid stability with a high level of integration of renewables (photovoltaic systems), energy storage, on the grid or in the homes, and demand response at the customer level. Nice Grid is one of the six demonstrations of the European GRID4EU project, the Large-Scale Demonstration of Advanced Smart Grid Solutions with wide Replication and Scalability Potential for Europe.
- Millener: in the context of isolated electric grids, with non-existent or small interconnections such as insular systems, the project, dedicated in the residential sector, aims at better integrating massive penetration of dispersed solar home systems through demand response and individual battery storage. It also tests energy saving solutions (information to customer).

3.2.5 Korea perspective

In order to establish Smart Grid infrastructure, Korea introduced the “Intelligent Power Grid Development and Distribution Promotion Act” in 2011. On the basis of this Act, standardization activities have been implemented mainly by the Korean Agency for Technology and Standards (KATS), and the Korea Smart Grid Association (KSGA), which are the governmental and private organizations, respectively.

KATS has designed the strategic policy of Smart Grid standardization, and the framework and roadmap of the Smart Grid interoperability, etc. Further, a coordinator appointed by KATS has the role to coordinate various related sectors and to support standard-related R&D and business. KSGA is involved in the standardization activities through the Smart Grid Standardization Forum, consisting of about 500 experts.

The framework and roadmap (see Table 2), the basis of Korean Smart Grid standardization, specify 9 domains (generation, transmission, distribution, marketing, operation, service provider, distributed resource, consumer, transportation), as well as selecting 50 developing items and 27 prioritized items out of 6 application services (AMI, DR, EV, wide area situational awareness (WASA), distributed energy resource/energy storage DER/ES, distribution grid management (DGM)). Further, a detailed standardization plan is scheduled to be added and the framework to be updated, reflecting the outcome of operating the test-bed and the implementation of the business plan.

With regard to the smart grid user interface, Korea is conducting various tests, including the Jeju Smart Grid test bed, intelligent DR, etc., the results of which are taken into account in designing the framework and application services.

Table 2 – Korean framework domains and relation to SGUI

<table>
<tr><th>Top 3 domains</th><th>9 domains</th><th>Application services</th><th>Relation to SGUI</th></tr>
<tr><td rowspan="3">Smart power grid</td><td>Generation</td><td rowspan="9">1. Advanced metering infrastructure
2. Demand response
3. Electric vehicles
4. Wide area system monitoring and situation awareness
5. Distributed energy resource /energy storage
6. Distribution grid management</td><td rowspan="9">1. High level
2. High level
3. High level
4. Low level
5. High level
6. Middle level</td></tr>
<tr><td>Transmission</td></tr>
<tr><td>Distribution</td></tr>
<tr><td rowspan="3">Smart service</td><td>Market</td></tr>
<tr><td>Operation</td></tr>
<tr><td>Service provider</td></tr>
<tr><td rowspan="3">Smart prosumer</td><td>Distributed energy resource</td></tr>
<tr><td>Customer</td></tr>
<tr><td>Transportation</td></tr>
</table>

NOTE 1 Pilot programs related to SGUI conducted in the Jeju Smart Grid test-bed include tests to optimize the power consumption of residence and commercial buildings, and to run the business model of selling power generated and stored by the consumer to the power company. Additionally, tests cover controlling electrical appliances by applying the Smart Energy Profile (SEP) transferred by the Energy Service Provider

NOTE 2 An intelligent DR program is operated in trial with a view to maintaining the reliability of the power system applied with OpenADR 1.0 in the structure of DRAS (demand response automation server)/client.

3.2.6 Japan perspective

In four demonstration tests from 2010 to 2014 (Table 3), utilities employed smart meters to test the effectiveness of seasonal and time-specific rates. In addition to TOU and CPP rates, which factor in price elasticity, they also tested rebates, including PTR (peak time rebates) and CBP (critical bottom pricing). The Kitakyushu demonstration test features, real-time pricing—a system where electricity prices change based on increases or decreases in demand each day. The test began in April 2012.

Table 3 – Four regional demonstration tests in Japan

Region	Overview
Yokohama City	Tokyo Electric Power et al. plan to begin testing demand response in the spring of 2013, with the ultimate goal of expanding targeted households to 4 000 homes. It plans to use data from the test in its evaluations of dynamic pricing and other flexible pricing options for its service area.
Toyota City	Toyota and Chubu Electric Power have been testing demand response since December 2011.
Keihanna District	Beginning in the summer of 2012, Kansai Electric Power et al. will be testing demand response in 900 households.
Kitakyushu City	In April 2012, the City of Kitakyushu, Nippon Steel et al. plan to test a “real time pricing” system, which changes electricity prices on any given day in response to supply and demand. This test, the first such attempt in the world, will involve 230 households and 50 factories and other industrial establishments. The findings from this test will be provided to Kyushu Electric Power.

3.2.7 India perspective

In August 2013, the Ministry of Power, Government of India, released the “Smart Grid Vision and Roadmap for India”. The road map covers the 12th, 13th and 14th 5-year plan periods from 2012 to 2027, and outlines a series of time-framed, target-driven measures, across different areas for development of the Smart Grid model for India. This document was created by the participation and collaboration of member organizations of the India Smart Grid Forum and the India Smart Grid Task Force.

In line with the roadmap, a set of 14 pilot projects have been initiated in India. The functional areas that will be demonstrated in these projects are listed as follows, with the number indicating the number of pilot projects in which that function is addressed.

a) Advance metering infrastructure, residential – 9
b) Advance metering infrastructure industrial – 13
c) Peak load management (PLM) – 10
d) Demand response (DR) – 10
e) Outage management (OM) – 7
f) Power quality (PQ) – 4
g) Distributed generation (DG) – 2
h) Micro grids (MG) – 1

It can be noted that in most of the pilot projects advanced metering infrastructure, peak load management, and demand response play an important role. These areas also come under the Smart Grid user interface between the grid side operators and the customer side operators. Hence, standardization of the Smart Grid user interface is of particular interest for India.

NOTE Link to India Smart Grid Vision and Roadmap:
http://indiasmartgrid.org/en/Lists/News/Attachments/154/India Smart Grid Forum Booklet.pdf

3.3 Use cases from PC 118 member countries

3.3.1 General

Subclause 3.3 presents an introduction to the use cases contributed by member countries. Member countries were asked to provide use cases each country believed relevant to the SGUI. More details on these use cases may be found in Annex C.

3.3.2 China use cases

Table 4 – China use case classification and use case summary

Use case	Name of use case category	Short description
CN01	Generic	Common and basic UC
CN02	Demand response (DR)	DR related UC
CN03	Energy efficiency (EE)	Evaluation of EE related UC
CN04	Distributed energy resource (DER)	DER management related UC
CN05	Electric vehicle charging (EVC)	EV charging related UC
CN06	Load management(LM)	LM related UC

Detailed descriptions for the Chinese use cases (Table 4) are given in Clause C.2.

3.3.3 Korea use cases

Table 5 – Korea use case category table summary

No.	Title
KR01	Visualization for interaction through existing users' screens
KR02	Managing devices through/by ESI (energy service interface)
KR03	Distributed energy generation and injection
KR04	Customers reduce their usage in response to pricing or voluntary load reduction events
KR05	Demand response signal generation for controlling home appliances
KR06	Energy storage clustering
KR07	Customers' EMS controls EV's electric charge and discharge

The Korean use case (Table 5) details are presented in Clause C.3.

3.3.4 Japan use cases

Table 6 – Japan use case category table summary

Number	Title
JP01	Control Battery via home energy management system (HEMS)
JP02	Control distributed energy resources (DER) via home energy management system (HEMS)
JP03	Control energy consumption with smart appliances by building energy management system (BEMS)
JP04	Control energy consumption with smart appliances by community energy management system
JP05	Control energy consumption with smart appliances by energy provider
JP06	Control energy consumption via home energy management system (HEMS) with smart appliances
JP07	Peak shift contribution by battery aggregation (virtual energy storage)
JP08	Control of smart home appliances based on price information by time slot
JP09	Control of smart home appliances in response to power saving request from electric power supplier
JP10	Control of smart home appliance before power cut
JP11	Control of smart home appliances in case of natural disaster

Japan use case (Table 6) details are presented in Clause C.4.

3.3.5 France use cases

Table 7 shows a synthesis of use cases (relevant to PC 118) provided by French experts, in the context of the M490 mandate of the European Commission (Standards Mandate for Smart Grids, Sustainable Process Workgroup):

Table 7 – France use case category table summary

#	Title	Reference	Comment
FR01	ECS load control	UC_ECS	This use case describes a load control system linking together an on/off peak tariff, the metering system and the electric water heating tank of the customer. This system is currently an existing load shifting and energy storage solution (for specific markets / geographical area). In particular, in France, addressing several millions of hot water tanks, it brings a major contribution to the balance of the French electric system.

#	Title	Reference	Comment
FR02	Dynamic pricing of electricity and energy management	UC_TEMPO	This use case describes a load control system using a dynamic pricing of electricity in order to help the electric system in the days of very high peak demand. This system currently exists in France: the tariff is named “Tempo”, and several hundreds of thousands customers have adopted it and, either manually or with the help of an energy manager device connected to the meter, they modulate the use of their electric heating according to the periods of the tariff.
FR03	Managing a superseding tariff schedule	UC_PC_14	The customer benefits from reduced tariffs in exchange for handing over control to the supplier during periods of peak demand. In case the customer does not transfer command the tariffs are higher.
FR04	Handle a tariff event through managed equipment	UC_PC_16	The customer optimizes costs for energy usage through granting / revoking permission to operate equipment in accordance with the tariff regime or tariff events.
FR05	Handle a tariff event by local intelligence	UC_PC_17	The customer optimizes costs for energy by managing the utilization (run, stop, reduced) of electrical appliances based on tariff regime and tariff events.

Details of these use cases are presented in Clause C.5.

3.3.6 India use cases

Table 8 – India use case category table summary

IN01	Energy efficiency	Including 5 sub-cases
IN02	Demand response for peak load reduction	Including 2 sub-cases
IN03	Home energy management	Including 6 sub-cases
IN04	Building energy management	Including 11 sub-cases
IN05	Local markets to enable consumer-prosumer open access transactions	
IN06	Deliver output reports of demand side equipment in standardized data formats to users	

Details of India use cases (Table 8) are given in Clause C.6.

3.3.7 U.S. use cases

The following United States use cases (Table 9) are derived from information developed in the SGIP and elsewhere for high-importance interactions across the SGUI. There are many more detailed use cases including those from the Energy Information Standards Alliance (EIS Alliance) that are not summarized here.

Table 9 – U.S. use case category table summary

US01	Convey price and product definition	Price and product definition was a cross-cutting priority in the US smart grid project.
US02	Enable markets (transactive energy)	Markets at the wholesale level are widely used globally. More local markets and interactions to determine price by open market operations have gained importance since 2000.
US03	Convey demand response and distributed energy resource requests and information	Demand response is one way of demanding the supply; the use of DER is another. These are functionally the same, differing primarily in what equipment might be used to carry out the requests. The so-called "fast DR/DER" is one kind of ancillary service.
US04	Monitor response to DR/DER requests	Monitoring may take place via measurement or end node response data.
US05	Convey ancillary services requests	This includes monitoring of response to service requests. Ancillary services include regulation, ready reserve, and other functions, many of which may be requested (and responded to) via so-called "fast DR" which in fact often uses DERs such as storage and generation. This use case focuses on the service, not the means for carrying out the service.
US06	Deliver historical, present, and future demand, usage, and price	Price and market results may flow either direction across the SGUI. Historical information is an important input to energy efficiency and commissioning analyses. Current information from the end node or via the top node (using meters installed for accumulation) helps manage facilities and end nodes using already paid-for equipment. Future demand may be projected or contracted. Future price may likewise be projected or contracted.
US07	Monitor and convey power quality	This affects both the supplier and consumer. Power quality around the world measures largely the same attributes of power, but establishes regional, national, or global criteria for acceptability. Power quality is important to consumers, and consumer behavior (e.g. power factor) may affect supplier power quality.
US08	Deliver requests for monitoring and status information	This is the dual of US04, independent of specific DR/DER events, and also overlaps with US06. The focus of this use case is on the delivery rather than the information requested.

3.4 Use case analysis

3.4.1 General

The use case analysis has been done in two parts. First, in Clause 2 above, the high-level functional requirements, quality requirements, architecture and actors have been presented. Subclause 3.4 presents an analysis that shows how the use cases fit into the different use case classes of 2.3.

Some exceptional use cases have been called out in 3.5 for potential further consideration and discussion.

3.4.2 Service and control interactions

There are generally two ends to the SGUI interaction scale, from top to bottom as shown in Figure 2 in 2.3. The DR interaction scale in 2.3 progresses from a direct control level at the bottom to a service-based interaction at the top. In this use case analysis, the lowest layer of Figure 2 is being called "control", the second layer of Figure 2 is being called "device class service request", and the top two layers together are being called "service request". The service request interactions have decoupled service requests and optional responses; the role of requester and responder may change from interaction to interaction. Services generally communicate a higher-level request of what is to be done, rather than detailed instructions on how to accomplish a desired result. The control interaction is most similar to control of specific devices (such as with building automation), requiring device-level information (capabilities, control protocol). However, if simply shutting off power to a simple device (i.e., DLC), then no knowledge of the device itself is required. Some use cases in the control category are DLC shutting off power, and some seem more like energy management control signals at the device level.

3.4.3 Use case taxonomy

Use cases have been classified based on interaction and information needs. We define a two-dimensional taxonomy: the first dimension is the use case classes, and the second dimension is the scale from "control" to "service request". The first dimension "use case classes" are shown in Table 10 and align with 2.4 functional requirements.

Table 10 – SGUI functional use case classes (UCC) and descriptions

UCC no.	Use case class (UCC)	Description (also see 2.4 for more details)
1	Market interactions	Market transactions and interactions.
2	Convey price information	Price information.
3	Convey ancillary services (AS) signals	AS including faster response change in use (e.g.) phase control; sometimes these functions are implemented using so-called "fast DR" which is a service provided by curtailment and increase.
4	Convey DR and DER signals	Demand response or distributed energy resource events.
5	Convey indications of impending power failure or grid instability	Notification of impending power failure or grid instability that may result from natural disasters, weather, or other events.
6	Convey directed interaction requests (includes DLC)	Use cases suggest direct interaction with a device through service or control-centric means to address specific device response or behavior.
7	Convey energy usage data (meter data)	Historical, present, and projected information. For example, projected demand, historical usage, and response to a curtailment event.
8	Convey monitoring information	Monitoring and verification of the state of energy management and use, e.g., with respect to response to a curtailment, generation, or storage draw request.

The second dimension is the classification of whether the use case uses a direct control (device-centric) approach, or a service request approach. This classification takes into account the degree of visibility and management of internal state in the facility system/device. This dimension runs from left to right in the columns, and is labelled "interaction style." The classes are:

- Control: potentially extensive information from the internal structure and programming of the facility system/device is available to the grid-side actor; requests may consider and specify internal information. This approach is used for facility automation system outsourcing. Direct load control (where power to a device is shut off) is also included.
- Device class service request: Certain communication may be communicated to and from known and specific subsystems or devices that may be attached to a facility. The use cases include electric vehicles, storage, appliances, and alternate supply sources such as wind or photovoltaic panels.
- Service request: only the limited information in the service interface is available to the grid-side service partner; requests are delivered to the boundary.

3.4.4 Analysis and classification of use cases

Some use cases from 3.3 describe the remote control and management of devices, as in cloud-based or energy management aggregation or outsourcing services. Those have been classified as control. For those cases, it may be possible to use a more indirect approach to accomplish the same use case and thereby receive the benefits of moving up the DR interaction stack (as explained in 2.3). However, this also may not be possible, as with simple devices with no local intelligence to receive and act on service requests. Then direct load control (2.3.2.2) is appropriate and needed to enable DR.

The 43 use cases in Clause 3 are listed as entries in Figure 9. Some classifications are uncertain or ambiguous, indicated with a question mark in the listing in the table; for the summary statistics these were counted as ½ unit. Some use cases fit in more than one cell, and are counted more than once.

Use case class	Control	Device class service request	Service request
Market transactions		US02	US02, IN04, IN05
Price		KR05, JP01, JP02, JP04, JP05, JP06, JP08, FR01, FR02, FR04, US01	KR01, KR02, KR03, KR04, JP02, JP03, JP04, JP05, JP08, FR02, FR03, FR04, FR05, US01, CN01, CN02, CN04, CN05, IN02, IN03, IN04, IN05
Ancillary services		KR06, KR07, JP07, FR01, US05	FR05, US05, CN02, CN04, CN05
DR/DER event	JP01, JP07, CN06	KR05, KR06, KR07, JP01, JP02, JP03, JP04, JP05, JP06, JP09, FR03, FR04, US03, US05, US08, IN02	KR02, KR03, KR04, JP02, JP04, JP06, JP09, FR03, FR04, FR05, FR06, US03, US05, US08, CN02, CN04, CN05, CN06, IN01
Power failure/ Grid instability		JP10, JP11	JP10?, JP11?
Directed interaction	JP05, JP07, CN06, IN01?	FR01, FR03, FR04, US01, US03, US05	FR03, FR04, US01, US03, US05, IN01, IN05
Information passed: history/present/future		US06, IN04	KR01, US06, CN01, IN04, IN06
Information passed: monitoring	CN06	KR06, KR07, JP01, US03, US04, US05, US07, US08, IN01, IN03, IN04, IN05	KR01, JP02, JP03, JP05, JP08, JP09, JP10, JP11, US03, US04, US05, US07, US08, CN01, IN01, IN02, IN03, IN04, IN05
Interaction style	**Control**	**Device class service request**	**Service request**

IEC

Figure 9 – Summary classification of submitted use cases with three interaction styles

The distribution of use cases in Figure 9 is reduced to the number of use cases in each category for the simplified presentation in Figure 10. It is difficult to classify some use cases. Also, the above classifications do not address the relative importance assigned by PC 118 to the various use cases.

	Control	Device class service request	Service request	*Row totals*
Market transactions		1	3	***4***
Price		11	22	***33***
Ancillary services		5	5	***10***
DR/DER event	3	16	18	***37***
Power failure/ Grid instability		2	1	***3***
Directed interaction	5,5	6	7	***18,5***
Information H/P/F		2	5	***7***
Monitoring	1	12	19	***32***
Column totals	***9,5***	***55***	***80***	***144,5***

IEC

Figure 10 – Cross-tabulations of use cases by category with three interaction styles

Based on the cross tabulations in Figure 10, we may observe that for the use cases:

- 26 % are classified as market interaction or price communication,
- 33 % together encompass ancillary services (7 %) and DR/DER (25 %),
- 13 % are classified as directed interaction,
- 27 % address monitoring and energy information of some nature; this total includes those for “control” and “device class service request” interactions.

3.4.5 Summary of use case analysis

The UC classes show the SGUI functions which group the information passed to meet specific SGUI functional requirements. The simple analysis presented above shows how the different use cases were classified within the different functional use case classes. The UC class descriptions are presented in more detail in 4.4, along with relevant standards.

3.5 Special considerations

3.5.1 General

Subclause 3.5 reviews several topics that have been identified as requiring some special attention. The scope of SGUI may or may not address these areas in detail and these and potentially other areas are open for consideration for future work.

3.5.2 Meter interactions

Automated metering infrastructure (AMI, or smart metering) is a networking technology that may be used to accomplish some or all of the use case functions as described in 2.4. Utility communications with utility meters over a utility network connection qualify as SGUI communications. Automated meter reading (AMR) requires meter data management protocols and meter data access. There are several existing national and international standards for communications with meters.

The IEC 62056 DLMS/COSEM suite [1] supports use cases for contract and billing (and others) as follows (for use case classes (UCC) refer to Table 10):

- Obtain meter readings on demand: UCC no.8.
- Obtain scheduled meter reading: UCC no.8.
- Set and maintain contractual parameters in the meter. The contractual parameters consider the credit mode or the debit mode (pre-payment) operation of the meter: UCC no. 2.
- Execute supply control: UCC no. 4.
- Execute load control: UCC no. 4.

To understand the complete set of the DLMS/COSEM suite refer to IEC 62056-1-0 [1] for further information.

The meter may contain the SGUI and serve as a gateway to a home/facility. However, the function of the meter as a metrology device and the data management protocols used by the energy service provider to talk to the meter are separate from the SGUI.

Energy revenue metering services include the following (the purpose of this report is not to fully dig into these related services, but by acknowledging these services are part of SGUI, to identify the area of inter-action/interoperation/optimisation between the requirements listed above, and revenue metering related functions listed below). These services may have to comply with local/regional regulation related to metrology as well as data privacy and security:

- support data retrieval for billing and other metrological or fiscally relevant purposes concerning energy usage and, where available, energy generation;

- enable remote collection of additional data regarding the operation of the meter and the network, including power quality, outage information, technical and non-technical losses;
- get configuration data to energy end-users, including contractual parameters, tariff schedules, pricing and operational information, time synchronization, firmware updating etc.;
- support advanced tariff and payment options;
- remote enabling / disabling of supply, including flexible load limitation where and when system conditions require.

3.5.3 Electric vehicles and other storage

Communications/interactions with EVs are handled in other IEC (and SAE) standards. Readers are referred specifically to the IEC SG3 roadmap section on e-mobility. Second, there is active work in TC 57 addressing mobility: 57/1254A/DC: IEC TR 61850-90-8: IEC 61850 object models for electric mobility. We agreed in PC 118 discussions that we would consider EV in the context of stationary batteries but not address mobility. It is not the desire of PC 118 to compete with other EV standards activity, although the goal is to understand the role of EVs as distinct from other storage, and then to consider potential standards gaps for SGUI.

Charge status is covered under UCC no. 8 in 2.4. Direct interaction to charge or discharge is included in UCC no. 6. Financial communications (tariffs and transactions) may be addressed in UCC no. 1 and UCC no. 2.

4 Smart grid user interface standards

4.1 General

The purpose of Clause 4 is to review existing standards (both completed and in development) relevant to SGUI requirements, analyze how these standards can fit together to meet the SGUI needs, identify use case classes and relevant standards to meet the SGUI requirements, and finally, identify any standards gaps for development.

4.2 Overview of existing standards

Subclause 4.2 includes existing published standards and standards currently in development that have some relevance to the SGUI. These include information model standards and communication protocol standards relevant to communications across the SGUI, relevant to actors on the grid side (touching the SGUI) or relevant to actors on the facility side (touching the SGUI). The purpose of 4.2 is to review work already done or in progress (i.e., draft standards) in order to compare and contrast the available standards to the identified SGUI requirements (Clause 3). The analysis in 4.3 helps to identify standards gaps for the SGUI, which are summarized in 4.5.

Existing standards have been organized into three tables. These tables correspond to the three parts shown in Figure 1. A more detailed version of that figure is in Figure 11.

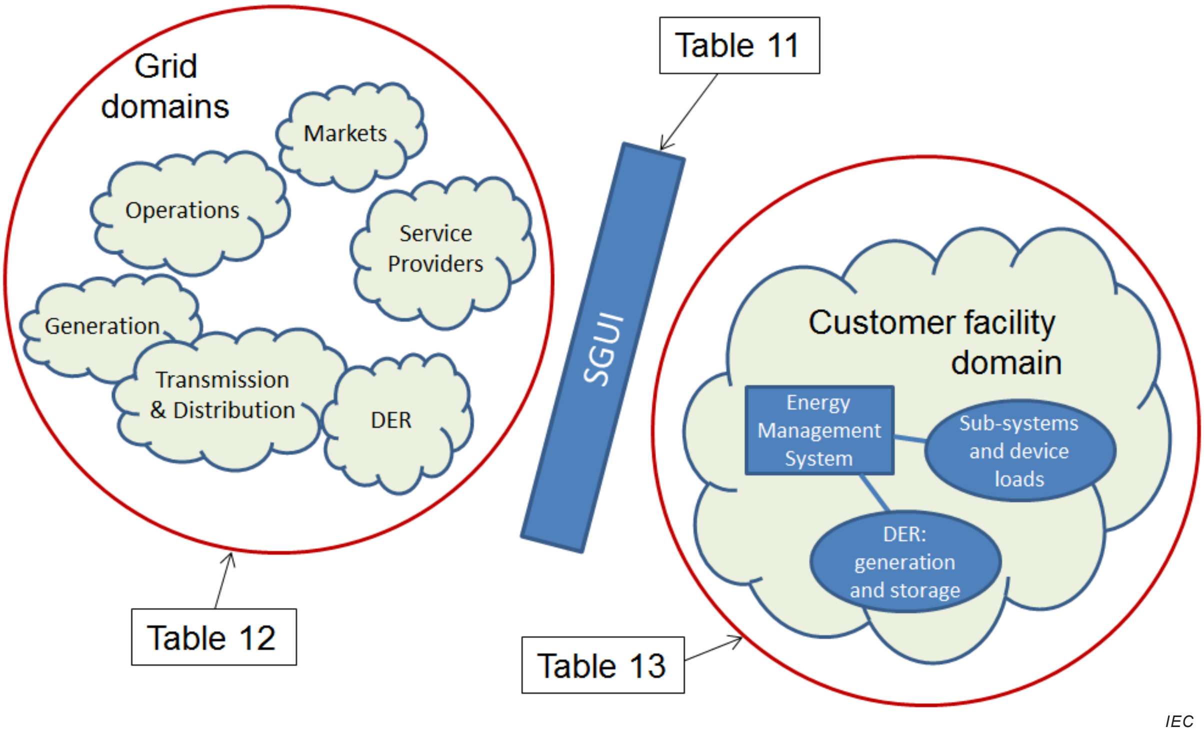


Figure 11 – Classification of standards in the following tables based on SGUI (Table 11), grid-side domains (Table 12) and facility-side domain (Table 13)

These three tables list standards that are at least potentially relevant to the SGUI standards analysis; a brief summary for each standard is in Annex D. The standards are listed in the category most appropriate to the predominant subject matter or scope. The three tables follow the Figure 1 pattern with two domains and the SGUI as the interface between the two domains. The three tables are:

- Table 11: Standards relevant to SGUI (the interface between the customer facility-side and grid-side domains). SGUI standards are relevant also to both the grid-side and facility-side.
- Table 12: Standard relevant to the grid-side of the SGUI.
- Table 13: Standards relevant to the customer facility-side of the SGUI.

Table 11 – Standards relevant to the SGUI

Standards category (sub-domain)	Short description	Standard status
System interface between customer energy management and power management	**IEC 62746** series: Systems interface between customer energy management system and the power management system. The IEC 62746 series defines system interfaces, communication protocols and profiles between power management systems based on TC 57 standards and Home/Building/Industrial Energy management systems.	Draft IEC standard
	IEC PAS 62746-10-1 ed1.0 Open Automated Demand Response (OpenADR 2.0b Profile Specification). Demand response (DR) and distributed energy resources (DER) communications and security, as well as price distribution for wholesale and retail markets. The OpenADR 2.0 public specification includes the following clauses: 1. Feature set profiles 2. Services and data model extensions 3. Transport protocols 4. Transport-specific security, and profile security 5. Conformance statements In addition, the package also has 2.0b Schema. OpenADR 2.0 is a profile and extension of OASIS Energy Interop 1.0. OpenADR 2.0 to the extent possible supports the use cases presented in this	IEC PAS

Standards category (sub-domain)	Short description	Standard status
	report. Any additional future use cases will be reviewed by PC 118.	
	IEC/TS 62872: Industrial process measurement, control and automation – System interface between Industrial Facilities and the Smart Grid, in development in IEC TC 65.	CD
	OASIS Energy Interoperation 1.0: Demand response (DR) and distributed energy resources (DER) communications as well as price communication and market transactions.	OASIS standard
	OASIS Energy Market Information Exchange (EMIX): Information model for price and product description for the Smart Grid and used by OpenADR.	OASIS standard
	OASIS WS-Calendar: Information model for energy schedule communication for the Smart Grid and used by OpenADR.	OASIS standard
	NAESB Energy Services Provider Interface (ESPI) standard and "**Green Button**" application. The Green Button defines energy usage (meter) information.	U.S. National standard
	SEP 2.0 (IEEE P2030.5): Communications of pricing, DR signals, messaging, and energy usage to in-home devices.	IEEE standard
	AS/NZS 4755 Framework for DR capabilities and supporting technologies for electrical products. DR standard for appliances, being considered in IEC TC 59.	IEC ANW 59-604

Table 12 – Standards relevant to the grid-side of the SGUI

Standards category (sub-domain)	Short description	Standard status
AMI standards	**IEC 62056:** Data exchange between the Meter Data Management system (or Head End System, HES) MDM, and the revenue meter. • International standard versions of the DLMS/COSEM specification. • Tariff structures and load control practices vary across countries. The data models of IEC 62056-6-2 are universal enough to cover the different tariffing and load control use cases established in different markets. Market specific configurations are achieved by market specific companion specifications based on the IEC 62056-6-2 standards (comp. IEC 62056-1-0). IEC 61968-9: The standard specifies data exchange between the ERP system and the MDM or HES for revenue metering. The mapping between the data models of IEC 62056 (COSEM) and IEC 61968 (CIM) is being defined in IEC/TS 62056-6-9	
Power distribution management system	**IEC 61968 series:** Application integration at electric utilities – System interfaces for distribution management • Part 1: Interface architecture and general recommendations • Part 2: Glossary • Part 3: Interface for network operations • Part 4: Interfaces for records and asset management • Part 8: Interface standard for customer support (work in progress) • Part 9: Interfaces for meter reading and control • Part 11: Common information model (CIM) extensions for distribution • Part 13: CIM RDF Model exchange format for distribution	
Power distribution management system (cont)	**IEC 61970 series:** Energy management system (note: NOT building EMS) application program interface (EMS-API) • Part 1: Guidelines and general requirements • Part 301: Common information model (CIM) base • Part 401: Component interface specification (CIS) framework • Part 402: Common services • Part 403: Generic data access • Part 404: High speed data access (HSDA) • Part 405: Generic eventing and subscription (GES) • Part 407: Time series data access (TSDA) • Part 453: CIM based graphics exchange	

Standards category (sub-domain)	Short description	Standard status
	• Part 501: Common Information Model Resource Description Framework (CIM RDF) schema	
	IEC 61588: Precision clock synchronization protocol for networked measurement and control systems	
	IEC 61850 series: Communication networks and systems for power utility automation • Part 1: Introduction and overview • Part 3: General requirements • Part 4: System and project management • Part 5: Communication requirements for functions and device models • Part 6: Configuration description language for communication in electrical substations related to IEDs • Part 7: Basic communication structure for substation and feeder equipment • Part 8X: Specific Communication Service Mapping (SCSM) • Part 9Y: Specific communication service mapping (SCSM) • Part 10: Conformance testing	
	IEC 62351 series: Cyber-security standards— • Part 1: Communication network and system security – Introduction to security issues • Part 3: Communication network and system security – Profiles including TCP/IP • Part 4: Profiles including MMS • Part 5: Security for IEC 60870-5 and derivatives • Part 6: Security for IEC 61850 • Part 7: Network and system management (NSM) data object models • Part 8: Role-based access control (work in progress)	
	IEC 62488-1: Power line communication systems for power utility applications – Part 1: Planning of analogue and digital power line	
Distributed generation and micro grid	**IEC 61400-25:** Wind turbines – Part 25: Communications for monitoring and control of wind power plants.	
	IEEE 1547: Standard for Interconnecting Distributed Generation and Micro-grid	
	IEC 61850-7-420: Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes	
	OpenADR 2.0b Profile Specification Demand response (DR) and distributed energy resources (DER) communications.	IEC PAS
Wholesale markets	**IEC 62325** – Framework for energy market communications. IEC 62325 series defines protocols for deregulated energy market communications to enable applications or systems access to public data and exchange information, with semantics based on IEC CIM.	Ed.1.0:IS, Ed.2.0:CD
	OASIS Energy Interoperation 1.0: Demand response (DR) and distributed energy resources (DER) communications as well as price communication and market transactions.	OASIS standard
	OASIS Energy Market Information Exchange (EMIX): Information model for price and product description for the Smart Grid and used by OpenADR.	OASIS standard

Table 13 – Standards relevant to the facility-side of the SGUI

Standards category (sub-domain)	Short description	Standard status
Building equipment communications	**ISO/WD 17800 Facility Smart Grid information model:** An information model to represent Smart Grid related energy information within a facility, and specifically the information that may need to be communicated to/from electric grid service providers across the SGUI (working draft; currently under development in ASHRAE/NEMA SPC 201P).	**WD**
	ISO 16484-5 BACnet (ANSI/ASHRAE 135-2012): A data communication protocol for building automation and control networks	**IS**
	ISO/IEC 14543 series communications architecture: Information technology -- Home electronic system (HES) architecture. • **ISO/IEC TR 14543-4**: Home and building automation in a mixed-use building • **ISO/IEC 14543-2-1**: Introduction and device modularity	
	ISO/IEC 14543-3 series communications protocol (based on **KNX**): • **ISO/IEC 14543-[3-1, 3-2]**, Communication layers: Application layer [3-1], network and data link layer [3-2] • **ISO/IEC 14543-3-3**, User process for network based control of HES Class 1 • **ISO/IEC 14543-3-4**, System management – Management procedures for network based control of HES Class 1 • **ISO/IEC 14543-[3-5, 3-6, 3-7]** , Media and media dependent layers for Power line [3-5], twisted pair [3-6], Radio frequency [3-7]	
	ISO/IEC 14543-5X series: Network configuration protocol (based on **IGRS**) Information technology – Home electronic system (HES) architecture -- Part 5-1: Intelligent grouping and resource sharing for Class 2 and Class 3 • **ISO/IEC 14543-[5-1, 5-21, 5-22, 5-3, 5-4, 5-5, 5-6],** Core protocol [5-1], Application profile – AV profile [5-21] and File profile [5-22], Basic application [5-3], Device validation [5-4], Device type [5-5], Service type [5-6]	
	ISO/IEC 14908 series communications protocol (based on LonTalk). IT -- Control network protocol • **ISO/IEC 14908-[1, 2, 3, 4]:** Protocol stack [1], Twisted pair communication [2], Power line channel specification [3], IP communication [4]	
	ISO/IEC 14543-4 series communications protocol (based on **ECHONET**): • **ISO/IEC 14543-[4-1, 4-2]:** Communication layers: Application layer [4-1] and Transport, network and data link layer [4-2] for network enhanced control devices of HES Class 1 **IEC 62394**: Service diagnostic interface for consumer electronics products and networks – Implementation for ECHONET **IEC 62480**: Multimedia home network – Network interfaces for network adapter **ISO/IEC 24767 series secure communications:** Information technology -- Home network security • **ISO/IEC 24767-[1, 2**:Security requirements [1], Internal security services: Secure Comm Protocol Middleware (SCPM) [2]	
	ISO/IEC 14762: Information technology -- Functional safety requirements for HBES	
	ISO/IEC 29145 series, wireless communications using a mesh network: Information technology –Wireless beacon-enabled energy efficient mesh network (WiBEEM) for wireless home network services. • **ISO/IEC 29145-[1, 2, 3]:** PHY layer [1], MAC Layer [2], NWK Layer [3]	
	IEC 61158-6 (ModBus): Modbus is a serial communications	

Standards category (sub-domain)	Short description	Standard status
	protocol commonly used for connecting industrial electronic devices	
	CENELEC EN 50491-12 Smart Grid interface and framework for Customer Energy Management CENELEC TC 205 WG 18. Specifies the data model to be used above the Application Layer, describes the general architecture and the main elements of the premises energy management system.	
Home energy management and gateway	**ISO/IEC 15067-3**: Information technology -- Home electronic system (HES) application model -- Part 3: Model of a DR energy management system for HES. Smart Grid application standard for DR, DER and local storage.	
	ISO/IEC 15045 series: Gateway to link home network and external network including Smart Grid communications. Information technology -- Home electronic system (HES) gateway • **ISO/IEC 15045-[1, 2]** residential gateway model for HES [1], Modularity and protocol [2]	
	ISO/IEC 18012 series (to be published)**,** Product interoperability to provide seamless operation of home system products including energy management complying with a diversity of communication protocols. IT-HES, Guidelines for product interoperability • **ISO/IEC 18012-[1, 2]** Introduction [1], Taxonomy and application interoperability model [2]	
	ISO/IEC 30100 series home network resource management. Information technology – Interconnection of information technology equipment – Home Electronic System – Home Network Resource Management • **ISO/IEC 30100-[1, 2, 3]:** Requirements [1], Architecture [2], Management applications [3]	
	Smart Energy Profile 2.0 (SEP2): Customer premises communications of pricing, demand response signals, messaging, and energy usage to in-home devices.	
	ANSI/CEA-2045: Modular Communication Interface: Details mechanical, electrical, and logical characteristics of a residential appliance socket interface that allows communication devices to be separated from end devices.	
EV standards	**SAE J2836** (use cases), **J2847** (requirements), and **J2931** (protocol) to address: Utility programs, DC Charging, Reverse power flow, Diagnostics, Customer to PEV and HAN, and wireless power flow.	

4.3 Standards gap context

4.3.1 General

Subclause 4.3 presents the procedure used for determining standards gaps and standards available to fill those gaps. In addition, it presents the classification system.

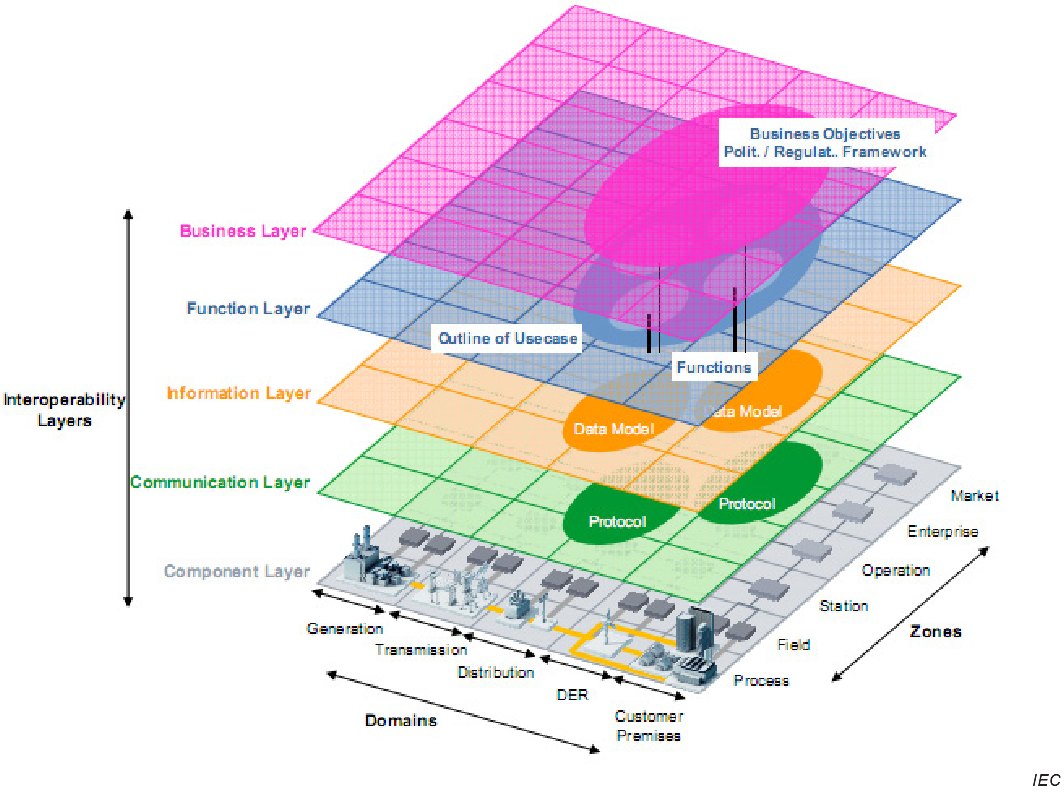
4.3.2 Standards gap analysis procedure

The standards analysis procedure is as follows:

1. Start with standards identified in 4.2.
2. Take the use case classes from 3.4 and examine available standards as to whether and how they meet the use case class requirements. We identify relevant and potentially relevant standards for each use case class (see 4.4).
3. From this analysis flows a summary of gaps and proposed plan for standards development (summarized in 4.5 and Clause 5).

To aid in the identification of standards gaps, the layers given in the Smart Grid architecture model (Figure 12) are used, recognizing that the communications across the SGUI are driven by business objectives with some specific function (use case). The use cases relevant to

SGUI are as given in Clause 3. The most important layers to analyse for standards gaps are the communication layer, the information layer, and the function layer.



NOTE Reference: SGCG/M490/B_Smart Grid Report. Extract from first set of standards (draft), version 1.1 (extract) Oct 16 2012.

Figure 12 – Smart Grid architecture model

In the tables that follow, the following identification categories are used:

- “C”, for “communication”, means that the given standard meets the communication (data exchange flow) requirements for the use case.
- “I”, for “information”, means that the given standard is an information model standard serving the use case class.
- “F” for “function” means that the given standard serves at the function layer for this use case class.
- The use of two or more letters “C”, “I”, or “F” means that each of the indicated requirements are (or are planned to be) met.
- Blank: means not applicable or not relevant.

4.3.3 Use case classification system

The following two tables classify the use cases in this technical report in two ways:

a) By use case class (3.4). This is used in Table 14.

b) By functional system. This is used in Table 15.

Classification by functional system indicates which system(s) in an implementation of today might contain or be related to actors in the use case.

The numbering convention throughout this technical report is two letters for country code and two digits for number.

Table 14 – Use case classes and relevant use cases

Use case class	Use case class name	Use case identifier
1	Market transactions	IN04 IN05 US01 US02 US06 JP08
2	Price	CN01 CN02 CN04 CN05 KR01 KR02 KR03 KR04 KR05 JP01 JP02 JP03 JP04 JP05 JP06 JP08 FR01 FR02 FR03 FR04 FR05 US01 IN02 IN03 IN04 IN05 US01
3	Ancillary services	CN02 CN03 CN04 CN05 KR06 KR07 JP02 JP07 KR03 FR01 FR05 US05 US08 IN03
4	DR/DER event	CN02 CN04 CN05 CN06 KR02 KR03 KR04 KR05 KR06 JP01 JP02 JP03 JP04 JP05 JP06 JP09 FR03 FR04 FR05 IN01 IN02 US03 US08
5	Power failure/ grid instability	JP10 JP11
6	Directed interaction	CN06 JP05 JP07 FR01 FR03 FR04 IN05 US01 US03
7	Historical, present, future projection information passed	CN01 KR01 IN04 IN06 US06
8	Monitoring information passed	CN01 KR01 KR06 KR07 JP01 JP02 JP03 JP05 JP08 JP09 JP10 JP11 IN01 IN02 IN03 IN04 IN05 US03 US04 US05 US07 US08

Table 15 – Functional systems and relevant use cases

System	Use case no.
AMI	CN06 KR04 IN01 IN05 US01 US04 US06 US07 US08
Distribution management system	CN01 CN02 CN04 CN05 CN06 IN06 KR02 US01 US05 US07 US08
EMS（customer）	CN01 CN02 CN06 KR01 KR02 KR04 KR05 JP01 JP02 JP03 JP04 JP05 JP06 JP08 JP09 JP10 JP11 FR01 FR02 FR03 FR04 FR05 IN01 IN02 IN03 IN04 IN05 IN06 US01 US02 US03 US04 US05 US06 US07 US08
DER management system	CN04 IN06 KR03 KR06 JP01 JP02 JP07 US03 US04
EV management system	CN05 IN06 KR07
DR system	CN02 CN06 KR04 KR05 JP05 JP09 FR01 FR02 FR03 FR04 FR05 IN02 IN06 US01 US02 US03 US04 US05
Transaction system	KR04 JP08 FR03 FR04 FR05 IN05 IN06 UN01 UN02 US01 US02 US06

4.4 Use case classes and relevant standards

4.4.1 General

Clause 4.4 presents details of the use case classes (UCC) as given in Table 14 above. Each UCC has a title, description, sources, discussion, and conclusion. Following the conclusions is a table listing relevant standards that apply to use case requirements for each UCC.

4.4.2 UCC 1—Interact with markets

Class 1: *Use case class title:* **Interact with markets**

Use case class description:

This requirement implies the communication of market prices and the ability to respond to price information. Market transactions between the grid and the user are used to buy or sell electricity under terms that can be negotiated using the interface. Market transactions require a client that knows its forecast demand or generation in order to bid into a market. Price-takers or price-accepting interactions are described in Class 2.

Use case class 1 sources:

IN04 US01 US02 US06 JP08.

Discussion:

Relevant standards for use case class 1 are presented in Table 16[8]. Details of market design are out of scope. IEC 62325 focuses on information models and structures for wholesale markets in the EU and the United States.

Conclusions:

No available international standards support CIF. Some national standards support CIF and may be used as reference for future international standards draft. While IEC 62325 provides an information model for market communications, with applications via different protocols in different wholesale energy markets, OpenADR 2.0 provides for price communications to the retail customer. The OpenADR information model extends the simple model in IEC 62325 in order to meet the specific DR needs for communications with customers. Energy Interoperation supports full transactive energy—that is, market operations. While IEC 62325 addresses the function of the market, Energy Interoperation only addresses the information that is communicated in order to support market transactions: tenders, quotes and transactions with specified delivery terms. Energy Interoperation is specifically designed to meet the needs of customer interactions for Smart Grid use cases. The information model extends IEC 62325, incorporating concepts from existing financial market protocols to meet the needs of facility domain systems.

---

8 More details for the standards listed in Table 16 and following tables can be found in Annex D.

Table 16 – Relevant standards for use case class 1

Relevant standards	Arguments	Avail	Pending	Notes
IEC 62325	IEC 62325 framework for energy market communication	I		Defines protocols for deregulated energy market communications with semantics based on IEC CIM.
OpenADR 2.0 (IEC PAS 62746-10-1)	Open auto demand response communication, security, conformance, certification, and information models. Addresses dynamic price, DER, and peak load reduction for both retail and wholesale DR markets.	CIF		OpenADR supports the “execution” aspect of market transactions between the Grid and the Customer Facility Domain. In general, OpenADR supports the tendering of offers (i.e. prices or incentive signals) by grid entities, but does not support the tendering of offers by users to the full extent defined in Energy Interoperation.
OASIS Energy Interoperation	EI energy interoperability services and functions, defining and extending information models in EMIX, WS-Calendar, including full transactive energy services.	CIF		Energy Interoperation supports full transactive energy, i.e., market or bilateral transactions between the Grid and the Customer Facility Domain, and includes both service operations and relevant information models. The OpenADR profile subsets the Energy Interoperation transactive capabilities.
OASIS Energy Market Information Exchange (EMIX)	EMIX describes an information model for energy price and product definition, enabling exchange by such standards as OpenADR2 and Energy Interoperation	CI		EMIX applies to any energy product with extensions; EMIX 1.0 addresses power and energy products and associated prices.
ISO/IEC 15045-1 and ISO/IEC 15045-2	ISO/IEC 15045-1 and ISO/IEC 15045-2 specify the architecture of a residential gateway which may be used to convey control signals, prices, and event data from a service provider to home and building equipment including an Energy Management Agent (specified in ISO/IEC 15067-3) and end devices.	I		
ISO/IEC 18012-1 and ISO/IEC 18012-2	ISO/IEC 18012-1 and ISO/IEC 18012-2 provide a model and a framework of interoperability at a semantic and syntactic level. This allows multiple markets standards to coexist and still interact with home energy usages.	I		Once a market standard is selected to implement at this interface, the market signals need to be translated to or converted to different control and communication protocols accepted by heterogeneous underlying network and appliances. ISO/IEC 18012-1 and ISO/IEC 18012-2 standards provide a model for such interoperability issue.
ISO/IEC 15067-3	ISO/IEC 15067-3 introduces information and energy management model for DR and DER and storage			

4.4.3 UCC 2—Convey price information

Class 2: *Use case class title:* **Convey price information**

Use case class description:

This requirement includes conveying fixed, scheduled, or real-time varying prices for electricity provided by the grid and consumed by the user, or vice versa. Prices cover other electricity market products and price information, and shall include product description. In some cases prices may be determined through a negotiation process that needs to be part of the interface (e.g. selection of a price rather than negotiation).

Use case class 2 sources:

CN01 CN02 CN04 CN05 KR01 KR02 KR03 KR04 KR05 JP01 JP02 JP03 JP04 JP05 JP06 JP08 FR01 FR02 FR03 FR04 FR05 US01 IN02 IN03 IN04 US01

Discussion:

Relevant standards for use case class 2 are presented in Table 17. Conveying price information is a key function for the SGUI.

Conclusions:

International standards address CIF in various incomplete ways, but only involving price information in descriptions of other applications. IEC 62746 is specifically designed as an extension of CIM for meeting DR requirements, although the information model is not as rich as expressed in OpenADR[9]. In addition, OpenADR is an established protocol for DR and price communication, while IEC 62746 is under development. OpenADR 2.0, Energy Interoperation and SEP 2.0 all support CIF. OpenADR is a profile of Energy Interoperation suitable for meeting all the DR needs of commercial and industrial customers. SEP is a residential-focused DR standard designed to meet the needs of utilities interacting with residential systems and devices. Both of these standards have information models that map well (extend) the CIM. These three standards may be used as the basis for further international standards.

9 SGIP PAP19 Wholesale Demand Response work products, available at http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP19WholesaleDR, and specifically the CIM-to-OpenADR mapping.

Table 17 – Relevant standards for use case class 2

Relevant standards	Arguments	Avail	Pending	Notes
ISO/IEC 15067-3	ISO/IEC 15067-3 introduces information and energy management model for DR and DER and storage	IF		High-level information model focused on residential domain.
IEC 62325	IEC 62325 framework for energy market communication	I		Defines protocols for deregulated energy market communications with semantics based on IEC CIM.
IEC 62056	COSEM (Companion Specification for Metering). The 62056 series defines the data exchange between the meter and the head-end system.	C		AMI-style communication of prices, defines communication only. The 62056-6-2 (COSEM) model can be extended with price information should it be required by the market.
IEC TR 61850-90-10	Scheduling model includes price information, defined in other standards.	I		Price is defined elsewhere.
IEC 62746	Prescribes system interfaces and communication protocol profiles relevant for systems connected to the Smart Grid.		CI	Will communicate price to customer interface from grid side using IEC 62325 information model with respect to price.
OpenADR 2.0 (IEC PAS 62746-10-1)	OpenADR delivers dynamic, tariffed and static price and product definition to its participants, addressing the needs of price-responsive facilities and devices.	CIF		OpenADR is a profile on Energy Interoperation information model to meet the implementation needs of DR use cases (e.g., secure transport).
OASIS Energy Interoperation	Energy Interoperation supports price and product definition delivery, based on the EMIX standard, and conveys dynamic, static, and complex tariffed prices.	CIF		Energy Interoperation supports full transactive energy, i.e., market or bilateral transactions between the Grid and the Customer Facility Domain, and includes both service operations and relevant information models. Price quotation and delivery is part of the transactive framework, allowing complex pricing structures to be communicated. The OpenADR profile subsets the Energy Interoperation transactive capabilities.
OASIS Energy Market Information Exchange (EMIX)	EMIX describes an information model for energy price and product definition, enabling exchange by such standards as OpenADR2 and Energy Interoperation. Dynamic, static, and complex tariffed prices are supported in the EMIX information model.	CI		EMIX applies to any energy product with extensions; EMIX 1.0 addresses power and energy products and associated prices. Prices may vary based on time and/or usage. Supports standing charges and similar pricing approaches. Prices are globally unique, tied to a market context.
Smart Energy Profile 2	Supports servers and clients of commodity price using objects from IEC 61968. Prices may vary based on time and/or usage. Supports standing charges, multiple tariffs, environmental costs,	CIF		Support provided by the SEP 2 pricing and response function sets. Additional capability present in the billing function set (for communicating overall bill information). Events are globally unique to support uncoordinated channels from a service

Relevant standards	Arguments	Avail	Pending	Notes
	randomization requests, measurement point linkage, and responses.			provider.

4.4.4 UCC 3—Ancillary services

Class 3: *Use case class title*: **Ancillary services**

Use case class description:

Convey ancillary services, operator signals, and responses. This includes things such as fast load response or voltage regulation. It may also involve providing standby generation capacity that can be made available to grid operators upon request. The latencies and features of generation capabilities need to be characterized so grid operators can determine if it is appropriate to dispatch it. Also potentially convey customer storage and generation availability, status and forecast information to enable effective management of grid resources, as this information is comparable to standard ancillary services information exchanges.

Use case class 3 sources:

CN02 CN03 CN04 CN05 KR06 KR07 JP02 JP07 KR03 FR01 FR05 US05 US08 IN03

Discussion:

Relevant standards for use case class 3 are presented in Table 18. Ancillary services requirements overlap in part with requirements for monitoring (use case class 8). Fast demand response may include open or closed loop regulation, with similar and overlapping reporting/monitoring requirements. See use case class 4.

Conclusions:

No available international standards support CIF. Some international standards address integration of DER regulation (IEC 61400-25-1, IEC TR 61850-90-7, IEEE 1547.3) and the model and communications for virtual power plants (IEC TR 61850-90-15). These standards represent the extension of existing grid standards for the integration of primarily large DER. For storage that may provide ancillary services, international standards touch on CI only with respect to DER and energy storage, but lack information models for energy status and forecast for user side.

Some national standards have detailed provisions for CIF related to ancillary service communication. OpenADR is used now for AS (“fast-DR”), including regulation, reserve and synchronized reserve. OpenADR is a profile of Energy Interoperation. SEP 2 also supports some AS requests. These standards should be considered for IEC standardization.

Table 18 – Relevant standards for use case class 3

Relevant standards	Arguments	Avail	Pending	Notes
IEC 61400-25-1	IEC 61400-25-1 addresses monitoring and control communication of wind power and describes relevant models.	CI		Required in the European Markets.
IEEE 1547.3	IEEE 1547.3 introduces monitoring, information exchange between DER interconnected with grid.	I		
IEC TR 61850-90-7	Object models for PV, energy storage and other DER	I		Current experimentation in Italy seems to show that it covers most of expected usages.
IEC TR 61850-90-15	Standard for building up and operating virtual power plants		I	
OpenADR 2.0	Open auto demand response services and functions address demand response, dynamic price, DER, and peak load reduction and shifting, as well as ancillary services including regulation, reserve, and synchronized reserve	CIF		OpenADR supports the full range of requirements to support ancillary services interactions as defined in PAP19 and PAP09 of the SGIP process. In addition, OpenADR has defined transport mechanisms and communication architectures that are specifically designed to satisfy the latency and throughput requirements necessary for ancillary services (e.g. “fast DR”). OpenADR 1 with extensions is used for ancillary services in the U.S.
OASIS Energy Interoperation	Energy Interoperation services and functions address demand response, dynamic price, DER and ancillary services functions including regulation, reserve, and synchronized reserve	CIF		Energy Interoperation supports the full range of requirements to support ancillary services interactions as defined in PAP19 and PAP09 of the SGIP process and as used with OpenADR1 extensions (PJM). The OpenADR profile subsets the Energy Interoperation transactive capabilities and includes transport and security. The capabilities of OpenADR2 are largely profiled from Energy interoperation.
Smart Energy Profile 2	SEP 2 supports certain ancillary services requests and related information exchange within a facility. Ancillary services supported include: volt/var support, DER information and control, network status information, time skew synchronization, power status information, software download, and reverse 911 capability for alerts to targeted areas.	CIF		
IEC 62325	IEC 62325 framework for energy market communication	I		Relevant in part: Use case class 3 is not about selling or buying ancillary services, rather dispatching and using them.
OASIS Energy Market	EMIX describes an information model for energy price and product definition, enabling exchange by such standards	CI		EMIX 1.0 addresses power and energy products and associated prices and supports ancillary services products.

Relevant standards	Arguments	Avail	Pending	Notes
Information Exchange (EMIX)	as OpenADR2 and Energy Interoperation. Regulation services, DR, and other ancillary services are explicitly addressed.			Prices may vary based on time and/or usage. Supports standing charges and similar pricing approaches. Prices are globally unique, tied to a market context.

4.4.5 UCC 4—DR & DER requests and supporting services

Class 4: *Use case class title:* **Demand response and distributed energy resources requests, and supporting services**

Use case class description:

This involves asking the user to shape electricity demand on a temporary basis and may be done through price changes or by invoking a previously agreed upon response to a DR event signal. Here we refer to an abstract interface where the energy provider does not control the load and relies upon the user to respond in an appropriate way (per contract) to the information provided. DR requests include for emergency DR. However, direct load control is in class 6. Supporting services include opt-in and opt-out and participant or resource registration/enrollment. Status of response is in Class 8 monitoring. Note that fast demand response strongly resembles and can address ancillary services requirements (class 3).

Use case class 4 sources:

CN02 CN04 CN05 CN06 KR02 KR03 KR04 KR05 KR06 JP01 JP02 JP03 JP04 JP06 JP08 JP09 FR03 FR04 FR05 IN01 IN02 US03 US05 US08.

Discussion:

Relevant standards for use case class 4 are presented in Table 19. Price "events" may be used to facilitate DR, so there are overlaps with class 2 convey price information. Some standards address both specific DR/DER events and price communication.

Conclusions:

No available international standards support CIF. National standards are available for conveying DR and DER requests in CIF.

IEC 61850-7-420 and IEC TR 61850-90-7, IEEE 1547.3 and IEC 61400-25-1 each provide information models and some communication specifications for DER communications. These are designed for direct control of these DER resources by grid-side service providers such as utilities and generation aggregators. ISO/IEC 15067-1 and ISO/IEC 15067-2 describe a residential DR gateway model. ISO/IEC 15067-3 introduces an energy management model for the same. ISO/IEC 18012-1 and ISO/IEC 18012-2 provide an interoperability model of DR application/communication protocols. These do not provide the needed DR protocols for retail customer interactions. IEC 62746 is under development for DR communications. OpenADR 2.0, Energy Interoperation and SEP 2.0 all support CIF. OpenADR is a profile of Energy Interoperation suitable for meeting all the DR needs of commercial and industrial customers. SEP is a residential-focused DR standard designed to meet the needs of utilities interacting with residential systems and devices. Both of these standards have information models that map well (extend) the CIM. These three standards may be used as the basis for further international standards.

Table 19 – Relevant standards for use case class 4

Relevant standards	Arguments	Avail	Pending	Notes
ISO/IEC 15045-1 and ISO/IEC 15045-2	ISO/IEC 15045-1 and ISO/IEC 15045-2 specify the architecture of a residential gateway. It can convey control signals, prices, and event data from a service provider to home and building equipment including an energy management agent (specified in ISO/IEC 15067-3) and end devices.	I		
ISO/IEC 15067-3	ISO/IEC 15067-3 introduces information and energy management model for DR and DER and storage.	IF		Abstract description of functional.
IEC TR 61850-90-7	Object models for PV, energy storage and other DER.	I		
IEC 62746	Prescribes system interfaces and communication protocol profiles relevant for systems connected to the Smart Grid – is based on IEC 62325 and IEC 61968/61970.		CI	
IEEE 1547.3	IEEE 1547.3 introduces monitoring, information exchange between DER interconnected with grid.	I		DER only.
IEC 61850-7-420	IEC 61850-7-420 introduces DER information model based on IEC 61850).	CI	CI (Ed. 2)	Defines the IEC 61850 information models to be used in the exchange of information with distributed energy resources (DER), which comprise dispersed generation devices and dispersed storage devices, including reciprocating engines, fuel cells, micro-turbines, photovoltaics, combined heat and power, and energy storage
ISO/IEC 18012-1 and ISO/IEC 18012-2	ISO/IEC 18012-1,2 provide interoperability model of application/communication protocols of demand-response software and hardware from different vendors and manufacturers.	I		
OpenADR 2.0	Open auto demand response services and functions address demand response, dynamic price, DER, and peak load reductions as well as ancillary services including regulation, reserve, and synchronized reserve. Events are globally unique; transitions are randomizable, categories and classes of participants can be identified, and explicit opt out and opt in are defined in addition to an availability schedule.	CIF		OpenADR can be used to convey a broad range of DR/DER event information. Specifically OpenADR 2 addresses: • Relevant temporal aspects of a DR event (e.g. ramp time, active period, etc.) • Indication to target specific DR resources based on their attributes such as resource identifiers, location, resource type, device type, generalized grouping mechanisms, etc. • Indication for different market products (i.e. DR programs). • A wide range of DR signals including incentives (i.e. prices),

Relevant standards	Arguments	Avail	Pending	Notes
				dispatches, and load control instructions. • Information related to resource performance criteria such as baselines.
OASIS Energy Interoperation	EI energy interoperability services and functions address demand response, dynamic price, DER and ancillary services functions including regulation, reserve, and synchronized reserve. DR and DER were the primary focus in defining its architecture. Events are globally unique; transitions are randomizable, categories and classes of participants can be identified, and explicit opt out and opt in are defined in addition to an availability schedule.	CIF		Functionality listed for OpenADR2 is profiled from Energy Interoperation; that information is not repeated here. The OpenADR profile subsets the Energy Interoperation transactive capabilities and specifies transport and security. Energy Interoperation was defined building on OpenADR1, the leading automated demand response architecture, with improvements for scalability and functionality.
Smart Energy Profile 2	Supports servers and clients of DR as well as direct load control. Supports servers and clients of DER based on IEC 61850. Supports device responses, multiple programs, randomizable events, device categories, forward load shifting, and overrides. Events are globally unique to support uncoordinated channels from a service provider. DER capabilities include: volt/var, curve setting, and DER program controls.	CIF		Supported by the SEP 2 DRLC, DER, Price, and Response function sets.
IEC 62325	IEC 62325 framework for energy market communication	I		Relevant in part: Used by IEC 62746.
OASIS Energy Market Information Exchange (EMIX)	EMIX describes an information model for energy price and product definition, enabling exchange by such standards as OpenADR2 and Energy Interoperation. Products include demand response, regulation, and present market-supported energy products.	CI		Relevant in part: EMIX applies to any energy product with extensions; addresses power and energy products and associated prices and supports ancillary services products.
IEC 61400-25-1	IEC 61400-25-1 addresses monitoring and control communication of wind power and describes relevant models.	CI		Relevant in part: It defines wind power plant specific information, the mechanisms for information exchange and the mapping to communication protocols.

4.4.6 UCC 5—Impending power failure or instability

Class 5: *Use case class title:* **Impending power failure or instability**

Use case class description:

Relevant standards for use case class 5 are presented in Table 20. Convey indications of impending power failure or instability. Use case class 5 communicates impending power failure or instability which may be due to foreseen disruptions including those resulting from natural disaster or weather events for which notification is possible.

Use case class 5 sources:

JP10 JP11

Discussion:

There are no standards for specifically communicating power failure or grid instability. Standards exist which define power quality and outage information, and a DR standard could potentially be used to transmit a “power quality” event. A DR standard could also add a “power failure” event.

In addition, there are currently existing standards for alerting emergency fire and safety officials of impending weather and natural disasters. Emergency event and response information are delivered through widely used standards such as the OASIS Common Alerting Protocol (CAP) [16] and OASIS Emergency Data Exchange Language (EDXL) [17]. These standards might be used to convey relevant information to the grid and user side and effectively address use case class 5 requirements. Use of these standards has the additional benefit that by using these standards electrical events that may cause safety issues can be communicated to safety authorities.

Conclusions:

Existing alerting protocols may be suitable but are not specific to energy; energy-related reactions may be better considered under use case class 4 (demand response). Some standards can convey signals that may be interpreted as a trigger for emergency action.

Table 20 – Relevant standards for use case class 5

Relevant standards	Arguments	Avail	Pending	Notes
IEC 61850 series	IEC 61850 conveys power quality components in six separate quality warnings (Qxxx).	CI		Offers a comprehensive set of models to measure power non-quality – i.e unexpected current, voltage or frequency variations.
IEC 61968	There are outage related classes. Also provides the means to carry such event.	CIF		
IEC 61970-301	CIM has abstract information model of power quality for generation and load area.	I		
OASIS Energy Market Information Exchange (EMIX)	Defines a power quality framework based on IEEE 1159 and its derivatives including CIM and portions of IEC 61400 and 61850 as well as CENELEC and many national standards.	CI		OASIS EMIX and OASIS Energy Interoperation, ASHRAE/NEMA 201P and related standards support all country and international power quality standards.
OASIS Common Alerting Protocol (CAP) [16] and Emergency Data Exchange Language (EDXL) [17]	CAP, EDXL, and related standards define alerting mechanisms for natural disaster and other incidents. Currently used in many countries for “next generation 911” notifications.	CIF		This group of standards is widely deployed for emergency notifications and responses.

4.4.7 UCC 6—Directed interaction and direct load control

Class 6: *Use case class title:* **Directed interaction and direct load control**

Use case class description:

With pre-agreement of the customer with financial compensation, the provider of energy is allowed direct management of specific devices and their load on the electrical grid. Techniques may include interruptible load management, power consumption management, and load shifting.

Use case class 6 sources:

CN06 JP05 JP07 FR01 FR03 FR04 US01 US03

NOTE Use case IN01 was not included: Energy efficiency monitoring information including summary and aggregate can cross the SGUI, but there is no indication of direct management across the SGUI.

Discussion:

Relevant standards for use case class 6 are presented in Table 21. Please refer to 2.3 for further discussion of description, definition, and details of directly managed loads.

Direct load control signals may be directed to specific end points (tailored to specific customer classes and end equipment). However, specific knowledge of a customer class or device requires description, definition, and significant details about the class and directly managed loads, which in turn limits scalability and management effectiveness. A generic information model for facility Smart Grid interactions is being developed in the ASHRAE/NEMA 201P Facility Smart Grid Information Model standard effort. This standard in turn allows for development of detailed device profiles that might be useful in direct load control applications. Definition of customer and device classes is likely out of scope for PC 118.

Conclusions:

The listed standards and specifications partially support CIF. Some national standards have provision for DLC, and many standards address the communications layer. We recommend drafting international standards based upon existing national standards that provide CIF.

Table 21 – Relevant standards for use case class 6

Relevant standards	Arguments	Avail	Pend-ing	Notes
ISO/IEC 15045-1 and ISO/IEC 15045-2	ISO/IEC 15045-1 and ISO/IEC 15045-2 specify the architecture of a gateway. The gateway can convey control signals, prices, and event data from a service provider to home and building equipment.	C		
IEC 62746	Prescribes system interfaces and communication protocol profiles relevant for systems connected to the Smart Grid –based on IEC 62325 and IEC 61968/61970.		CI	
ISO/IEC 15067-3	Defines direct load control in residential environments.	IF		
ECHONET Specification Ver1.0	ECHONET specification involves DLC to household appliance inside home, and remote control through a home gateway.	C		Carry out e.g. appliance, storage system, and DER management communication.
OpenADR 2.0	Open auto demand response communication, security, conformance, certification, and information models. Addresses dynamic price, DER, and peak load reduction. Flexible sets of intended recipients are supported, as well as device types. Events are globally unique.	CIF		OpenADR can be used to convey bi-directional DR/DER event information for the purposes of load control. Generalized load control instructions can be specified and directed to DR resources that are specified by device types.
OASIS Energy Interoperation	EI energy interoperability services and functions, defining and extending information models in EMIX, WS-Calendar. Flexible sets of intended recipients are supported, as well as device types. Events are globally unique. Events are globally unique.	CIF		Energy Interoperation can be used to convey bi-directional DR/DER event information for the purposes of load control. Generalized load control instructions can be specified and directed to DR resources that are specified by device types.
Smart Energy Profile 2	Supports servers and clients of direct load control. Supports device responses, multiple programs, randomizable events, device categories, forward load shifting, and overrides. Events are globally unique to support uncoordinated channels from a service provider. Control functions include: duty cycle, temperate offset, temperature setpoint, target reductions, and appliance load reductions (in compliance with new EnergyStar requirements).	CIF		Supported by the SEP 2 DRLC and response function sets.
IEC 62325	Prescribes information model of energy market	I		Defines protocols for deregulated energy market communications with semantics based on IEC CIM.
IEC TR 61850-90-10	Object model for energy dispatching	I		
IEC 61968-11	Information model extension for distribution	I		
IEC 61968-9	System interface for meter reading and control	I		

Relevant standards	Arguments	Avail	Pend-ing	Notes
IEC 62055-32	Electricity metering – Payment systems	C		
IEC 62056	Electricity metering data exchange for meter reading, tariff and load control (bottom of networking stack)	C		
ISO/IEC 18012-1 and ISO/IEC 18012-2	Direct load control shall address interoperability between high-level demand control signals generated at utility energy management level and various physical control signals that are specific to the load devices and appliances. ISO/IEC 18012-1 and ISO/IEC 18012-2 standard provides semantic model to such interoperability issue.	I		

4.4.8 UCC 7—Historical, present and future projection information

Class 7: *Use case class title:* **Historical, present, future projection information passed**

Use case class description:

Convey historical or real-time energy usage (such as meter measurements). This involves providing a way for a user to supply aggregated, whole building, systems, or sub-system energy usage information to the energy provider, which can be used to meet DR program participation requirements and assist in measurement and verification of the participating user. The same software mechanisms can convey forward power usage and demand projections, providing a way for a user to supply forecast information to the energy provider that can be used to manage grid resources, and be useful for evaluating and measuring energy efficiency and for facility commissioning and green building/LEED continuous commissioning. The energy provider may also provide validated energy usage data to the user. Demand is more specific and is included in use case class 8 monitoring.

Use case class 7 sources:

CN01 KR01 IN04 US06

Discussion:

Relevant standards for use case class 7 are presented in Table 22. Aspects of historical, present, and projected information overlap with other areas; we have factored out the information aspects for simplicity of analysis.

Projected availability may be used by DR, DER, ancillary services, and more. Projected prices may be used for market interaction and price responsiveness, applying understanding of the semantics of price. Historical and present information may come from many sources, including third party or distribution/transmission utility-owned meters, or from aggregated historical information.

The United States Green Button standard (NAESB REQ.21) is relevant for meter reading information.

Conclusions:

There are no international standards that directly address this class of use cases. Metering information models do not address the content, rather the form, and do not include projection. Partially relevant standards address subsets of needed information. Some available national standards support CIF and support historical, present, and future projections. These national standards should be adopted and used as a basis for further international standards.

Table 22 – Relevant standards for use case class 7

Relevant standards	Arguments	Avail	Pending	Notes
OASIS Energy Interoperation	EI energy interoperability services and functions, defining and extending information models in EMIX, WS-Calendar.	CIF		The EiReport service addresses in a single extensible mechanism reporting/monitoring including but not limited to ancillary services-type monitoring and telemetry, power quality, DR and DER event response.
OASIS Energy Market Information Exchange (EMIX)	EMIX provides models for power quality and energy/power for use in reporting and monitoring.	CI		Note that OASIS Energy Interoperation and OpenADR2 and their services are used in conjunction with EMIX.
OpenADR 2.0	Open auto demand response communication, security, conformance, certification, and information models. Addresses dynamic price, DER, and peak load reduction for both retail and wholesale DR markets.	CIF		Relevant in part: Portions of the EiReport service are in OpenADR2b. See Energy Interoperation.
Smart energy profile 2	Historical usage information and billing information is supported.	CIF		Relevant in part: Supported by the SEP 2 metering and billing function sets.
IEC 62746	Prescribes system interfaces and communication protocol profiles relevant for systems connected to the Smart Grid – is based on IEC 62325 and IEC 61968/IEC 61970		CI	Relevant in part: Can convey single interval future price, not projection. Not clearly useful for historic and present price information.

4.4.9 UCC 8—Monitoring and energy efficiency analysis

Class 8: *Use case class title:* **Enable monitoring and energy efficiency analysis**

Use case class description:

Convey monitoring information. Monitoring is key to DR and DER management and verification, as well as energy efficiency information with respect to the Smart Grid user. Information that may be monitored includes customer storage and generation availability, status, present and forecasted demand and capacity, and other forecast information to enable effective management of the grid. Usage forecasts are addressed in UCC no. 7. Metrology, that is, the measurement of energy usage at a transfer boundary, is important for monitoring and verification; the details of how those measurements are made are the subject of many widely deployed standards. Monitoring of meters (for outage, resumption, power quality and turn-on/turn-off information) is out of scope.

Compared to use case class 7, historical, present, future projection Information, monitoring suggests more extensive and specific data collection and interaction.

Use case class 8 sources:

CN01 KR01 KR06 KR07 JP01 JP02 JP03 JP05 JP08 JP09 JP10 JP11 IN01 IN02 IN03 IN04 US03 US04 US05 US07 US08

Discussion:

Relevant standards for use case class 8 are presented in Table 23. Monitoring suggests great breadth and fine detail. For the SGUI, monitoring is relevant to both the progress of a DR event—how much is present demand, possibly with respect to a baseline—and to general and largely aggregated facility information. Detailed sensor nets and monitoring structures are not in scope for PC 118. For example, only part of what might be monitored for a detailed energy efficiency analysis is relevant to the SGUI.

Conclusions:

There are no available international standards which support CIF. With respect to more general monitoring, OASIS Energy Interoperation defines an extensible and self-defining framework to address relevant monitoring and information exchanges for ancillary services, DR, DER, and much energy efficiency monitoring.

Detailed monitoring such as that provided by sensor networks is not in scope for the SGUI; such information may be and is used by the actors on both sides of the SGUI.

Table 23 – Relevant standards for use case class 8

Relevant standards	Arguments	Avail	Pending	Notes
OASIS Energy Interoperation	EI energy interoperability services and functions, defining and extending information models in EMIX, WS-Calendar.	CIF		Definition of framework for monitoring information. The EiReport service addresses in a single extensible mechanism reporting/ monitoring including but not limited to ancillary services-type monitoring and telemetry, power quality, DR and DER event response.
OpenADR 2.0	Open auto demand response communication, security, conformance, certification, and information models. Addresses dynamic price, DER, and peak load reduction for both retail and wholesale DR markets.	CIF		Includes monitoring for DR and DER events. As described above, OpenADR defines historical and telemetry type reports that can be used for monitoring DR resources and for baselines and forecasting needs. Subsets class of Energy Interoperation reports.
Smart Energy Profile 2	SEP 2 supplies metering, response, and DER function sets, relevant to DR/DER monitoring.	CIF		
IEC 62056	IEC 62056 electricity metering data exchange for meter reading, tariff and load control.	CI		Meter reading; may convey information for that purpose. May be more appropriate to use case class 7 than more general monitoring.

4.5 Smart Grid user interface standards gap analysis conclusions

The SGUI is cross-domain, connecting the traditional grid domain to the facility domain with its many established protocols and separate information models. The SGUI is a bridge for moving information common to both sides, mapping one information model to another, to satisfy the relatively new use cases of many Smart Grid applications. There are many TCs and standards organizations involved in standards pertinent to the end points and the actors that communicate across the SGUI. Of those the greatest number is on the facility-side; several including IEC TC 57 address the grid side. Coordination is thus necessary with TC 57 and other identified TCs and organizations as described in this technical report.

Examining the use case standards analyses in 4.4, one finds that some use case requirements are not well served by international standards, while some existing national standards serve many use case class requirements. There are multiple criteria for determining which standards should be advanced in IEC: meeting SGUI use case requirements; adherence (or distance) to the existing IEC framework (alignment with IEC 61850 and CIM); addressing the pressing needs of the Smart Grid; established standards (in use widely); meeting quality requirements (2.7); and perhaps others.

IEC currently has a suite of standards in TC 57 that apply well to the traditional power grid domain. This is true of CIM (IEC 61970, IEC 61968 and IEC 62325) and IEC 61850. The work of TC 57 on IEC 62746 is a valuable effort to address demand response, but it might be strengthened by adopting some work already done and in use in OpenADR. The ISO/IEC 15067-3, ISO/IEC 18012 and ISO/IEC 15045 standards provide abstract models for DR interactions along with a gateway architecture, but do not provide the needed protocols for DR and other SGUI requirements. A number of standards in the IEC 61850 family are seen to define information models and communications for DER communications along with some other available standards. However, these use a direct control approach to interactions with the devices. ECHONET (suite of IEC standards) is an existing standards set that meets the needs for direct load control in some residential applications.

OpenADR 2.0, OASIS Energy Interoperation, and SEP 2.0 (now also IEEE P2030.5) are candidate standards that should be considered for IEC standardization to address existing and future needs. These standards are broadly applicable to most of the SGUI use case classes (4.4). They provide an approach to customer interaction that places more control in the hand of the customer, thus enabling greater demand response while enabling new technologies for Smart Grid in the customer domain. OpenADR is a profile on Energy Interoperation and in use today, with support of a vendor community. The SEP 2.0 information model profiles and extends the CIM with a goal to enable utilities to interact more easily with residential devices in the customer domain. OASIS Energy Interoperation bridges from the CIM and IEC 61850 to the multitude of standards, specifications, and software in the customer domain. This bridging creates a joint information model [18] that enables mutually beneficial management of energy.

In regard to cybersecurity, this report addresses a rational approach for SGUI standards in 2.7.2. Security is typically composed with an interoperation specification for a specific deployment; a single security profile does not address all possible implementations. In addition, security requirements and functionality generally evolve more quickly than interface specifications. Different parties involved in interactions require different choices for security, privacy, and reliability. At the same time, we note that IEC 62351 provides a set of security guidelines for IEC power system communications. They are specific to those protocols, although the principles apply more broadly to other electronic communications. Nonetheless, they are limited in scope. We recommend reference to IEC 62351 as appropriate. We also recommend reference to the work of NIST/SGIP (e.g., NISTIR 7628 [12]) for relevant Smart Grid security measures.

5 Recommendations for IEC SGUI standards development

5.1 General

The SGUI TR embodies two years' hard work of PC 118 members, bringing together the perspectives, applications, functional requirements, quality requirements, architectures and other aspects of SGUI. Working Groups 1 and 2 have reached consensus on the nature of the SGUI, and many use cases for its application. That understanding serves as a foundation for future IEC standards development.

We have shown in this TR a clear need for normative SGUI standards, with recommended actions presented below. We also propose to draft a technical specification to clarify the architectural understandings we reached during the TR work, which understandings provide the guiding principles for standards development and use.

As the SGUI bridges between diverse applications and standards on both the grid and user sides, it should also address the continuing evolution of all of those standards and applications. It is critically important for SGUI standards to bridge between key standards on the grid side including IEC 61850 and CIM, and key standards on the user side.

It is the intent of PC 118 to work cooperatively with other IEC TCs, and IEC SG3. Following are some specific recommendations that have followed based on the analysis presented in Clauses 2 to 4 above. The use case analysis for market interactions (4.4.2), price information (4.4.3), ancillary services (4.4.4), DR and DER (4.4.5), and DM and DLC (4.4.6) all share a common recommendation to develop international standards based on available national standards. These standards are OpenADR 2.0, OASIS Energy Interoperation and Smart Energy Profile 2. Furthermore, these standards address all three layers of the analysis (communication, information, and functional). These standards are therefore broadly applicable to the needs of the SGUI and worthy of consideration as IEC standards.

As published national standards they provide a mature starting point as the basis for IEC standards.

5.2 OpenADR 2.0

PC 118 has approved the circulation of OpenADR 2.0b as an IEC PAS. This was completed and the PAS was confirmed by member country vote. The intent is that during the period of the PAS the CIM will be extended to meet DR needs, that the OpenADR standard will be advanced by PC 118 with an adapter, and that finally there will also be a CIM-based DR standard to meet utility requirements.

The work to complete, as agreed on by PC 118 in conjunction with TC 57, and the organization of that work are as follows. There are three tasks:

a) CIM extensions (task T1) – these extensions to the existing CIM model will include elements currently only in the OpenADR model.
b) Adapter (task T2) – in parallel with task T1, to map the existing OpenADR data model to the CIM extensions for DR.
c) "OpenADR CIM-based" (task T3) – a separate IEC DR standard that is based more strictly on the CIM-extensions that are to be more aligned with utility back-end CIM-based systems.

Task 1 (CIM extension) is a joint effort between PC 118 and TC 57. The details of cooperation on that work are in ongoing discussion. A joint task force with TC 57 WG 21 has been established to determine the work plan and schedule for moving the OpenADR tasks forward.

Task 2 (OpenADR adapter) is led by the OpenADR Alliance, working with PC 118 and TC 57 experts.

Task 3 (Full CIM-based OpenADR standard) will follow development of the CIM-extension and adapter. A work plan is in progress.

5.3 OASIS Energy Interoperation

IEC PC 118 has agreed to register the Energy Interoperation document provided by OASIS as a committee draft for developing as an IEC standard under the scope of Working Group 1.

5.4 Smart Energy SEP 2.0

IEC PC 118 has proposed that IEEE work together with IEC PC 118 to jointly develop a dual logo standard based on IEEE 2030.5-2013 (SEP 2.0)[10].

10 More information on SEP2.0 is provided in D.1.24.

Annex A
(informative)

IEC establishment and history of PC 118

Since the first meeting of PC 118 held in Tianjin, 2012, the role and mission of PC 118 have been refined and reminded as the working strategy of the committee. PC 118 is a temporary Project Committee (PC), managing two cross cutting projects under two approved NWIPs that originally motivated the creation of PC 118. Choosing the Project Committee as the vehicle to handle the two NWIPs reflects the very nature of PC 118. When the two NWIPs were proposed, many TCs claimed to be covering these areas (TC 57, TC 13, TC 8, TC 69, TC 59, TC 100, TC 72, etc.). But the SMB could not establish a consensus of the NC in assigning the work to one existing group, or to create a TC (the initial SG3 proposal was not approved), or to set up a JWG of TC 57-TC 13-TC 8. This is where the idea to set up PC 118 emerged.

SMB and SG3 were discussing options for 18 months, and this was discussed at three consecutive SMB meetings. The instruction and decision process can be traced as follows:

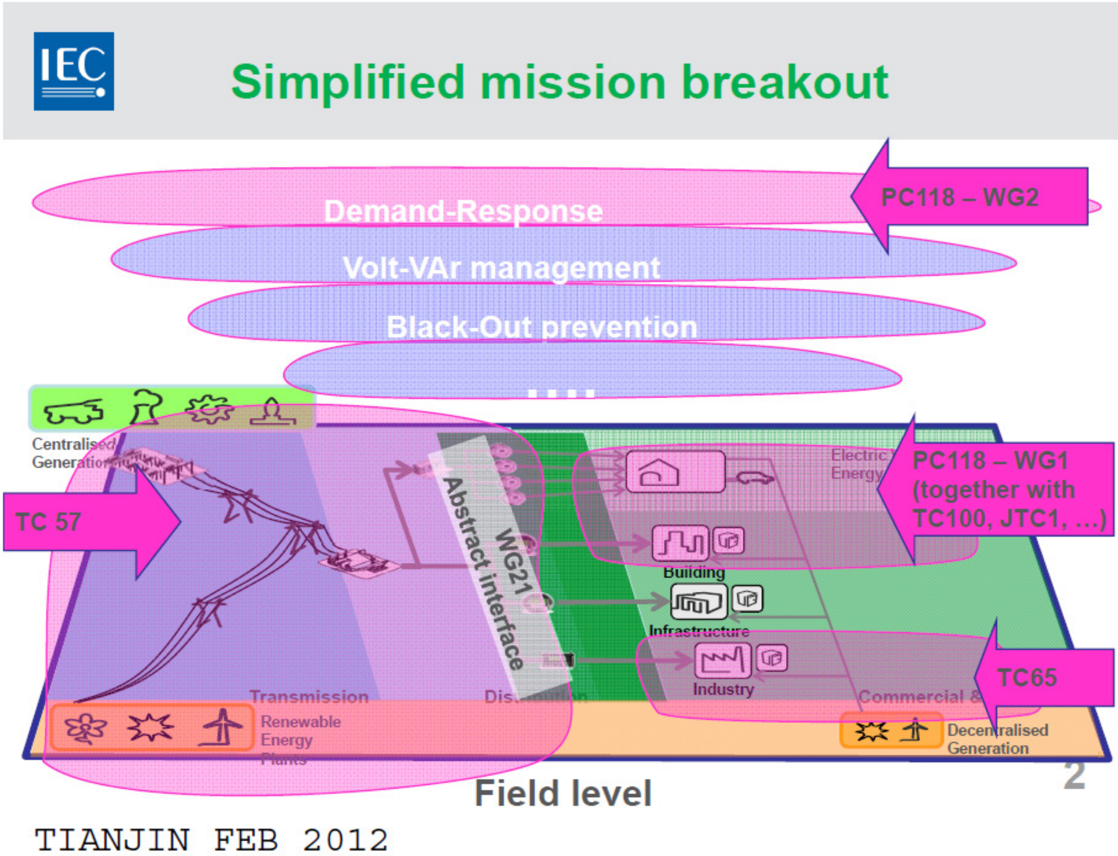
- Decisions on 3 CN NPs (remand to SG3) resulting from the SMB meeting held in Geneva, 2011-02-16 (February 2011).
- 4496e SG3 report to SMB after the meeting held on 2011-02-22 in Geneva, Switzerland (SMB/4496/R, dated 29 April, 2011).
- Comments received on the report of SMB SG3, Smart Grid, after the meeting held on 2011-02-22 (SMB/4496A/R, dated 31 May, 2011).
- SMB SG3 CN comments added to SMB/4496/R (SMB/4496/R, dated 3 June 2011).
- 4541e Vote to form PC 118: Submission of two Chinese NC NPs for smart grid user interface – Project Committee (SMB/4541/NCP, dated 24 June 2011).
- SG3 explanation on the SMB decision to create PC 118 (internal SG3 email, subject: SMB decision on the Project Committees, dated 15 Sept, 2011)

PC 118 is a project (actually a pair of related projects), and not a group per se. This was very innovative as PCs exist within ISO, but there were none at IEC. PC 118 is supposed to offer a cross cutting collaborative platform for experts belonging to relevant TCs (and other collaborating organizations) to develop the two cross cutting projects. The Project Committee will exist until significant deliverables are published for each NWIP/WG. Acceptable significant deliverables can be International Standards or Technical Specifications requiring 2/3 consensus. Technical Reports are mainly for information, and PAS will be considered as intermediate steps.

NOTE It is noted that TS can be a faster solution to meet the urgent need of the industry, as it only requires one voting stage for 3 months, compared to the IS which requires two voting stages, 3 months for CDV and 2 months for FDIS.

At the first meeting of PC 118, a consensus reference drawing/chart (Figure A.1) was designed in order to explain and display a clear and crisp mission breakout for PC 118. This reference chart shows the respective positions of key groups: TC 57/WG 21 (abstract interface from the grid side), PC 118/WG 1 (interface from the customer side – residential and building), PC 118/WG 2 (demand response cross cutting the electric system), TC 65 (industry), etc.

This reference chart is shown at each WG or plenary PC 118 meeting.



IEC

Figure A.1 – Consensus reference drawing for PC 118 work relative to other TCs

PC 118 has as its goal to address the standards that serve to connect consumers to the Smart Grid. Three separate ecosystems have been developing solutions independently of one another: home automation, telecommunication, and entertainment. But now with the fourth value stream of energy, each of the three has begun to develop standards. Besides this, energy players are also considering to address some of the existing three areas. And then the electric vehicles community, which needs those converged solutions, is also starting to develop their own. The industry needs and expects as soon as possible the emergence of some converged solution, compatible with the IEC suite of standards.

According to the decision made by SMB, for the sake of speed and optimization of the global expertise resources, it is far preferable to attempt to leverage preexisting or ongoing efforts, rather than starting from scratch to develop a new standard:

SMB Decision 137/10 – SG 3 Smart Grid, document SMB/4175/R (2010-02-10)

SG3 DECISION 2: Fast-track new standards to close the gaps

Before starting any work on new standards for Smart Grid (NWIPs), TCs are required to perform a survey of what exists or is under development in other SDO's and then make decisions to adopt / harmonize or develop that standard. The "candidate standard" from the other SDO can come from anywhere, providing that enough consensus has been embedded in it to increase the chances that it will pass the NC vote.

Additionally, the individual TCs shall inventory the other SDO standards in their area of expertise to further identify major Smart Grid related standards, and report it in their Strategic Business Plan within 60 days and thereafter on a yearly basis. Moreover TC/SCs should *consider decisions to adopt / harmonize that standard, and make the maximum use of the Publicly Available Specification (PAS) process.*

SG3 Decision 2 Responsibility: All relevant TCs/SCs in charge of standards identified in the IEC Smart Grid Framework (current version on-line).

Outside IEC there are already many existing industrial solutions for these topics developed by different parties. As a strategy to meet the urgent needs of the industry, it is ideal to position the industry requirements and the existing near-standards products, and dig into the existing work to see whether it meets the industry expectations, and if so, to use an existing product as foundation for international standards instead of developing from scratch, and make them fit into the IEC standards family.

So the idea was to look at all the existing solutions, and attempt to characterize those regarding different essential aspects, according to Table A.1. This is why IEC issued an open call to the industrial players having developed some solutions for participation to the Tianjin meeting and presentation. This is the "bottom-up" approach.

Table A.1 – Chart used for capturing existing solutions during PC 118 meetings

IEC Master inventory of user interfaces solutions

	FPC 201 ISO TC205	Oasis Energy Interop Open ADR	ECHONET	AS/NZS4753	Q/GDWZ620	Zigbee SEP	ISO/IEC 2907/2908	ISO/IEC 15067-3	....
Uses Cases									
Requirements									
Architecture									
Data models									
Objects									
Protocols									
....									
....									
....									3

TIANJIN FEB 2012

Concurrently, an analysis is completed by a "top-down" approach for the two Working Groups in order to identify the needs and the expectations from the industry to be covered, as represented in Figure A.2.

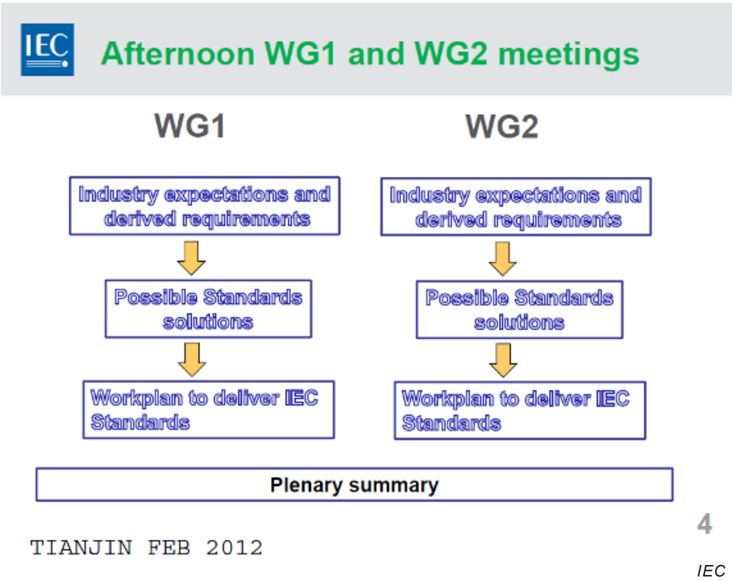


Figure A.2 – Top-down approach to identify industry expectations

And PC 118 issued an open call to any organization to propose what they have developed for consideration as a starting point for some IEC international standard development. But very few propositions have been received, and of course IEC can work only from proposals received from organizations granting a free licence to develop derivative deliverables. Propositions that have been received officially are: OpenADR (OpenADR Alliance), Smart Energy Profile (Zigbee Alliance, then IEEE), and Energy Interoperation (OASIS).

Each Working Group has been asked to propose an action plan answering the following check-list (see Figure A.3) discussed at the Rosslyn meeting (March 2013).

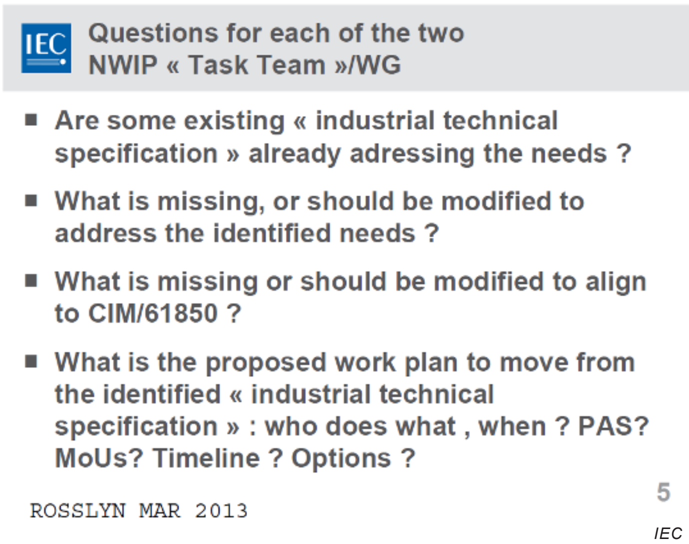


Figure A.3 – Questions to be addressed by PC 118 working groups leading to work plan

During the Bangalore WG 1 and WG 2 meetings, the following action plans have been formulated, reviewed and advanced.

PC 118 started by developing this SGUI TR to characterize the market needs (this work lasting about two years), by showing the standardization need from the user and market perspectives. In the demand response area, PC 118 has made an open call to the industry for submission of close-to-standard solutions and published the OpenADR PAS as a signal to the industry. Energy Interoperation has been taken into WG1 as a work item.

The next step is to develop the IEC value added deliverables from these industry solutions.

The third step for PC 118 is to publish the TS which has been already launched in WG 1, and recommended to be processed in coordination for consistency with the development of industry proposals such as SEP 2.0, EI, etc.

The sum total of the PC 118 work plan, aimed at accelerating SGUI standards convergence, is presented in Figure A.4, as presented and discussed in the Bangalore PC 118 meeting.

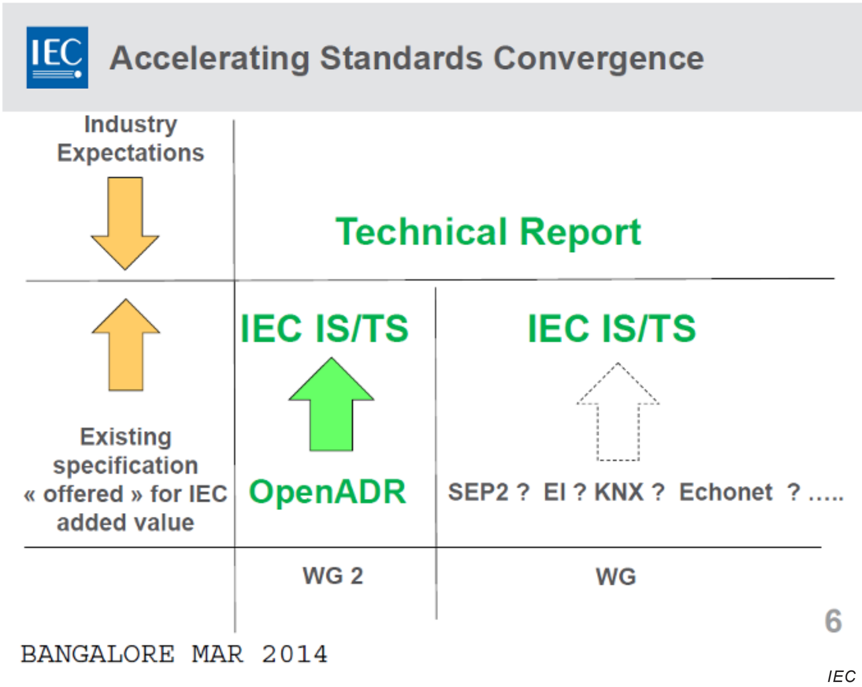


Figure A.4 – Conceptual work plan for PC 118

Annex B
(informative)

SGUI perspective – More details

B.1 General

Annex B lists more detailed contributions from member countries (and the EU).

B.2 European standardization for Smart Grid realization in buildings

European framework: The standardization is pushed by two mandates of the EU for Smart Metering M441 and for Smart Grid M490. The standardization in the field of the so called “home and building electronic system” (HBES) is handled by Cenelec (CLC) TC 205. For the Smart Grid related items CLC established a special working group – CLC TC 205 WG 18. IEC TC 57 WG 21 defines the protocol delivered to buildings.

For the handling of Smart Grid and smart metering in Europe the reference architecture in Figure B.1 was defined.

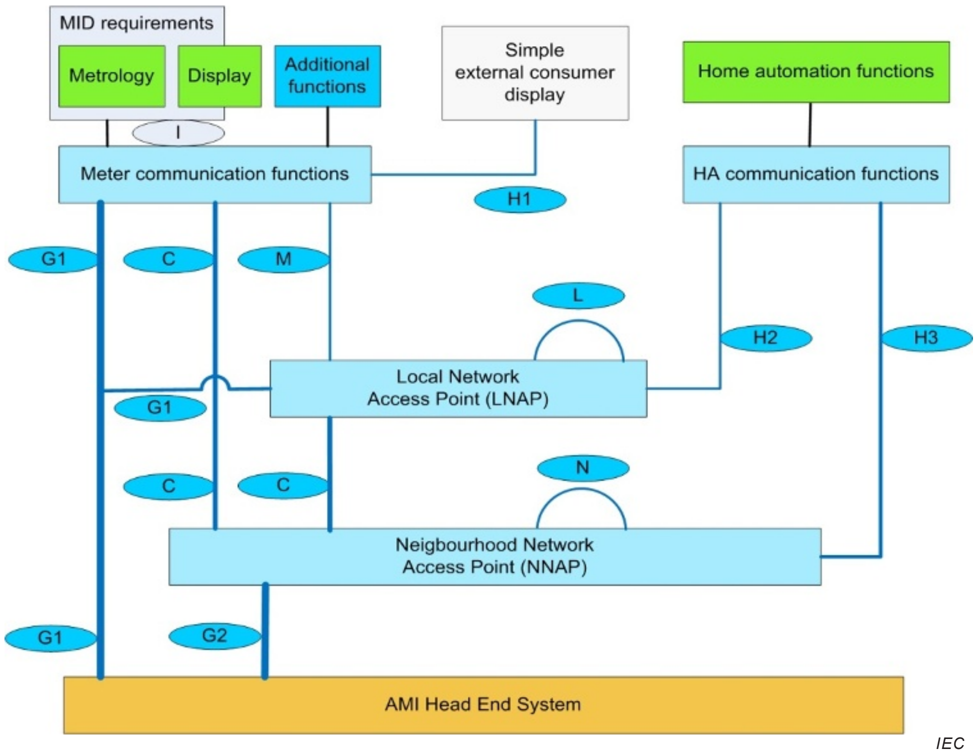


Figure B.1 – Reference architecture for smart metering communications [19]

The management of loads, e.g. switching on or off, in a building (or residential) can be controlled by the grid (in dependence of the electricity generation). For the execution of the management of loads in the building a “home and building electronic system” (HBES) is necessary.

This leads to the following expansion of the architecture, Figure B.2.

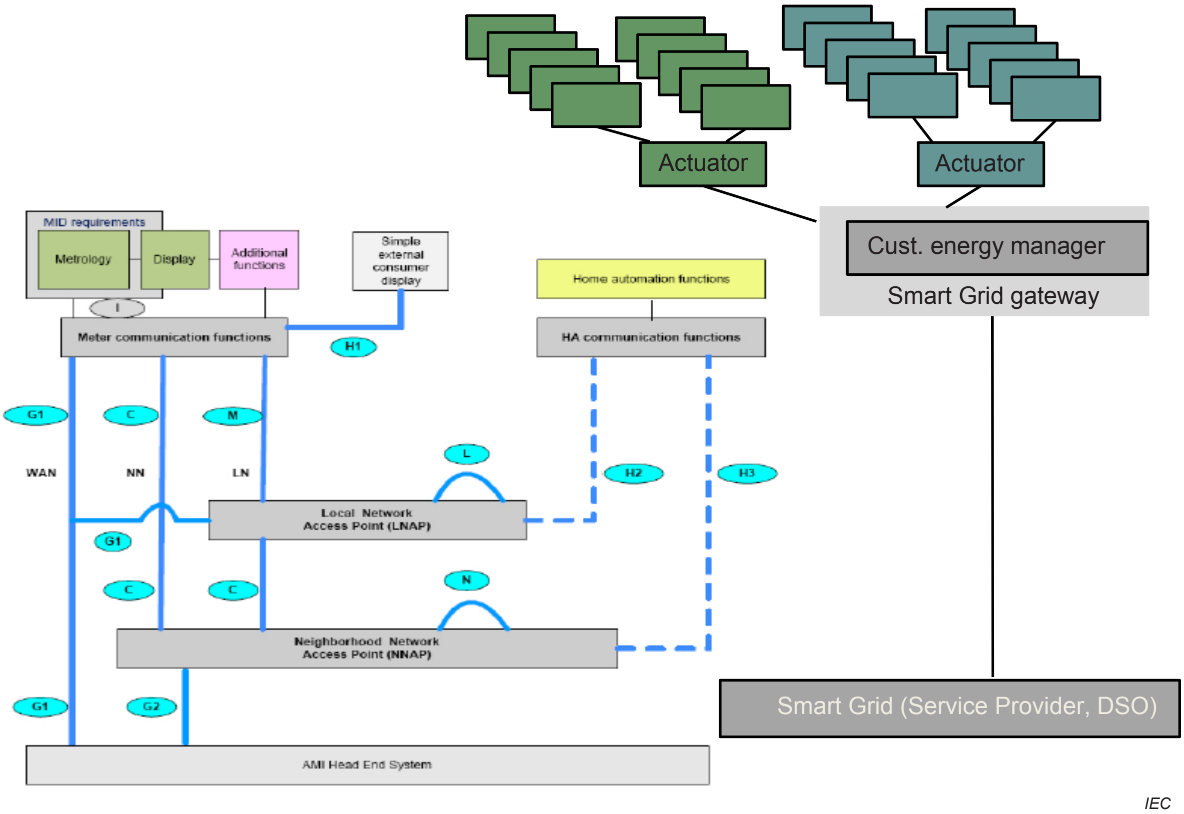


Figure B.2 – Expanded smart metering reference architecture

To enable the Smart Grid functions in the building the Energy Management Gateway and the Customer Energy Manager (CEM) play a key role, Figure B.3. To assure the interworking of devices from different manufacturers all units shall work on standardized basis.

As result there are the following responsibilities: TC 57 WG 21 for the grid side of the SG user interface, CENELEC TC 205 for the SG connection to the HBES and TC 59 WG 7 for customer devices like washing machines, refrigerators, etc.

In order to enable a differentiation between various vendors, the Customer Energy Manager itself, this means its behavior, will not be standardized, but rather the framework and the data structures.

If interoperability and the independence of the Customer Energy Manager is a requirement, then a Customer Energy Manager Framework (CEMF) is needed. The task of CENELEC TC 205 WG 18 is to describe this CEMF in a normative way. The result of this WG will be the EN 50491-12.

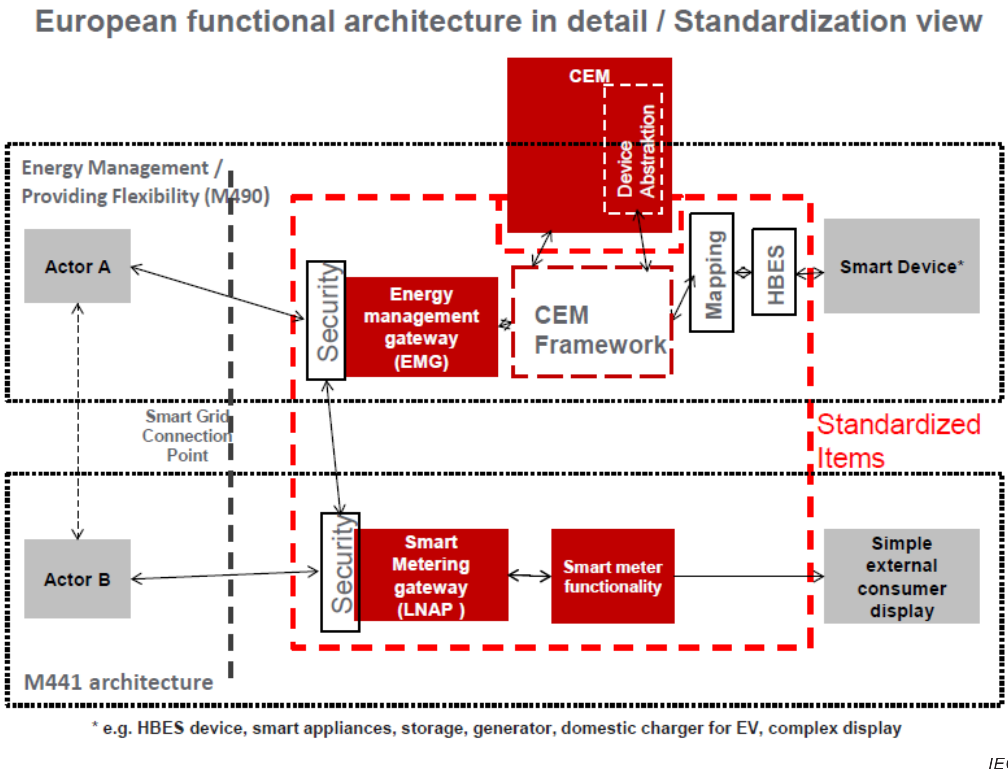


Figure B.3 – European functional architecture

As in reality there is not only one type of HBES in the market it is necessary to define a solution that enables to have a unique standardization in the grid and at the CEM, Figure B.4.

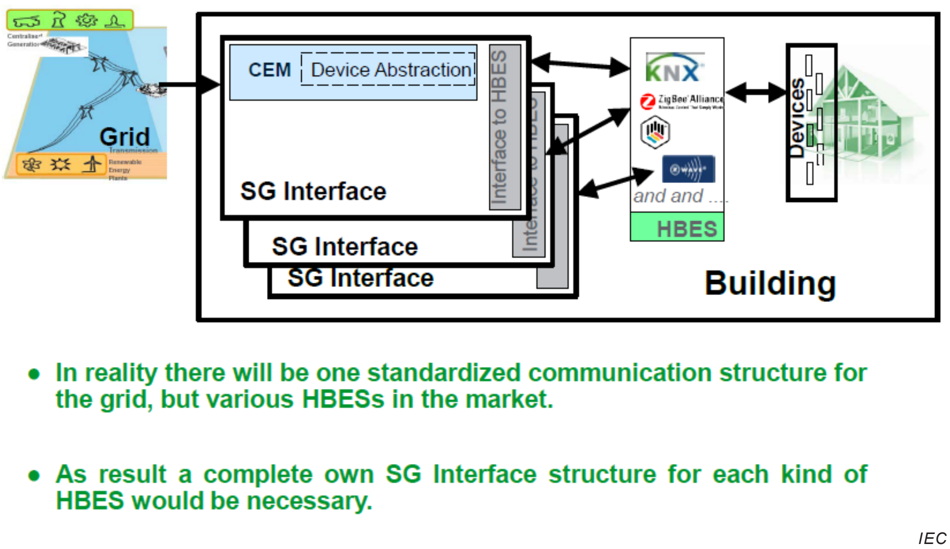


Figure B.4 – Reality of multiple HBES in market

The solution is one common framework with one neutral standardized interface for the connection (mapping) of any HBES, Figure B.5.

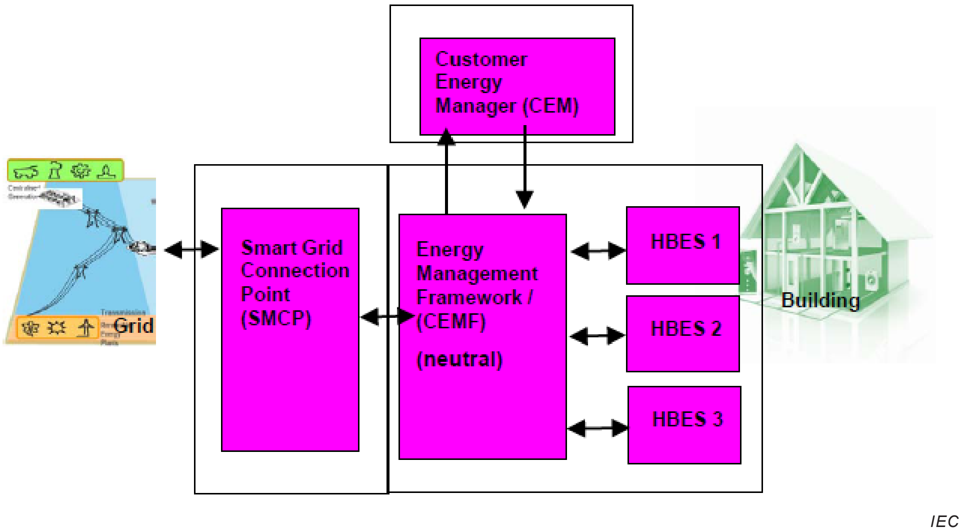


Figure B.5 – Common framework with one standard interface for mapping to any HBES

The input of the framework is described in the IEC 62746 series.

The framework will be described in EN 50491-12 [14]. The mapping to the HBES/BACS is described in the specifications of the different systems (e.g. EN 50090 series).

B.3 DR through smart meter infrastructure (France)

Three cases may be considered:

a) smart meter + customer without an (Internet) e-Box (standalone AMM); this is one hardware example of the functional smart metering centered architecture;

b) smart meter + customer with an e-Box; this is one hardware example of the functional generic architecture.

c) Stand-alone gateway

Figures B.6 and B.7 propose hardware perspectives of functional architectures detailed in 3.2.4 and in particular of the devices hosting SGUI functions.

Table B.1 presents infrastructure comparisons on services and roles for the above three options.

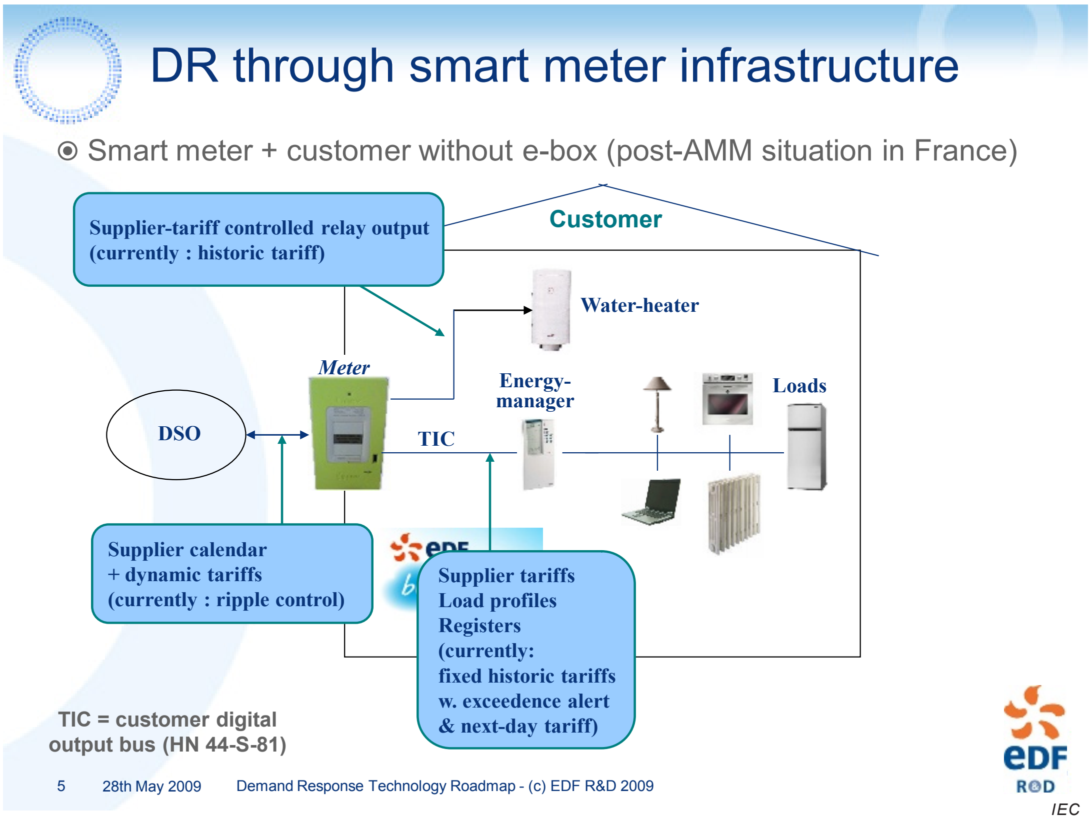


Figure B.6 – DR through smart meter infrastructure, without (Internet) e-Box

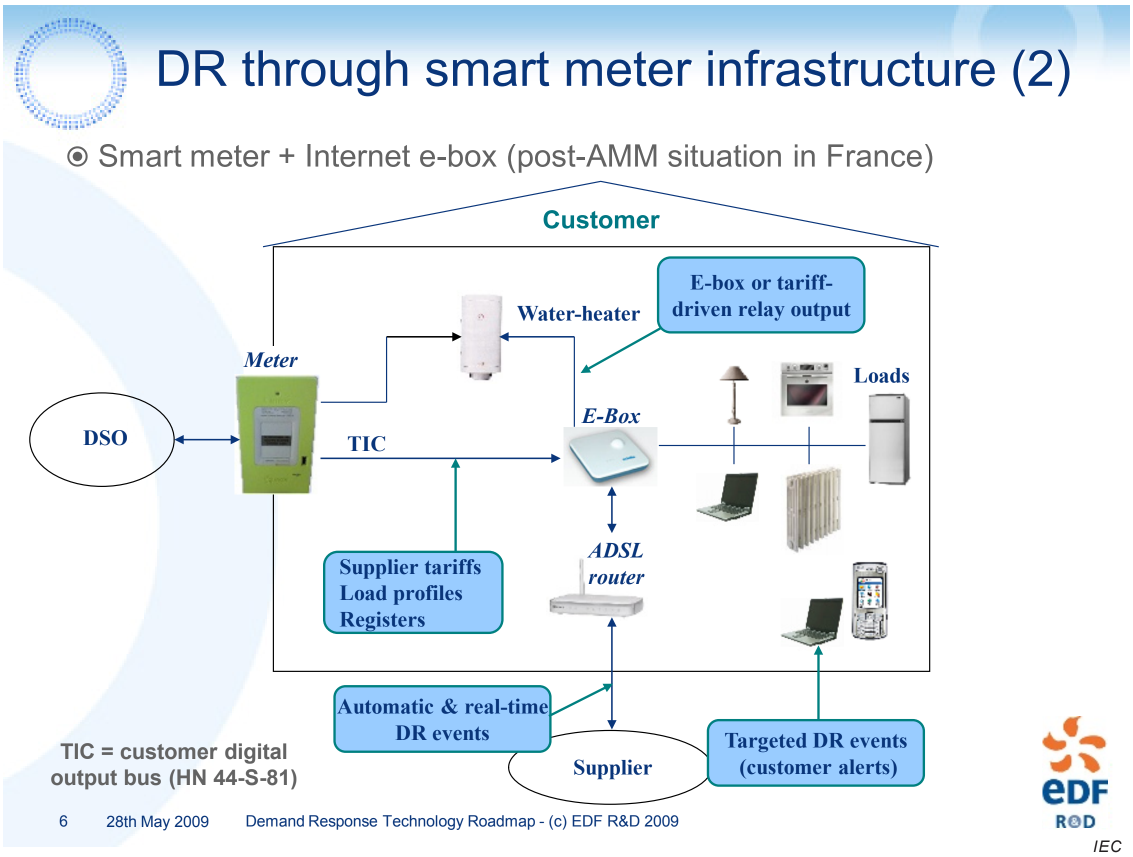


Figure B.7 – DR through smart meter infrastructure, with (Internet) e-Box

Table B.1 – DR infrastructure comparison – Services and roles

DR infrastructure comparison – Services and roles	Services	Roles
Stand-alone AMM	• Dynamic tariffs programmed by AMM system • Support of legacy EMS • Supplier TOU-tariff controls water-heater	• DSO-centric system operation • Supplier uses DSO portal to program dynamic DR events
AMM + Internet eBox	• Customized load-control (relay outputs or smart-home protocol for white-ware) • Supplier can inform customers on DR events • Customer can customize e-box configuration • Supplier TOU tariff or e-box controls water-heater • Support for multi-metering (gas,water,heat) • Curtailable load-capacity may be known to supplier	• Supplier manages dynamic DR events • DSO may continue to support direct load control through meter • Supplier freedom to use DSO portal to send any DR or energy efficiency action required • Fits market with aggregators
Stand-alone gateway	• Only limited by installation and operational costs • Due to costs, residential customers may have limited access to efficient DR services	• Commercial offers carried by suppliers of aggregators

Annex C
(informative)

Use cases

C.1 General

Use case notation has been normalized to use the two-letter country abbreviation and a two-digit use case number. Subject to minor editorial change, Annex C includes the use cases as submitted by delegates to PC 118 for inclusion in this technical report.

C.2 China use cases

C.2.1 CN01 – Use case of generic use cases

The category of generic use cases consists of common and generic UCs from customer domains, which are beneficial to collect SGUI UCs and distinguish them from others. For the grid side of the system, the user's system and devices, some use cases are common, and have to be supported by all systems and devices.

This CN01 generic category includes collection of basic customer data, real-time data and historic data, energy price, synchronic time signal, registration and login/out.

C.2.2 CN02 – Use case of demand response

Demand response is one of the most important interactive resources under the framework of the Smart Grid. With the direction of the government, national Smart Grid strategy and DR action plans have been developed with the goal to integrate Smart Grid technology and DR into Smart Grid. At the same time, related policies and regulations are being developed and reasonable incentive mechanisms introduced to reduce investment risks, guide users' optimized power consumption method and improve power consumption efficiency in the customer facility. The end goal is to use economic, technological and administrative methods to control the rapidly growing electric power system load and adjust the load curve of electric power system to obtain optimum economic benefits.

The demand response use case contains time-of-price and multi-step electricity price:

- Time-of-use price: The power service company provides a time-of-use tariff mainly aimed at industrial and commercial users, especially for high energy consumption users. Users can rearrange production shifts according to the tariff in order to save on energy costs. The power service company can encourage users to change power consumption methods and achieve the results of peak load shaving.
- Multi-step electricity price: The power service company sets average power consumed by the users into several steps, where the price per kWh per step increases with the increasing average power consumed by the users. Using multi-step electricity price with residential users can improve energy efficiency. This approach can be used with different pricing for different market segments in order to improve power consumption efficiency.

The category of DR UC includes the creation, updating, deleting of DR projects and peak demand, identification of DR contract, etc.

C.2.3 CN03 – Use case of energy efficiency

The evaluation of energy efficiency (EE) serves to monitor the status of the use of energy and to assess the status of EE enterprises, and to send proposals of technical improvement for: real-time collection of energy consumption data, general analysis of energy consumption data, and energy consumption equipment control, operation and management of energy consumption equipment and system and user archive management.

EE CN03 includes requests for EE assessment, the creation, updating, deleting of EE projects; the collection of EE data for customers' equipment.

C.2.4 CN04 – Use case of distributed energy resource

Distributed energy resource is a use case for interaction with a customer generation resource. DER has the functions of: "plug and play", remote control, bi-directional metering, and billing. The customer DER is connected to the grid and realizes plug-and-play power, long-distance monitoring and control, two-way measure and calculation. This may be done in cooperation with distributed energy storage devices in order to optimize control of power flow into the system depending on: changes of grid flow and regional load balance; limiting the disturbance to power distribution grid made by intermittent power generation at maximum, and providing information status on the operation of micro-grids.

CN04 of DER includes the creation, updating, deleting of DER projects, the registration and login/out of user, and the monitoring of DER information.

C.2.5 CN05 – Use case of electric vehicle charging

Electric vehicle (EV) charging and discharging is an important business for utilities to manage peak load by publishing price and conveying DR events. The EV UC here focuses on how EV (as a special load) can interact with DR, EE and others. This use case considers large vehicle charge and discharge stations, optimization of charge and discharge control strategies for time management and quick charge and discharge, replacement of whole groups of batteries, two-way communications, tariffs and other functions. At the same time, this use case considers additional functions including battery test and battery maintenance, satisfying self-help charge and discharge demands of the users, etc. As for smaller size auto charge and discharge stations, it can realize plug-and-play convenient charging and discharging anywhere anytime.

CN05 of EV includes the registration and login/out, the updating, deleting of EV users, the request for integration of the EV, and the conveying of the price to the EV.

C.2.6 CN06 – Use case of load management

Load management (LM) technology is one of most important means of DSM. The government and power service company incentive policy aims to cut load in peak period by providing users with economic compensation. The grid operation works with the user to develop a load management plan according to its own power consumption load status in order to perform power consumption management in peak and valley periods, to cut load in peak period, or transfer it into the valley. Meanwhile, by taking part in power market transactions according to its own load management ability, benefit accrues to the power utility at its maximum level. The aim of LM is to improve the shape of the load curve on the grid.

CN06 of LM includes remote control, local control, collect of curtailed load and conveying of the curtail command.

C.3 Korea use cases

- **KR01 – Visualization for interaction through existing user's screens**
  - Displays used by customers/managers to access information and control about the grid; real-time prices, energy and appliances monitor, energy management system, remote monitoring, home grid alarm and so on. Mobiles/smart phones, (IP) TV, internet video phone, (Tablet) PC, wall-pad, etc. can be used for this purpose.
- **KR02 – Managing devices through/by ESI (energy service interface)**

- Inside the user's premises, PEV (plug-in Electric Vehicle), PV (photo voltaic system), home appliance, and household equipment participate in a home network and in local management that a GW (gateway) governs. The energy service interface (ESI) is allowed to handle charging and power management for home appliance including PEV. Street light control, instant read, pricing signal could be considered sub-items under the management of ESI as well.
- This provides various managing capabilities for using electric energy such as monitor, control and operation of various devices which are used in home environments by considering two different types of devices: smart home devices with electric metering, and communicating capabilities and legacy home devices without such capabilities.

- **KR03 – Distributed energy generation and injection**
  - Distributed energy resources (DER), i.e small-scale power generation sources located close to where electricity is used, provide an alternative to or an enhancement of the traditional electric power grid. DER allows the managing of electrical power generating/injection system to be used within the end user premise environment such as home, building.
- **KR04 – Customers reduce their usage in response to pricing or voluntary load reduction events**
  - This includes the actual mechanism to distribute price signals and voluntary load reduction events to customers (direct electronic delivery to the customer meter, display device within the home/business, automated telephone calls, e-mail, pager, commercial broadcast radio, newspapers, etc.). It includes the mechanism by which the AMI will display current pricing and voluntary load reduction event information within the customer's home/business. The AMI will initiate automatic load reduction at the customer's site by communicating event and pricing information to customer equipment and the customer equipment will take action based on the customer's predefined setting. The customers will be able to program their load control specifications and refuse utility load reduction requests with a device within their home/business. The customer will also be able to manually curtail load based upon informational messages communicated to them through the AMI.
- **KR05 – Demand response signal generation for controlling home appliances**
  - This is a use case for demand response signal generation for controlling home appliances. The electricity service provider's operating system makes several DR (demand response) signals that are generated by the multiplication of individual CBL (customer baseline loads) representing the customer's electricity usage patterns and dynamic pricing from power exchanges. DR signals in the operating system are transmitted to the 3^{rd} party service provider's operating system or the gateway in the customer houses. DR signals pass to the consumer electronics and appliances. Power consumption of appliances varies depending on DR signal.
- **KR06 – Energy storage clustering**
  - This use case is to control ESS (energy storage system) clusters that are made up of individual ESSs distributed in specific areas: home, commercial, industrial, etc. In one cluster, there exists one operating center that takes some roles in controlling each ESS individually for storing electric power originated from renewable power sources. An operating center detects input/output of energy at each ESS and can make distribution of electric energy by comparing the energy level that each ESS has. Through the pattern analysis and prediction of power consumption, the ESS operation mode can be determined. It consists of 3 management parts: ESS, energy supply, and load management part.
    i) The ESS management part takes obtains battery SoC (state of charge) information and calculates the energy storage capacity by integrating the assessed information. It also manages energy storage quantity information of each ESS and controls charging/discharging of each ESS.
    ii) The energy supply management part judges the energy level of each ESS based on the energy storage information and determines the operation modes – whether it is charged or discharged – linked with the ESS management part. It also distributes

energy among ESSs in the cluster considering the excess/short supply of energy level.

iii) The load management part obtains real-time energy consumption amount and computes the predicted value of the energy consumption by analyzing the pattern of the load energy consumption level. It also controls energy consumption of each load based on the energy storage capacity of the ESS. By introducing a higher level control centre that controls each cluster-unit TCC, electric power transmission and trade can be possible.

- **KR07 – Customer EMS's control of EVs electric charge and discharge**
  - Based on information including a dynamic pricing message and/or a DR message from the utility, the customer EMS (xEMS (the × stands for home, building, industrial, etc.)) is able to control the charge/discharge of the EV's ES. xEMS has to consider the EV's state such as the storage state, operating schedule to optimize energy usage by the EV and the building energy consuming component.

C.4 Japan use cases

C.4.1 General

Japan DR use cases are presented in Table C.1 below.

Table C.1 – Summary of Japanese use cases

Number	Title
JP01	Control Battery via home energy management system (HEMS)
JP02	Control distributed energy resources (DER) via home energy management system (HEMS)
JP03	Control energy consumption with smart appliances by building energy management system (BEMS)
JP04	Control energy consumption with smart appliances by community energy management system
JP05	Control energy consumption with smart appliances by energy provider
JP06	Control energy consumption via home energy management system (HEMS) with smart appliances
JP07	Peak shift contribution by battery aggregation (virtual energy storage)
JP08	Control of smart home appliances based on price information by time slot
JP09	Control of smart home appliances in response to power saving request from electric power supplier
JP10	Control of smart home appliance before power cut
JP11	Control of smart home appliances in case of natural disaster

C.4.2 JP01 – Control battery via home energy management system (HEMS)

- Objectives of function:
  - avoid the risk of black out;
  - react to real time peak power signals;
  - balance the load between consumption and local production;
  - optimize the consumption to use cheaper, greener and/or safer energy (depending on personal preferences);
  - maintain power quality.
- Scenario
  - batteries can be operated by direct requests (or through HEMS) from Consumers or HEMS users to adjust their charge and discharge. (without the energy management system);
  - batteries might autonomously function to adjust their charge and discharge (equipped with the energy management system);

– HEMS may control the smart appliances and battery in order not to exceed a maximum threshold for household power consumption and charge/discharge.

C.4.3 JP02 – Control distributed energy resources (DER) via home energy management system (HEMS)

- Objectives of function
  - avoid the risk of black out;
  - react to real time peak power signals;
  - balance the load between consumption and local production;
  - optimize the consumption to use cheaper, greener and/or safer energy (depending on personal preferences);
  - maintain power quality.
- Scenario
  - DER can be controlled by direct requests (or through HEMS) from consumers or HEMS users to adjust power generation (without the energy management system);
  - DER autonomously functions to adjust its generation (equipped with the energy management system);
  - HEMS may also control smart appliances in order not to exceed a maximum threshold for household power consumption and generation.

C.4.4 JP03 – Control energy consumption with smart appliances by building energy management system (BEMS)

- Objectives of function
  - avoid the risk of black out;
  - react to real time peak power signals;
  - balance the load between consumption and local production;
  - optimize the consumption to use cheaper, greener and/or safer energy (depending on personal preferences);
  - maintain power quality.
- Scenarios
  - smart appliances can be operated by direct requests from BEMS to adjust power consumption (without the energy management system);
  - smart appliances might autonomously function to adjust their consumption (equipped with the energy management system).

C.4.5 JP04 – Control energy consumption with smart appliances by community EMS

- Objectives of function
  - avoid the risk of black out;
  - react to real time peak power signals;
  - balance the load between consumption and local production;
  - optimize the consumption to use cheaper, greener and/or safer energy (depending on personal preferences);
  - maintain power quality.
- Scenarios
  - smart appliances can be operated by direct requests (or through BEMS) from the community energy management system to adjust power consumption (without the energy management system);
  - smart appliances might autonomously function to adjust their consumption (equipped with the energy management system).

C.4.6 JP05 – Control energy consumption with smart appliances by energy provider

- Objectives of function
  - avoid the risk of black out;
  - react to real time peak power signals;
  - balance the load between consumption and local production;
  - optimize the consumption to use cheaper, greener and/or safer energy (depending on personal preferences);
  - maintain power quality.
- Scenarios
  - smart appliances can be operated by direct requests from external users to adjust power consumption (without the energy management system);
  - smart appliances might autonomously function to adjust their consumption (equipped with the energy management system).

C.4.7 JP06 – Control energy consumption via home energy management system (HEMS) with smart appliances

- Objectives of function
  - avoid the risk of black out;
  - react to real time peak power signals;
  - balance the load between consumption and local production;
  - optimize the consumption to use cheaper, greener and/or safer energy (depending on personal preferences);
  - maintain power quality.
- Scenarios
  - smart appliances can be operated by direct requests (or through HEMS) from consumers or HEMS users to adjust power consumption (without the energy management system);
  - smart appliances might autonomously function to adjust their consumption (equipped with the energy management system);
  - HEMS may control the smart appliances in order not to exceed a maximum threshold for household power consumption.

C.4.8 JP07 – Peak shift contribution by battery aggregation (virtual energy storage)

- Objectives of function
  - online power control;
  - peak shift contribution.
- Scenarios
  - default plans setting for peak shift contribution;
  - displaying potential for default plans of peak shift contribution (case 1, case2);
  - making plan for peak shift contribution;
  - execution notification of the plan for peak shift contribution;
  - control of the stationary battery;
  - monitoring of peak shift contribution.

C.4.9 JP08 – Control of smart home appliances based on price information by time slot

- Objectives of function

- to plan the operation time table:
  - i) the peak power consumption does not exceed the maximum by determining the combination of what smart home appliances are working in the same time slot, and
  - ii) smart home appliances that work continuously for a longer time and/or may work spanning a couple of time slots, such as water heating, battery charging, are assigned to work in the time slot whose price is relatively inexpensive.

- Scenarios
  - HEMS
    - i) receives the latest price information for the next 24 hours from the electric power supplier
      - a) ex. at Day N, AM6 -> Day N+1, AM6 to Day N+2, AM6,
    - ii) is triggered to start planning the time table of the smart home appliances operation from Day N+1 AM6 to Day N+2, AM6,
    - iii) interprets the given price information into time duration, start time, end time and price of each time slot, and compares them to see which time slot is longest and/or most inexpensive,
    - iv) plans which smart home appliances will work, and/or will not work,
  - the integral power consumption is unchanged but the maximum peak power changes according to the participating appliances at the time slot.

C.4.10 JP09 – Control of smart home appliances in response to power saving request from electric power supplier

- Objectives of function:
  - to generate the operating plan of the smart home appliances for power saving.
- Scenarios:
  - HEMS
    - i) receives the power saving request from the electric power supplier,
    - ii) is triggered to start planning,
    - iii) plans what appliances are working, and/or not working, from when to when and with what detailed operating conditions,
    - iv) starts controlling the smart home appliances according to the plan,
    - v) discards the plan or quits planning if:
      - a) the consumer does not accept the plan,
      - b) the HEMS is not able to conclude the plan that meets the power saving conditions and the detailed operating conditions given by the consumer in advance.

C.4.11 JP10 – Control of smart home appliance before power cut

- Objectives of function:
  - to generate the operating plan of smart home appliances connected to the HEMS network for the period before the power cut occurs.
- Scenarios
  - HEMS
    - i) receives the power cut information from the electric power supplier,
    - ii) is triggered to generate the operating plan of the smart home appliances,
    - iii) controls the smart home appliances according to the operating plan if it is acceptable for the consumer.
- Behavior of the smart home appliances in case of power cut:

– they continue working with different conditions and turn off before power cut,
– they start working according to Consumer's preset and turn off before power cut,
– they work as long as possible during the grace period before the power cut and turn off with the normal shut down process,
– they stop at the time when the preset conditions are satisfied.

C.4.12 JP11 – Control of smart home appliances in case of natural disaster

- Objectives of function
  – to generate the operating plan of the smart home appliances in response to the alert from the electric supplier that instability of power supply and/or power cut is possible due to a natural disaster.
- Scenarios
  – part of power grid is affected due to natural disaster.
  – electric power supplier initiate special accommodation of power and/or intentional power cut .
  – in the case the customer receives an alert from the electric power supplier, the consumer can prepare against such a situation by:
    i) filling the tank with heated water,
    ii) charging the battery, etc.
  – the HEMS receives the alert of a natural disaster from the electric power supplier,
  – the HEMS is triggered to start controlling the smart home appliances by
    iii) prioritizing appliances to work to store energy,
    iv) saving energy,
  – The consumer differentiates those preset conditions from the normal period,
  – when a natural disaster is no longer expected to be an obstacle:
    v) the electric power supplier informs the HEMS of the alert cancellation
    vi) the HEMS cancels the special conditions and resumes to normal control status.

C.5 France use cases

C.5.1 General

Table C.2 – Summary of French use cases

#	Title
FR01	ECS load control for electrical water heating tank coupled with on/off peak tariff
FR02	Dynamic pricing of electricity and energy management
FR03	Managing a superseding tariff schedule
FR04	Handle a tariff event through managed equipment
FR05	Handle a tariff event by local intelligence

The complete and general versions of the use cases mentioned (in a summarized form) below are available at:

http://www.cen.eu/cen/Sectors/Sectors/UtilitiesAndEnergy/SmartGrids/Pages/default.aspx

C.5.2 FR01 – Load control for electrical water heating tank coupled with on/off peak tariff

Name of author(s) or committee:

EDF R&D

Scope and objectives of function:

This use case describes a Load Control System linking together an on/off peak tariff, the metering system and the electric water heating tank of the customer. This system is currently an existing load shifting and energy storage solution (for specific markets / geographical area). In particular, in France, addressing several millions of Hot water tanks, it brings a major contribution to the balance of the French electric system.

The objective of this use case is:

- for customers:
  - to have the hot water they need at any time
  - to optimize the cost of this service by switching on the electric water heating tank only when the price is low, at low peak hours.
- for the producer/supplier/network operators:
  - to reduce the gap between night and day consumption, both for generation and network.

Short description:

A load control event derives from the change between on-peak and off-peak periods. The meter has an information port to which an appliance is connected. This appliance can get the event data, directly interpret it and react accordingly.

Complete description:

When a daily pricing load control signal occurs, the electrical water heating tank main supply is switched ON or switched OFF, so that the electric water tank is only allowed to consume energy during a specific timeslot of the day (mainly at night) when prices are low. However, the consumers can always derogate if they wish.

The electrical water heating tank can be considered as an energy storage appliance which help electricity utilities to keep the global load curve as flat as possible by shifting the electricity water tank consumption to night usage only.

Actor names:

- electricity supplier
- Distribution system operator (DSO) / meter operator (MO)
- Smart meter (SM)
- Consumer
- Appliance control module
- Electric hot water tank

C.5.3 FR02 – Dynamic pricing of electricity and energy management

Name author(s) or committee:

EDF R&D

Scope and objectives of function:

This use case describes a load control system using a dynamic pricing of electricity in order to help the electric system in the days of very high peak demand. This system currently exists in France: the tariff is named “Tempo”, and several hundreds of thousands customers have adopted it and, either manually or with the help of an energy manager device connected to the meter, they modulate the use of their electric heating according to the periods of the tariff.

Short description:

For a small number of peak days in the year, a special peak day tariff may apply, which is particularly high, overriding the regular daily and weekly price variations, and encouraging the customer to lower his consumption during these peak periods; the customer is informed the day before every peak day. These peak periods may be handled either manually by the customer, directly by the appliances, if they are smart enough to get the metering data from the metering data port, or with an energy management device, connected to the metering data port, and which controls the equipment.

Complete description:

A dynamic tariff may include both a regular price variation, such as on-peak (day)/off-peak (night), and a more dynamic component, for example under the form of the “colour” of the day. As an example, the Tempo tariff includes 3 colours: blue, for most of the days of the year (300), white, for medium peak days (43), and red for high peak days (22). As for each of these 3 colours there are still on-peak and off-peak rates, it makes 6 different rates, going from blue off-peak, for the cheapest, to red on-peak for the most expensive.

Customers–preferably those who have a load as electrical heating that they can moderate in peak days (for example if they have an alternative non electric heating system)–can advantageously subscribe to this tariff.

The colour of the day is always given the day before. The customer can receive this information by any mean he wishes (including SMS and email). This information is also downloaded and displayed on the meter or on any display connected to the meter. The meter also makes this information available on the meter data port. An appliance, for example a heat pump, connected to this port may directly adapt its working mode according to this information and according to the preferences programmed by the user. The same may be also done by an energy manager that would typically be connected to electric heaters and control them. The customer may always derogate to the pre-programmed mode.

Actor names:

- Electricity supplier
- Distribution system operator (DSO) / meter operator (MO)
- Smart meter (SM)
- Consumer
- Energy manager
- Electric heating
- Smart appliance

C.5.4 FR03 – Managing a superseding tariff schedule (peak demand) UC_PC_14

Name author(s) or committee:

EDF R&D

Scope and objectives of function:

The customer benefits from reduced tariffs in exchange for handing over control to the supplier during periods of peak demand. In case the customer does not transfer command the tariffs are higher.

Short description:

The supplier detects that it needs to react to a peak demand. For this purpose it determines the characteristics of the peak demand period and the demand response groups concerned. It then sends a message indicating peak demand to the customers concerned.

Complete description:

The supplier detects that it needs to react to a peak demand. For this purpose it determines the characteristics of the peak demand period (date, time, duration, etc.) and the demand response groups concerned. It then sends a message indicating peak demand to the customers concerned.

Within the 'fixed' tariffs regime the notion of peak demand provides the opportunity to set a period of some hours in which the tariff regime is overruled. This period is signalled in advance to the customer. In these cases the 'fixed' tariff in the metering equipment is replaced for the period concerned with the specific tariffs for peak demand which depends on the day of the week.

Assumptions:

- Specific contract
  - The customer subscribes to a specific type of contract in which he agrees with the mechanism for peak demand and the associated tariffs.
  - The tariff regime associated with the contract is loaded in the metering equipment after the customer subscribes to the contract. The tariff regime is updated periodically.
- Peak demand signal
  - The peak demand signal is issued to the metering equipment at J-1.
  - The customer is not charged for the demand signal if he has subscribed to the contract for peak demand.
- Local system:
  - In order to assure the service for peak demand in this UC, the local system does not intervene. However the system can provide capabilities to display the peak demand signal and is able to apply the customer's preconfigured peak demand settings.
- The supplier:
  - The initiating actor for the peak demand in the UC is the supplier but there is a need to define a new UC where the initiating actor is the generation buyer (where the managed equipment consists of distributed energy resources). The interactions between actors will not differ from the current use case.

Actor names:

- Customer
- Local system
- Intelligent electrical appliances
- Metering equipment
- Distribution system operator
- Supplier

C.5.5 FR04 Handle a tariff event through managed equipment UC_PC_16

Name author(s) or committee:

EDF R&D

Scope and objectives of function:

The customer optimizes costs for energy usage through granting/revoking permission to operate equipment in accordance with the tariff regime or tariff events

Short description:

The managed equipment responds to signals (based on the parameters set by the customer) associated with tariff events.

Complete description:

Description:

In case of a tariff event (for instance in case of a shift between peak and off-peak hours or in case of peak demand), the managed equipment including the production equipment, responds according to the parameters set by the customer. This means the equipment can continue to work, stop working, interrupt operation etc.

Remarks:

- The customer has the opportunity to overrule the automated operation
- In case of a peak demand signal the customer can receive a preconfigured alarm

If the tariff event is caused by peak demand, UC_PC_16 is preceded by UC_PC_14 (issue and signal advice for peak demand to J-1).

Assumptions:

- HAN equippment
  - The HAN equipment (both consumption and production) is managed. This means it reacts to tariff signals issued by the local system.
- The local system:

  In order to provide the services mentioned in this UC, the local system shall at least include:
  - The functionality to issue a command to the managed equipment as a result of tariff events.
  - The functionality to display the peak demand signal if requested.
  - A user interface that provides functionality to set and modify parameters associated with tariff events.

Actor names:

- Consumer/user
- Distributed energy resource
- Managed electrical appliances
- Local system
- Metering system

C.5.6 FR05 – Handling a tariff event by local intelligence UC_PC_17

Name author(s) or committee:

EDF R&D

Scope and objectives of function:

The customer optimizes costs for energy by managing the utilization (run, stop, reduction) of electrical appliances based on tariff regime and tariff events.

Short description:

Handling of a tariff event by local intelligence. The local intelligence is embedded in the local system and may include production equipment. The situation where the tariff event is associated with peak demand is handled by the customer and is not covered in this UC.

Complete description:

Description:

In case of a tariff event (for instance in case of a shift between peak and off-peak hours or in case of peak demand), the local system manages the local demand based on the parameters set by the customer.

– The customer can overrule the local intelligence.
– The customer may receive an alarm in case this was configured (peak demand).

Two scenarios are presented below:

– SC1: Handle a tariff event through intelligence embedded in the local system.
– SC2: Handle a tariff event through intelligent appliances or intelligent production equipment.
– Both scenarios are mutually exclusive (refer to the assumption on HAN equipment) although mixed configurations are possible.

In case the tariff event is associated with peak demand, UC_PC_17 is preceded by UC_PC_14 (issue a peak demand signal to J-1).

Assumptions:

- HAN equipment
  – The HAN equipment (both consumption and production) is considered to be managed by the local system. The equipment only responds to commands (run, stop, reduction) issued by the local system.
  – The HAN equipment (both consumption and production) is considered to be intelligent as no intelligence is available beyond the local system
  – In practice mixed configurations will be available.
- Demand management signals
  – Production equipment is managed by signals (produce, stop producing, reduced production).
  – Consuming equipment is managed by signals (run, stop, reduced).
- Equipment management
  – Scenario 1: The equipment is orchestrated to ensure a smooth exit of the peak demand period.

  - Scenario 2: It is assumed that each intelligent equipment (both consumption and production) do not take into account the demand management strategies established by the other equipments.

- Local system:

  In order to provide the functionality mentioned in the UC, the local system shall at least be composed of:

- in case the intelligence is embedded in the local system (SC1)
  - functionality to compute the demand management strategy
  - functionality to manage demand by issuing commands to both equipment for production and consumption
  - functionality to display the peak demand signal and / or the demand management strategy is necessary
  - a user interface that provides functionality to set and modify parameters for load management
- in situations where intelligence is embedded in equipment for production and consumption, meaning that the local system does not intervene or only repeats/displays the signal for a tariff event (SC2)
  - functionality to display the peak demand signal when necessary

Actor names:

- Consumer or user
- Supplier
- Managed equipment
- Smart appliances
- Local system
- Metering equipment

NOTE For the sake of simplicity, the electrical HAN is composed of a single component; the presence of any additional equipment does not alter the interactions.

C.6 India use cases

C.6.1 IN01 – Energy efficiency

- Energy efficiency through demand response
- Active energy efficiency using smart/ intelligent controls and equipment
  - can be independent of DR- Focus on standalone sensors and controls
  - identifying loads and work out strategies to shift their usage to non-peak time
  - advanced systems to manage energy, e.g software based systems, plc's advanced controllers,
- Energy monitoring, measurement
  - identification of critical and non-critical loads at site for EE
  - energy normalization
  - can meters capture temperature along with other electrical parameters?
- Demand side management
  - TOU based load limits
  - identify the major energy consumer segments (e.g agriculture, buildings, etc.) and suggest strategies for DSM

  - manage generation shortages through selective load control thereby converting a blackout scenario into a brownout
- Equipment efficiency
  - pump efficiency, chiller efficiency, etc.
  - superior EE appliances; major consumer segments; recommendations based on similar equipments and appliances available world-wide

C.6.2 IN02 – Demand response for peak load reduction

- Managing devices through/by ESI (energy service interface)
  - Inside the home user's device network (e.g. appliances, home invertors)/commercial users (e.g HVAC, pumps, elevators etc), the energy service interface (ESI) is permitted to manage power consumption for appliances; tariff information can be used by the ESI to effectively manage the loads.
  - Different DR strategies could be worked out for different categories of customers.
- Load reduction through price
  - Consumer will participate in voluntary load reduction events based on the pricing information received during the particular DR event. In response the consumer has to convey to the utility/aggregator/program manager about its participation in the DR event.
  - Demand response signal generation for partial or full control of the commercial and industrial loads such as controlling the HVAC set points or dimming the lights in order to reduce power consumption by energy consuming systems. Here the utility/aggregator/program manager is able to control the loads at consumer premises directly based on their requirements.

C.6.3 IN03 – Home energy management

- Overall near real time energy monitoring
  - Contractual versus actual consumption to indicate violation for taking corrective action.
- Appliances wise consumption monitoring and control
  - Appliance shall show energy consumption on periodic basis for better monitoring and control to encourage energy conservation and better cost control.
  - This will also perform energy benchmarking.
- Optimization of energy usages
  - Use of sensor for automatic lighting loads, temperature control, etc.
  - Use of sensors for home entertainment systems control.
- Stand-by smart appliances
  - The control mechanism to switch off the appliances whenever they are in standby mode for more than the pre-set duration.
- Inverters – Battery charging through solar PV/wind
  - A very large number of homes have battery and inverter systems which supply power in the event of outages (which may be very frequent). A lot of energy is consumed to charge these batteries which can be provided by small renewable sources such as rooftop solar PVs/micro wind. These renewable sources may also be used to supply to loads and the grid, if possible.
- Operation of different appliances during off-peak hours based on the price signals received from the utility
  - To interpret the price signals to identify ideal time slots for load usage.

C.6.4 IN04 – Building energy management

- Monitor energy use

  - Monitoring energy consumption at each load point in the building.
- Generate energy locally
  - This use case promotes local energy generation at building level by renewable sources such as PV panels and micro-wind turbines.
- Provide emergency electricity
  - This use case represents the ability of the building energy management system to provide a minimum amount of electricity in case of power outages for safety purposes, for example providing emergency supply for lighting and provide graceful elevator shutdown.
- Store energy locally
  - This use case represents the ability to store electricity and hot water locally using equipment like batteries, fuel cell, hot water tanks, etc.
- Optimize energy use
  - This use case represents the ability of the building energy management system to have a beneficial effect on the energy consumption patterns of the building, either with respect to conserving energy or optimizing costs or delivering benefits to the external grid/micro-grid by helping shape the energy load.
- Increase awareness of energy consumption
  - The BEMS provides regularly updated historic, real-time and/or forecast energy usage data of the office building via displays/information screens/web browsers to the end-users with the goal to motivate the occupants to use energy conservatively.
- Support online community
  - The basic idea behind this use case is that energy conservation and a greener life-style can also be encouraged by facilitating the formation of an online community of like-minded people who can use the online platform to share ideas, experiences, know-how, or even participate in competitions.
- Benchmarking for energy efficiency
  - This use case represents the ability to regularly check the energy benchmarking to validate energy efficiency and energy conservation in comparison with recommended requirements.
- Optimize the data center air conditioning
  - The air conditioning systems (with their heat pump for winter) consume close to 50 % of the total data centre consumption. A real-time monitoring of temperatures (which vary with the load of servers) allows significant savings in energy consumption by control of air conditioning.
- Monitor instantaneous power quality to validate power service level agreement
  - A utility offers a service level agreement (SLA) on power quality to a customer. The customer receives power quality information in real-time. The customer can track and project performance against the SLA over various periods of time
- Balance power purchases between different utilities
  - The building energy manager selects the cheapest or most reliable supplier and the amount to be purchased using “open access” regulations.

C.6.5 IN05 – Local markets to enable consumer-prosumer open access transactions

- Electricity open-access consumers are special type of consumers who can buy/sell power across the system through different contracts without having any regional boundaries. This use case promotes consumers-prosumers partnership and enables to carry-out open access transactions through SGUI. These transactions are bilateral in nature and the information flow between the users can be represented as consumer1 (prosumer1) → SGUI → Grid → SGUI → consumer2 (prosumer2).

C.6.6 IN06 – Deliver output reports of demand side equipment in standardized data formats to users

- This is a use case for delivering output reports of demand side equipment in standardized data format to the users. It includes information such as equipment consumption over a certain period, demand response event records, demand response transactions, electric vehicle management records, etc. User requests for such reports shall be processed through SGUI. This use case has the potential to provide third-party access and promote innovative third-party services operating on the output reports of demand side equipment.

Annex D
(informative)

Standards

D.1 Short summary of Clause 4 relevant standards

D.1.1 General

Clause D.1 includes brief introductions to each of the standards listed in the tables in Clause 4.

D.1.2 ISO/IEC 15067-3

Smart Grid application specification for demand response, distributed energy resources and local storage. This standard specifies a framework for methods that can align residential needs for electricity with available supplies. These supplies may be provided by a public utility plus local generation and storage.

D.1.3 ISO/IEC 15045 series

Gateway to link a home network and an external network including Smart Grid communications. The residential gateway is the interface between a public Smart Grid and a home network. This gateway may also be applied to other home services that interact with external service providers. The gateway translates between different communication protocols and has options for enhancing consumer privacy, safety and data security.

In Clause 7 of ISO/IEC 15045-2:2012, the HES-gateway system specifies the information exchange model and protocols of the home gateway, and is applicable on layer CI, while further research is needed to see to what extent the specification meets the requirement.

D.1.4 ISO/IEC 18012 series

Product interoperability to provide seamless operation of home system products including energy management complying with a diversity of communication protocols. Customer energy management may involve devices designed for a variety of communications protocols. This standard allows these products to exchange messages and data within the house and with energy management service providers. This protocol may be implemented in an ISO/IEC 15045 gateway to interconnect networks running different protocols.

D.1.5 ISO/IEC 14543 series

Residential communication architecture, protocols, network configuration and network management that could carry Smart Grid signals. This series of standards specifies a generic interface architecture for connecting devices to a home network. Specific communication protocols for command, control and discovery are included in this series.

D.1.6 ISO/IEC 14543-3 (EN 50090) KNX

KNX bus system is independent from manufacturers and application areas, through which all devices are connected to the KNX medium (these media include twisted pair, radio frequency, power lines, or IP/Ethernet), therefore enabling information exchange. Bus devices can either be sensors or actuators, utilized for control of building management device, such as: lighting, shading/shutters, security systems, energy management, heating, ventilation and air conditioning systems, signalling and monitoring systems, service interface and building control systems, remote control, metering, video/audio controls, large home appliances, etc.

All of these functions can be performed through a unified system that is capable of control, monitoring, and of sending signals, without the need for an additional control centre.

D.1.7 ISO/IEC 14908-1

ISO/IEC 14908-1 specifies a communication protocol for local area control networks. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies. ISO/IEC 14908-1:2012 describes services in layers 2 to 7. In the layer 2 (data link layer) specification, it also describes the Medium Access Control (MAC) sublayer interface to the physical layer. The physical layer provides a choice of transmission media. In the layer 7 specification, it includes a description of the types of messages used by applications to exchange application and network management data.

D.1.8 ISO 16484-5 (ASHRAE/ANSI 135)

BACnet: a data communication protocol for building automation and control networks. The purpose of this standard is to define data communication services and protocols for computer equipment used for monitoring and control of HVAC&R and other building systems and to define, in addition, an abstract, object-oriented representation of information communicated between such equipment, thereby facilitating the application and use of digital control technology in buildings.

This protocol models each building automation and control computer as a collection of data structures called “objects,” the properties of which represent various aspects of the hardware, software, and operation of the device. These objects provide a means of identifying and accessing information without requiring knowledge of the details of the device’s internal design or configuration.

- Clause 4: BACnet is based on a four-layer collapsed architecture that corresponds to physical, data link, network, and application layers of the OSI model.
- Clause 5 to Clause 11: A four-layer collapsed architecture is chosen after careful consideration of the particular features and requirements of BAC networks, which is described from these parts.
- Clause 12: An object-oriented approach has been adopted to provide this network-visible representation. This clause defines a set of standard object types.
- Other kinds of services are introduced among Clause 13 to Clause 17.

D.1.9 ISO 17800 (ASHRAE/NEMA 201P)

ISO WD 17800 (ASHRAE/NEMA 201P), *Facility Smart Grid information model*

This standard is currently under development as an ANSI/ASHRAE/NEMA standard. It is also part of the work program of ISO/TC 205. The purpose of this standard is to define an abstract, object-oriented information model to enable appliances and control systems in homes, buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a “smart” electrical grid and to communicate information about those electrical loads to utility and other electrical service providers. This model provides the basis for common information exchange between control systems and end use devices found in single- and multi-family homes, commercial and institutional buildings, and industrial facilities that is independent of the communication protocol in use. It provides a common basis for electrical energy consumers to describe, manage, and communicate about electrical energy consumption and forecasts.

The model defines a comprehensive set of data objects and actions that support a wide range of energy management applications and electrical service provider interactions including: on-site generation, demand response, electrical storage, peak demand management, forward power usage estimation, load shedding capability estimation, end load monitoring (sub metering), power quality of service monitoring, utilization of historical energy consumption data, and direct load control.

More details in D.2.6.

D.1.10 ISO/IEC 14762

ISO/IEC 14762:2009, *Information technology – Functional safety requirements for HBES*

ISO/IEC 14762:2009 specifies the general functional safety requirements for HBES following the principles of the basic standard for functional safety IEC 61508. This International Standard sets the requirements for functional safety for Home and Building Electronic Systems (HBES) products and systems, a multi-application bus system where the functions are decentralised, distributed and linked through a common communication process. The requirements may also apply to the distributed functions of any equipment connected in a home or building control system if no specific functional safety standard exists for this equipment or system. This International Standard only addresses HBES products. HBES and HES products in this International Standard are for non-safety related applications.

D.1.11 ISO/IEC 29145

ISO/IEC 29145 series, *information technology – Wireless Beacon-enabled Energy Efficient Mesh network (WiBEEM) for wireless home network services*

Physical, MAC, and network layers for home network services that support a low power-consuming wireless mesh network topology as well as device mobility and QoS.

D.1.12 ISO/IEC 30100

ISO/IEC 30100 series, *Home network resource management* (to be published)

This standard specifies the general information model and architecture for managing resources of home networks. Essential resource definitions are specified for devices, networks, and service resources. The home resource model is an abstract, formal representation of resource objects in a home that includes their properties, relationships and the operations that can be performed on them.

D.1.13 IEC 61158-6

IEC 61158-6, *Industrial communication networks – Fieldbus specifications – Part 6: Application layer protocol specification*

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the three-layer Fieldbus Reference Model. This standard describes the Fieldbus application layer protocol that defines the information interchange and the interactions between application entity invocations (AE-Is) to support application services.

D.1.14 IEC 61400-25 series

IEC 61400-25 (all parts), *Wind turbines – Part 25-X: Communications for monitoring and control of wind power plants*

IEC 61400-25-1 is drafted by IEC technical committee 88: Wind turbines, which is considered as an expansion of IEC 61850 to wind generation. The IEC 61400-25 series is developed to provide a uniform communications basis for the monitoring and control of wind power plants, with intention to realize free communication between equipments from different vendors. It defines specific information, mechanisms for information exchange and the mapping to communication protocols. By abstracting, modeling and standardizing of wind farm information, these standards enable interconnection, interoperability and expandability in various equipments.

a) IEC 61400-25-1, *Communications for monitoring and control of wind power plants – Overall description of principles and models*, describes monitoring communication theory and models in wind farm, and provides an overview of the whole standard.
    - IEC 61400-25-1:2006, Clause 6: This clause provides a detailed description of the wind farm information model, with an object oriented view, clearly defines and describes common information related to wind farm.
    - IEC 61400-25-1:2006, Clause 7: The major goal of the wind power plant information exchange model defined in the IEC 61400-25-3 is to exchange information between an instantiated information model of various classes, including logical nodes, data, data attributes and control blocks.
b) IEC 61400-25-2, *Wind turbines – Part 25-2: Communications for monitoring and control of wind power plants – Information models*, describes information models of monitoring communication in wind farm, with the introduction of a modeling method, logical node and common data class.
c) IEC 61400-25-3, *Wind turbines – Part 25-3: Communications for monitoring and control of wind power plants – Information exchange models*, describes a functionality model and abstract communication service interface for information exchange in wind farm.
d) IEC 61400-25-4, *Wind turbines – Part 25-4: Communications for monitoring and control of wind power plants – Mapping to communication profile*, describes mapping communication protocols and mapping method.
e) IEC 61400-25-5, *Wind turbines – Part 25-5: Communications for monitoring and control of wind power plants – Conformance testing*
f) IEC 61400-25-6, *Wind turbines – Part 25-6: Communications for monitoring and control of wind power plants – Logical node classes and data classes for condition monitoring*

The core content of the 61400-25 series inherited the IEC 61850 standard and contains most of the characteristics of IEC 61850.

D.1.15 IEC 61588

IEC 61588:2009, *Precision clock synchronization protocol for networked measurement and control systems*

This standard specifies the measurement and control system used in network communication, local computing and distributed object technology, precision clock synchronization and precision time protocol, as well as the required node system and communication features to support the precision time protocol.

SGUI related clauses: Clauses 5 and 6. The standard defines the basic and derived data types using a PTP system, provides the general specification of data set, as well as of the ordinary clock, boundary clock, and transparent clock. It also provides a universal message and event message format, the basic model of the PTP protocol, and an overview of the main aspects of the PTP system messages, device type, the synchronization mechanism and the PTP protocol communication. The standard clarifies the PTP device type model and internal relevant correction process, request-response message exchange as well as delay measurement delay mechanisms and peer-to-peer delay mechanism, timestamps generated, PTP communication topology.

D.1.16 IEC TR 61850-90-7

IEC TR 61850-90-7:2013, *Communication networks and systems for power utility automation – Part 90-7: Object models for power converters in distributed energy resources (DER) systems*

The TR describes the functions for inverter-based Distributed Energy Resources (DER) systems, including photovoltaic systems (PV), battery storage systems, electric vehicle (EV) charging systems, and any other DER systems with a controllable inverter. It defines the IEC 61850 information models to be used in the exchange of information between these inverter based DER systems and the utilities, Energy Service Providers (ESPs), or other entities which are tasked with managing the volt, var, and watt capabilities of these inverter-based systems. These inverter-based DER systems can range from very small grid-connected systems at residential customer sites, to medium-sized systems configured as microgrids on campuses or communities, to very large systems in utility-operated power plants, and to many other configurations and ownership models. They may or may not combine different types of DER systems behind the inverter, such as an inverter-based DER system and a battery that are connected at the DC level.

D.1.17 IEC TR 61850-90-8

IEC TR 61850-90-8, *Communication networks and systems for power utility automation – Part 90-8: IEC 61850 object models for electric mobility* (to be published)

The document defines the information model considering EV, charging facilities and charging interface as logic objects. The technical report describes how current standardization for electric road vehicles and the vehicle-to-grid communication interface can be linked to the IEC 61850-7-420 standard for distributed energy resources (DER). The technical report provides necessary background information and proposes an object model for e-mobility in order to establish an electric vehicle plugged into the power grid as DER according to the principles of IEC 61850-7-420. The basic information modeling in the IEC 61850 series and IEC 61850-7-420 already covers a lot of needs for the e-mobility domain. Missing parts can be modeled as new logical nodes and data objects, which this technical report defines.

D.1.18 IEC 61968 series

IEC 61968 (all parts), *Application integration at electric utilities – System interfaces for distribution management*

The IEC 61968 series is intended to facilitate inter-application integration, as opposed to intra-application integration, of the various distributed software application systems supporting the management of utility electrical distribution networks.

a) IEC 61968-1:2012, *Interface architecture and general recommendations*
   - It defines interface architecture and general requirements of the major components associated with the DMS. It gives out the general IEC 61968 compliant interface architecture for distribution management system.

b) IEC 61968-2:2011, *Glossary*
   - It defines the glossaries used in the IEC 61968 series. The terms, corresponding definitions and abbreviations are all given out for the distribution management system.

c) IEC 61968-3:2004, *Interface for network operations*
   - It defines the reference and information model for distribution grid operation, and relative network operation message types are defined.

d) IEC 61968-4:2007, *Interfaces for records and asset management*
   - It defines the reference and information model for asset management and records (such as with distribution grid planning, network topology / parameters of the cross-system replication, etc.). Corresponding records and asset management message types are defined too.

e) IEC 61968-9:2013, *Interfaces for meter reading and control*
   - It specifies the information content of a set of message types that can be used to support many of the business functions related to meter reading and control. Typical uses of the message types include meter reading, controls, events, customer data synchronization and customer switching. The purpose of IEC 61968-9 is to define a

standard for the integration of metering systems (MS), which includes traditional manual systems, and (one or two-way) automated meter reading (AMR) systems, and meter data management (MDM) systems with other enterprise systems and business functions within the scope of IEC 61968. The scope of IEC 61968-9 is the exchange of information between metering systems, MDM systems and other systems within the utility enterprise.

f) IEC 61968-11, *CIM extensions for distribution*

- Information model that extends the base CIM for the needs of distribution networks, as well as for integration with enterprise-wide information systems typically used within electrical utilities.

g) IEC 61968-13:2008, *CIM RDF Model exchange format for distribution*

- Based on the Common Information Model ("CIM"), IEC 61968-13 specifies the format and rules for information exchanging model related to distribution network data, allowing exchange of instance bulk data. Thus, the imported network model data should be sufficient to perform network connectivity analysis, including network tracing, outage analysis, load flow calculations etc. These standards could also be used for synchronizing geographical information system databases with remote control system databases.

D.1.19 IEC 61970 series

IEC 61970 (all parts), *Energy management system application program interface (EMS-API)*

By providing a standard method expressing the electric power system resources through object classes and attributes and the relationship between them, CIM greatly facilitates the integration of various applications in energy management systems and full EMS developed independently by different vendors, as well as EMS and other systems involved in different aspects of power system operation.

SGUI related parts: IEC 61970-1, IEC 61970-301

- IEC 61970-1 provides a set of guiding principles and general infrastructure required in the application of EMSAPI interface standard. This part describes the typical integration use cases and applications needed to be integrated under these standards.
- IEC 61970-301 defines the CIM model, as an abstract model, which describes all major objects in electric power enterprise, especially those involved in power operation. By providing an standard method expressing the electric power system resources through object classes and attributes and the relationship between them, CIM greatly facilitates the integration of various applications in energy management systems and full EMS developed independently by different vendors, as well as EMS and other systems involved in different aspects of power system operation.

D.1.20 IEC 62056 series

IEC 62056 (all parts), *Electricity metering – Data exchange for meter reading, tariff and load control*

This standard provides the standard method, object identity, object modelling, object access and services, communications, and media access methods to establish the instrument interface model from the communication perspective; it does not contain the contents of the instrument's data acquisition and data processing. SGUI related parts: IEC 62056-21, IEC 62056-53, IEC 62056-62: These standards describe direct local data exchange and COSEM application layer and interface classes.

D.1.21 IEC 62325 series

IEC 62325 (all parts), *Framework for energy market communications*

The IEC 62325 series defines protocols for deregulated energy market communications by defining message exchanges to enable these applications or systems access to public data and exchange information. The common information model (CIM) specifies the basis for the semantics for the message exchange.

D.1.22 IEC 62351 series

IEC 62351 series, *Power systems management and associated information exchange – Data and communications security*

The scope of the IEC 62351 series is information security for power system control operations. The primary objective is to "Undertake the development of standards for security of the communication protocols defined by IEC TC 57, specifically the IEC 60870-5 series, the IEC 60870-6 series, the IEC 61850 series, the IEC 61970 series, and the IEC 61968 series. Undertake the development of standards and/or technical reports on end-to-end security issues."

D.1.23 IEC 62394

IEC 62394, *Service diagnostic interface for consumer electronics products and networks – Implementation for ECHONET*

IEC 62394:2013 specifies requirements for service diagnostic software to be implemented in products that incorporate a digital interface It does not specify requirements for carrying out remote diagnosis or for manufacturer dependent software. Part of this controller software should be standardized while another part of this controller software is manufacturer-/product-related. IT is the minimal specification necessary to be able to carry out computerized diagnosis and covers the standardized software of the controller as well as the standardized software and provisions in the DUT.

D.1.24 IEC 62480

IEC 62480, *Multimedia home network – Network interfaces for network adapter*

IEC 62480:2008 specifies the requirements for the characteristics of the Network Adapter itself and the interface between the Network Adapter and Network-ready equipment. Data exchanged between the Network Adapter and Network-ready equipment are basically for HES Class1.

D.1.25 IEC 62488 series

IEC 62488-1, *Power line communication systems for power utility applications – Part 1: Planning of analogue and digital power line carrier systems operating over EHV/HV/MV electricity grids*

IEC 62488-1:2012 describes the planning of analogue and digital power line carrier systems operating over EHV/HV/MV electricity grids. The object of this standard is to establish the planning of the services and performance parameters for the operational requirements to transmit and receive data efficiently over power networks. The transmission media used by the different electricity supply industries will include analogue and digital systems together with more common communication services including national telecommunications authorities, radio links and fibre optic networks and satellite networks. With the developments in communication infrastructures over the last two decades and the ability of devices connected in the electricity communications network to internally and externally communicate, there is a variety of architectures to use in the electricity distribution network to provide efficient seamless communications.

D.1.26 IEC 62746 series

IEC 62746 (all parts), *Systems interface between customer energy management system and the power management system*

The IEC 62746 series defines system interfaces, communication protocols and profiles between power management system based on TC 57 standards and home/building/industrial energy management systems.

D.1.27 IEC TS 62872

IEC TS 62872, *System interface between Industrial Facilities and the Smart Grid* (to be published)

This Technical Specification defines the interface, in terms of information flow, between industrial facilities, containing industrial automation processes, and the electrical “smart grid”. It identifies, profiles and extends, where required, the standards needed to allow the exchange of the information needed to support the planning, management and control of electrical energy flow between the industrial facility and the smart grid. Standards are already being developed for home and building automation interfaces to the grid; however the requirements of industry differ significantly and are addressed in this Technical Specification. Specifically excluded from the scope of this Technical Specification are the protocols needed for the direct control of energy resources within a facility where the control and ultimate liability for such control is delegated by the industrial facility to the external entity.

D.1.28 OASIS Energy Interoperation 1.0

Energy Interoperation specifies an information model and messages to enable standard communication of DR events, real-time price, market participation bids and offers (tenders), and load and generation predictions. Energy Interoperation serves primarily at the interface to deliver DR and DER communications from a grid-side service provider (e.g., a distribution utility, or an aggregator) to a customer facility/home. The standard includes a) the specification document with scope, architecture, and service descriptions including Unified Modelling Language (UML) diagrams, along with b) service descriptions in XML schema (web services messages shall conform to the schema). Standard profiles include OpenADR, Price Distribution, and Transactive Energy Market Information Exchange. Published in December 2011 and presently being implemented. The specification and schema are all freely available from OASIS. More details in D.2.2.

D.1.29 OpenADR 2.0 (IEC PAS 62746-10-1)

OpenADR 2.0 is a strict profile on Energy Interoperation serving DR and DER communications as well as price distribution for both wholesale and retail markets. The OpenADR 2.0 Profile specifications are developed and maintained by the OpenADR Alliance and available to the public. There are currently two profiles (*a* and *b*) to serve less and more capable devices, and diversity in DR and price-responsive programs. The OpenADR 2.0 conformance, test, and certification suite for Profile *a* and *b* are now in use. OpenADR was developed by the Lawrence Berkeley National Laboratory to address a low-cost and reliable automation infrastructure to support demand response and price communication, allowing electric service providers to communicate DR event signals to customers with automated response capabilities. More details in D.2.3.

D.1.30 OASIS Energy Market Information Exchange

This standard defines an information model and XML vocabulary for the interoperable and standard exchange of prices and product definitions in transactive energy markets, including price information, bid information, time for use or availability, units and quantity to be traded, characteristics of what is traded. Published in 2011.

D.1.31 OASIS WS-Calendar

This standard defines an information model and XML vocabulary for communicating schedule and interval between Smart Grid domains. It provides an XML serialization of IETF iCalendar for use in calendars, buildings, pricing, markets, and other environments. WS-Calendar describes a limited set of message components and interactions providing a common basis for specifying schedules and intervals to coordinate activities between services.

D.1.32 CENELEC EN 50491-12

CENELEC EN 50491-12, *Smart Grid interface and framework for Customer Energy Management* specifies the data model to be used above the Application Layer, describes the general architecture and the main elements of the premises energy management system. The purpose of this standard is to define an interoperable Smart Grid environment for public or private building / Home. The standard is since Q2 2014 in the enquiry process

The scope of the standard covers:

- The general architecture of a premises energy management system
- The main elements of a premises energy management system
- Technology independent data structure used to exchange information over interface II
- Compliance of the data structure described in XSDs (XML schema Definitions)
- This standard applies for public or private building / Home, industrial areas are excluded

D.1.33 IEEE P2030.5 Smart Energy Profile 2.0

Smart Energy Profile™ 2.0 has been finalized by ZigBee Alliance and HomePlug Power line Alliance. SEP 2.0 specifies a standards-based application profile for use in Smart Grid home area networks (HANs), based on the IEC CIM (IEC 61968) and following a RESTful architecture on an Internet Protocol (IP) stack. This standard addresses many functions (e.g., pricing communication, demand response and load control, usage information) and many types of devices (e.g., smart meters, thermostats, pool pumps, smart appliances, distributed energy resources, plug-in electric vehicles). Communication could be within a consumer home area network, to a consumer (energy management system or individual devices), or even to equipment directly connected to the distribution system such as DER and PEVs. SEP 2.0 has a testing and certification program to ensure interoperability of SEP 2.0 implementations. The standard is freely and publicly available.

SEP 2.0 is now also published as IEEE P2030.5.

More details in D.2.4.

D.1.34 ECHONET

ECHONET, which has been developed by ECHONET CONSORTIUM (http://www.echonet.gr.jp (Japanese site), http://www.echonet.gr.jp/english/index.htm (English Site)), is a specification to realize home automation. It defines the control model named Device Object, which is a set of remote control parameters of each type of White Goods, and the procedure named ECHONET Communication Middleware, which is the procedure to change the control parameters in the Device Object. 87 types of Device Objects are already defined. ECHONET is characterized by its flexible remote control with fine-grain White Goods control.

ECHONET Specification Ver 1.0 Part 3, "Transmission media and lower-layer communication software specification" specifies the bottom communication of EMS, and is applicable on layer C, while further research is needed to see to what extent the specification meets the requirement.

D.1.35 ANSI/CEA-2045, Modular Communication Interface

Adopted in 2011. The specification details the mechanical, electrical, and logical characteristics of a socket interface that allows communication devices to be separated from end devices. Although the potential applications of this technology are wide-ranging, it is intended at a minimum to provide a means by which residential products may be able to work with any load management system through user installable plug-in communication modules. This specification identifies the physical and data link characteristics of the interface, along with certain network and application layer elements as needed to assure interoperability over a broad range of device capabilities. In addition, it defines a mechanism through which application layer messages (defined in other standards) may be passed across the interface.

More details in D.2.7.

D.1.36 AS/NZS 4755

AS/NZS 4755, *Framework for demand response capabilities and supporting technologies for electrical products*

Published in 2007. Australian/NZ national standard for communicating DR commands to residential appliances. Communications end at the demand response enabling device (DRED) external to the appliance. The standard allows communication of basic commands: turn on, shut off, reduce load, increase load. This standard is currently supported by several air conditioning manufacturers. The standard is compatible with a range of policy, pricing, regulatory and metering frameworks (which cannot be standardised). Messages can be communicated across any network, including AMI. Specifications currently cover air-conditioners, pool pumps, water heaters (electric, solar, and heat pump). EV/energy storage charger/discharger is in development.

D.1.37 IEEE 1547

This first publication of IEEE 1547-2003 is an outgrowth of the changes in the environment for production and delivery of electricity and builds on prior IEEE recommended practices and guidelines developed by SCC21.This standard addresses that critical need by providing uniform criteria and requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. This standard focuses on the technical specifications for, and testing of, the interconnection itself, and not on the types of the DR technologies. This standard aims to be technology neutral, although cognizant that the technical attributes of DR and the types of EPSs do have a bearing on the interconnection requirements.

IEEE 1547.3, *Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems,* describes the functionalities, parameters and implement methods of monitoring and information exchange of distributed generation connected to power system, focusing on monitoring, information exchange, and data exchange control during direct communication between distributed generator and relevant sectors. The standard provisions information modeling, and applies case analysis, with a skeleton including overview of monitoring and information exchange, data exchange guideline based on IEEE 1547-4.16, modeling of business and operation process, information exchange mode, relevant protocols and guideline for secure implementation of distributed generation.

Interconnected systems is the core of IEEE 1547, which connects distributed resources and region power systems. IEEE 1547.3 intends to facilitate interoperability of distributed resources interconnected with an area electric power system. IEEE 1547.3 (Clause 4 “Monitoring, information exchange and control of general information”, Clause 5 “Data Interchange Standards”, Clause 7 “Information exchange model”) describes the functionality, parameters, and methodologies for monitoring, information exchange, and control related to distributed resources interconnected with an area electric power system. The focus is on monitoring, information exchange, and control data exchanges between distributed resource controllers and stakeholder entities with direct communication interactions.

D.2 Additional standards information

D.2.1 General

Clause D.2 presents some additional details on some of the standards from Clause D.1.

D.2.2 Standard: OASIS Energy Interoperation (EI)

D.2.2.1 Development status

Published as OASIS Energy Interoperation 1.0, December, 2011, and currently being implemented by the OpenADR Alliance and others. The Energy Interoperation standard has ongoing maintenance. The Energy Interoperation Technical Committee has added transport for ebXML, and will begin to look at requested changes to the standard submitted by the OpenADR Alliance based on their implementation work.

D.2.2.2 Standard scope and references

OASIS EI specifies an information model and messages to enable standard communication of: DR events, real-time price, market participation bids and offers (tenders), and load and generation predictions. The standard includes a) the specification document with the scope, architecture, and service descriptions including Unified Modeling Language (UML) diagrams, along with b) service descriptions in XML schema (web services messages shall conform to the schema). The specification, schema and WSDLs are all freely available from OASIS [20].

The Energy Interoperation standard uses two other standards for price and product definition and for schedule definition.

a) OASIS Energy Market Information Exchange 1.0 (EMIX 1.0) [21]
   - Two SDO effort + three organizations (NAESB, OASIS, SGIP, IRC, OpenADR Alliance)
   - Common price and product definition cross-cutting the Smart Grid
   - Describes products from wholesale, retail, other markets with full international approach
   - Describes prices as related to products
   - Information model, not a protocol
   - The HTML specification [21] links to the freely available authoritative PDF and schemas via the namespace document.
b) OASIS WS-Calendar 1.0 [22]
   - Three SDO + two organizations effort (NAESB, IETF, OASIS, CalConnect, SGIP)
   - Common schedule cross-cutting the Smart Grid
   - Energy and facility scheduling extensions to IETF iCalendar RFCs
   - Integrates energy with facility and personal schedules

D.2.2.3 Policy goals

The U.S. Congress gave NIST the responsibility to coordinate development of interoperability standards for the Smart Grid, and part of the plan for accomplishing this was to establish the SGIP. NIST and SGIP members identified DR and price communications as one of the highest priority standards needed. The Energy Interoperation standard was developed under the direction of the SGIP, with the engagement of two standards development organizations (North American Energy Standards Board (NAESB) and OASIS) along with three other organizations (SGIP, OpenADR Alliance, and the ISO RTO Council (IRC)).

D.2.2.4 Applications (use cases)

The Energy Interoperation standard specifies three profiles which can be seen as three primary use cases described in the published standard Clause 14.

a) **OpenADR**—this profile defines the services required for DR event and price communication similar to what was originally developed for the OpenADR technology (in OpenADR 1.0) [23].
b) **TEMIX** (transactive EMIX)—this profile defines the services required to implement functionality for energy market interactions. The TEMIX use case is presented in detail in the TEMIX white paper [24].
c) **Price distribution**—this profile defines the minimal set of services required to interact within a pure price distribution context, without requiring transactive energy or event-based interactions.

D.2.2.5 Communication/transport architecture (actors and networks)

Energy Interoperation is defined to serve for DR and market communications between domains of the Smart Grid (see Figure 1). The EI architecture is very simple, reduced to service interactions between two parties. A party can be a facility energy management system or device, a demand response provider, market operator, distribution system operator, microgrid, or any other participant in a DR event or market transactions of energy. Parties may participate in many interactions concurrently as well as over time. In theory, any party can transact with any other party subject to applicable regulatory restrictions. In practice, markets will establish interactions between parties based on regulations, economics, credit, locations, and other factors. This simple two-party interaction allows for multiple actors to pass messages in a hierarchical format. In the context of DR events, we refer to these two parties as the “Virtual Top Node (VTN)” and the “Virtual End Node (VEN)”. The resulting DR message distribution might start at a wholesale market actor, proceed to a distribution utility, then to a company headquarters, and finally be delivered to a single customer facility. This kind of progression can be seen in Figure D.1.

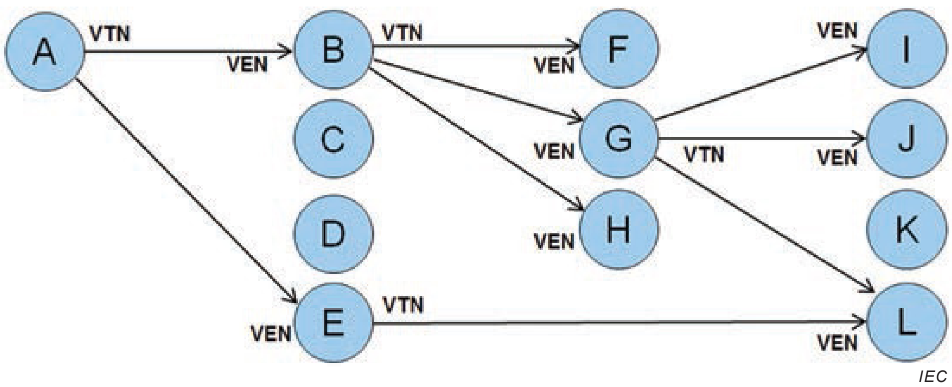


Figure D.1 – Energy Interoperation directed interaction graph

D.2.2.6 Information model

Energy Interoperation includes the information model for DR event communications. Energy Interoperation relies on EMIX for its price and product information model and on WS-Calendar for its schedule information model.

D.2.2.7 Communication protocols

Energy Interoperation uses a simple SOA/web services protocol, and other transport bindings are in progress. Security is composed as required.

D.2.3 Standard: OpenADR 2.0 Profile Specification (OpenADR 2.0)

D.2.3.1 Development status

The OpenADR 2.0 conformance, test, and certification suite from the OpenADR Alliance is ready for use. The OpenADR Alliance has developed multiple profiles to meet the different product and market needs for DR and DER. The first profile, OpenADR 2.0a, designed for simple DR applications, was approved in May, 2012. OpenADR 2.0a includes comprehensive security solutions, which are intended to meet the SGIP Cybersecurity Working Group requirements. The OpenADR 2.0b profile, supporting more complex DR clients, was released to the public in July, 2013.

D.2.3.2 Standard scope and references

DR, pricing (real-time and dynamic pricing), DER communications. The public OpenADR 2.0 profile specification and schema are posted at: http://www.openadr.org/specification.

D.2.3.3 Policy goals

The original goal of OpenADR, which has been in ongoing development and testing since 2002, is to address U.S. and California policy goals to provide cost-effective and standardized DR and DER signals to:

a) Develop low-cost, automation infrastructure.
b) Evaluate reliability and readiness for common signals through any communication protocols.
c) Evaluate control strategies within facilities to modify electric loads.

D.2.3.4 Applications (use cases)

Wholesale and retail demand response, real-time pricing, dynamic pricing, electric grid reliability, and distributed energy resources.

D.2.3.5 Communication/transport architecture (actors and networks)

OpenADR is an application-layer data model, which could use any transport. The test and certification programs are available for both simple HTTP (REST-styled) and XMPP, which includes the security testing.

D.2.3.6 Information model

OpenADR 2.0 is an application layer-based information model providing services for standardized DR and DER signals.

D.2.3.7 Communication protocols

Similar to the OASIS Energy Interoperation, OpenADR 2.0 uses Internet Protocol (IP) based communications, simple SOA/web services protocol, and Simple HTTP (REST-styled) and XMPP transport bindings. The OpenADR Alliance is working on other transport bindings.

D.2.4 Standard: Smart Energy Profile (SEP) 2.0

D.2.4.1 Current development status

SEP 2.0 has been in development by the ZigBee Alliance and other collaborating groups (e.g., HomePlug Alliance, Wi-Fi Alliance) for the past four years and is now complete. More than ten interoperability events have taken place already to validate the specification, and certification testing is nearing completion. SEP 2.0 has also undergone further standardization, in an unchanged format, as IEEE P2030.5.

D.2.4.2 Summary of standard scope and references for more technical information

The scope of SEP 2.0 pertains to the home area network (HAN), which spans from the edge of the AMI System or other backhaul connection such as the Internet, where the energy services interface resides, to all relevant HAN Devices in the home. It is the intent of SEP 2.0 to unify the mix of communication technologies that will be present in the customer premises network domain with a common, IP stack based, application layer to reflect a cleanly layered architectural model in which the layers are loosely coupled. SEP 2.0 initially borrowed from the UtilityAMI 2008 HAN SRS v1.04 guiding principles, and further in collaboration with OpenSG and recently updated OpenHAN 2.0. Future versions of SEP 2.0 may address communications with other field devices upstream from the home or utility customer premises, though in its initial form the focus is on premises-connected devices.

SEP 2.0 uses several dozen technical references, and these are well documented in the major technical documents (the Marketing Requirements Document, Technical Requirements Document) available online at zigbee.org/smartenergy. For instance, the Marketing Requirements Document contains an extensive list of use cases that were also incorporated into OpenHAN 2.0.

While this standard is actually a revision of a previous standard (SEP 1.x), it is a significant update. A testing and certification program has been established in the Consortium for the Smart Energy Profile (CSEP) that has created a test plan to be used by all of the relevant consortia (e.g., ZigBee Alliance, Wi-Fi Alliance, HomePlug Powerline Alliance). A UML model was created for this standard and it as well as the derived schema (XSD) and WADL are publicly available and referenced. The XSD and WADL are normative documents.

The purpose of this document is to define the application protocol used by the Smart Energy Profile release 2.0. The Smart Energy Profile Application Protocol 2.0 is designed to meet the requirements stated in the Smart Energy Profile 2.0 Marketing Requirements Document (SEP 2.0 MRD) [ZB 09-5162] and the Smart Energy Profile 2.0 Technical Requirements Document (SEP 2.0 TRD) [ZB 09-5449]. Per *Req[DataModel-1]*, this application protocol is an IEC 61968 common information model [61968] profile, mapping directly where possible, and using subsets and extensions where needed, and follows a RESTful architecture [REST].

This standard specifies a standards-based application profile for use in Smart Grid home area networks (HANs), based on the IEC CIM (IEC 61968) and following a RESTful architecture. This standard addresses many functions (e.g., pricing communication, demand response and load control, usage information) and many types of devices (e.g., smart meters, thermostats, pool pumps, smart appliances, distributed energy resources, plug-in electric vehicles).

Technology based on the standard would be used in applications in home area networks, to inform consumers and allow consumer devices to respond to grid signals. Communication could be within a consumer home area network, to a consumer (energy management system or individual devices), or even to equipment directly connected to the distribution system such as DER and PEVs.

With respect to the OSI network model, the Smart Energy Profile 2.0 Application Protocol is built using the four-layer Internet stack model. This specification defines the “Application” layer with TCP/IP and UDP/IP providing functions in the “Transport” and “Internet” layers. Depending on the physical layer in use (e.g., 802.15.4, 802.11, 1901), a variety of lower layer protocols may be involved in providing a complete solution. Generally, lower layer protocols are not discussed in this document except where there is a direct interaction with the application protocol. The scope of this document is defining the mechanisms for exchanging application messages, the exact messages exchanged including error messages, and the security features used to protect the application messages.

From the Foreword:

> The empowerment of consumers to manage their usage and generation of energy is a critical feature of the Smart Grid and is a basis of innovation for new products and

services in energy management. To enable this capability, information flow between devices such as meters, smart appliances, plug-in electric vehicles, energy management systems, and distributed energy resources (including renewable energy and storage elements) shall occur in an open, standardized, and interoperable fashion. The following specification is intended to fulfill those needs.

Readers should note that this document was prepared to be balloted under the policies set forth in the ZigBee Alliance. Previous revisions of this document have gone through review both within the ZigBee Alliance as well as made available for public comment. All previously received comments have been considered for this draft. This specification is intended to meet the requirements set forth in the previously published Technical Requirements Document (TRD).

This document is also intended to enable communications that are link layer agnostic and run over the Internet Protocol. Careful consideration was given to premises networks with various architectures, numbers of devices, and constraints while maintaining flexibility, extensibility, and security.

D.2.4.3 Policy goals which have helped motivate the standard development

The goal of SEP 2.0 is to develop a common application profile interface for home energy devices, supported by a comprehensive certification process that delivers secure, robust, reliable, plug and play interoperability with AMI and Smart Grid applications. Further, SEP 2.0 embraces important principles such as: open standards based, robust and comprehensive certification processes, a clean and layered architecture, and a focus on the application programming interfaces and not specific applications.

SEP 2.0 has been developed with many policy goals in mind including those set forth by EISA 2007 in the United States, the European Mandate on Smart Metering (M/441), as well as similar efforts in Australia, the United Kingdom, Japan, and China, to name only a few.

D.2.4.4 Application (use case) needs that the standard satisfies

SEP 2.0 embodies several use cases to satisfy the goal of enabling energy management devices, including at a high level:

- Utility, customer and 3rd party installation
- Energy usage and information
- Distributed energy resources
- Prepayment
- User information and messages
- Plug-in electric vehicles
- Load control and demand response

For a comprehensive listing of use cases, please see the SEP 2.0 Marketing Requirements Document, Technical Requirements Document, and OpenHAN 2.0.

D.2.4.5 Communication/transport architectures (actors, networks)

As SEP 2.0 is designed to work over an IP network using familiar protocols such as HTTP, mDNS, and TLS, network infrastructure simply consists of typical IP routers.

Many devices in the customer premises are intended to be addressed by SEP 2.0, including:

- Plug-in Electric Vehicles
- Distributed energy resources, such as solar inverters
- Utility meters and sub-meters (electric, gas, water, etc.)
- Smart appliances

- Programmable communicating thermostats
- In-premises displays
- Energy services interfaces
- Home energy management systems
- In-premises displays
- Pool pumps
- Water heaters
- Prepayment terminals
- Personal computers
- Mobile phones, tablet computers, etc.

D.2.4.6 Information model the standard uses

To achieve the goal of turning the many sources of data at a premises into a coherent body of information so that new application functionality can be based on consistent data and to maintain consistency with other components of the Smart Grid (such as utility billing systems), the SEP 2.0 vocabulary is based on the IEC 61968 Common Information Model (CIM), which includes proposed extensions necessary to satisfy all SEP 2.0 data requirements. Any semantic conflicts discovered across SEP 2.0 functions or within existing CIM definitions will be resolved in the CIM.

D.2.4.7 Communication protocols used

To support interoperability and a wide application of SEP 2.0, requirements in the standard are not dependent on any particular physical network technology. SEP 2.0 is built atop an Internet Protocol (IP) stack and utilizes other familiar underlying protocols such as mDNS, DNS-SD, HTTP, XML, and EXI.

D.2.5 Standard: NAESB REQ.21: Energy Services Provider Interface (ESPI)

D.2.5.1 Development status

ESPI is a ratified NAESB (North American Energy Standards Board) standard as of October 2011. Conformance and certification test development is underway at the UCAIug OpenADE task force. Evolution of this standard, testing and certification, and open source tools are being facilitated under the auspices of the SGIP via PAP20 Green Button ESPI Evolution: https://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/GreenButtonESPIEvolution.

D.2.5.2 Standard scope and references

The scope of REQ.21 [25] is the exchange of Energy Usage Information. Provided in the standard are: a) the business requirements behind ESPI, b) a UML model, and c) an XML Schema.

The Green Button Initiative defines a subset of ESPI, based on the EUI payload that defines the ability of a retail customer to download EUI directly from a data custodian web site.

The full ESPI standard defines the automated data exchange between authorized third party providers and data custodians based on the permissions provided by the retail customer.

D.2.5.3 Policy goals

The U.S. Congress gave NIST the responsibility to coordinate development of interoperability standards for the Smart Grid, and part of the plan for accomplishing this was to establish the SGIP. NIST and SGIP members identified Energy Usage Information communications as one of the highest priority standards needs.

The concept of a Green Button—inspired by successes in getting Americans online access to their own health care data, but developed by the energy industry in a consensus process and adopted voluntarily—builds on policy objectives in the Administration's Blueprint For a Secure Energy Future [26] and Policy Framework for the 21st Century Grid [27] to ensure that consumers have timely access to their information that can help them better manage their energy use and take advantage of opportunities to help reduce their costs. The widespread and standardized availability of this data is inspiring an ecosystem of independent organizations building products and services to generate and consume this data.

D.2.5.4 Applications (use cases)

ESPI and Green Button support the following use cases:

a) Access by retail customers to their EUI from a data custodian (i.e. utility) via s secure web site.

b) Access by a third party from the data custodian via a secure authorization by the retail customer. There are several component use cases that together allow this interaction:

   1) relationship establishment

   2) relationship termination

   3) information exchange

      i) push: the data custodian feeds an information stream to a third party,

      ii) pull: the third party retrieves information from the data custodian.

   Figure D.2 illustrates the set of automated transfer use cases envisioned by the standard:

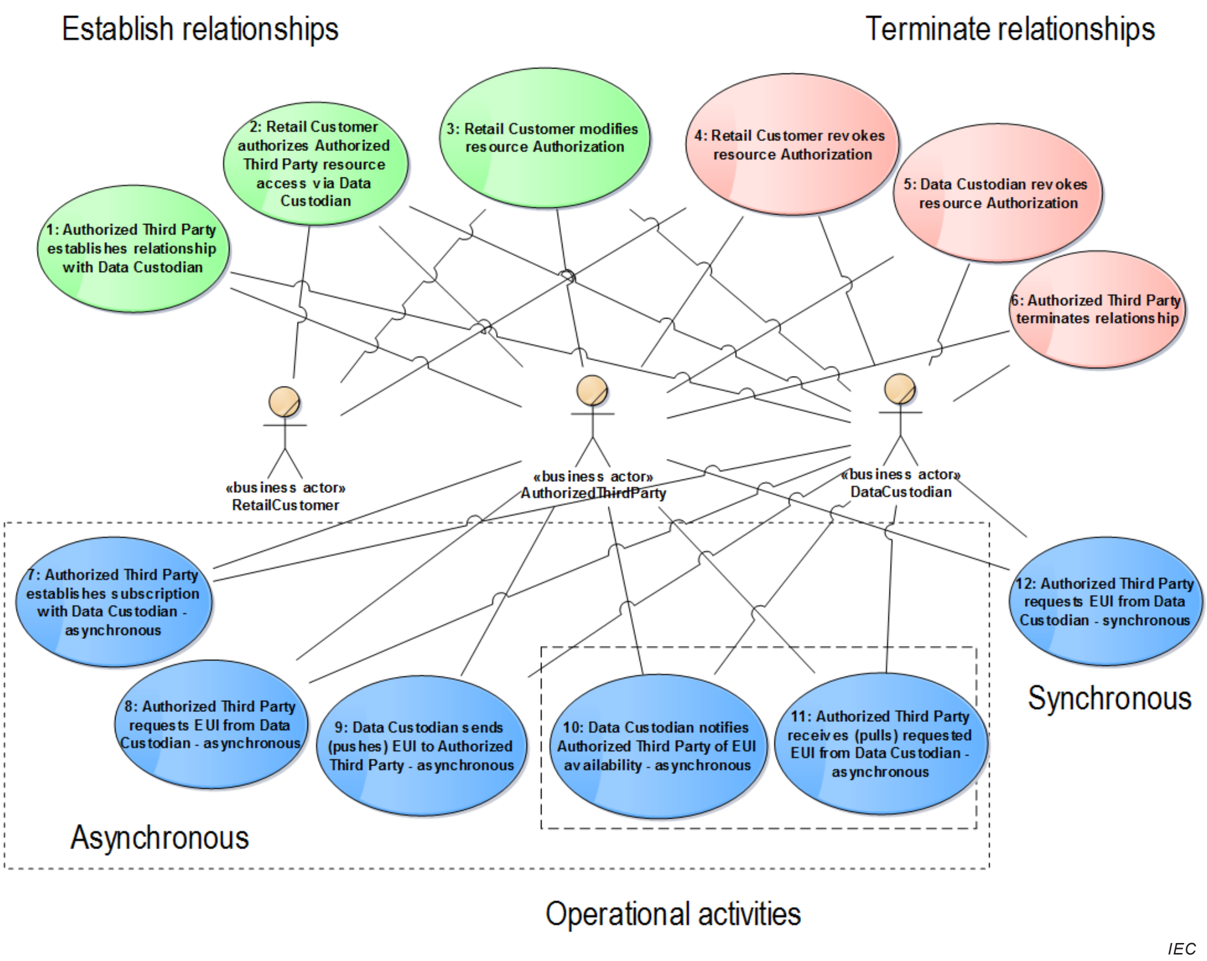


Figure D.2 – ESPI automated exchange use cases

D.2.5.5 Communication/transport architecture (actors and networks)

The architecture of ESPI is based on RESTful communications between three actors – retail customer, data custodian, and third party. As shown in Figure D.3, while the retail customer is recognized as the key actor, the standard does not specifically define communication protocols for the interaction of this actor with the others. It is assumed that the interactions between the retail customer and (individually) the data custodian and third party occur via the Web portal.

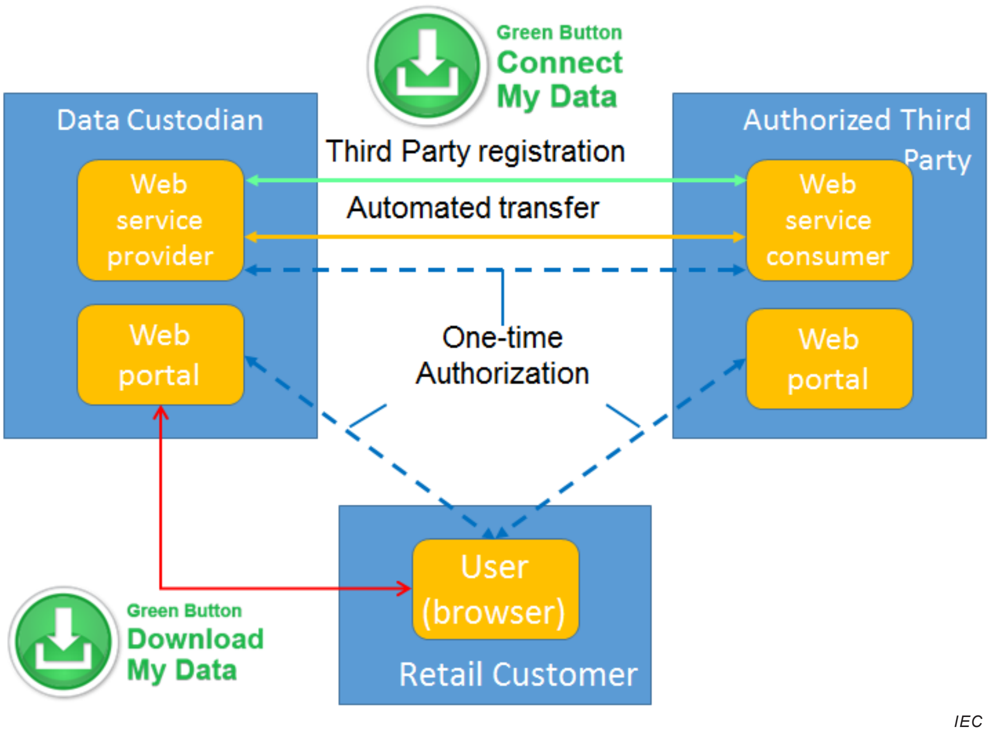


Figure D.3 – Overview of ESPI actors

D.2.5.6 Information model

The following addressable objects (specializations of IdentifiedObject) are defined by the ESPI schema, and can be made available using AtomPub feeds.

- UsagePoint – the point of reference for EUI data. This is typically the revenue meter at the service entrance. However, it can also be a submeter or even an appliance or subsystem.
- ReadingType – defines the metadata associated with readings – scale, units of measure, how acquired, etc.
- IntervalBlock – contains groupings of related measurements such as daily collections of hourly load profile.
- MeterReading – contains a set of related measurements with the same ReadingType.
- ElectricPowerUsageSummary – a summary dashboard of EUI for current and previous billing period.
- ElectricPowerQualitySummary – a summary dashboard for key power quality statistics.
- Authorization – authorization data structure represents the persistent relationship between the data custodian and the third party.
- ApplicationInformation – metadata about the EUI relationships.
- Subscription – defines a subscription of EUI exchanged between the data custodian and the third party.

UsagePoint, MeterReading, ReadingType, IntervalBlock are profiled directly from IEC 61968-9:2013. The other components come from NAESB REQ.18/WEQ.19 and some extensions made in REQ.21.

D.2.5.7 Communication protocols

ESPI relies on well-established Internet RFCs for all messaging. The standard defines how they are used to affect the interchange of information. The communications protocols used for ESPI are the following:

a) For RESTful data transfer – HTTPS and Atom Publishing – ESPI endpoints use HTTP and/or HTTPS, IETF RFC 2616 and 2818, to expose ESPI resources using the method conventions in Atom Publishing Protocol, IETF RFC 5023.
b) For authorization -- OAuth, as documented in IETF RFC 5849, is used for authorization grant and access by retail customers and authorized third parties to shared data custodian resources. This protocol results in access tokens that are used to subscribe to specific user EUI or to request it immediately, if supported.

D.2.6 Standard: ASHRAE/NEMA 201P Facility Smart Grid Information Model (FSGIM)

D.2.6.1 Development status

This standard is currently under development as an ANSI/ASHRAE/NEMA standard. It is also part of the work program of ISO/TC 205. A second public review draft is expected to be published in September 2014.

D.2.6.2 Standard scope and references

Purpose: The purpose of this standard is to define an abstract, object-oriented information model to enable appliances and control systems in homes, buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a “smart” electrical grid and to communicate information about those electrical loads to utility and other electrical service providers.

Scope:

This model provides the basis for common information exchange between control systems and end use devices found in single- and multi-family homes, commercial and institutional buildings, and industrial facilities that is independent of the communication protocol in use. It provides a common basis for electrical energy consumers to describe, manage, and communicate about electrical energy consumption and forecasts.

The model defines a comprehensive set of data objects and actions that support a wide range of energy management applications and electrical service provider interactions including:

a) on-site generation,
b) demand response,
c) electrical storage,
d) peak demand management,
e) forward power usage estimation,
f) load shedding capability estimation,
g) end load monitoring (sub metering),
h) power quality of service monitoring,
i) utilization of historical energy consumption data, and
j) direct load control.

References:

This draft standard references and builds on the work of IEC 61850, OASIS Energy Interoperation and EMIX, NAESB Energy Usage Information, and WXXM standards.

D.2.6.3 Policy goals

The U.S. Congress gave NIST the responsibility to coordinate development of interoperability standards for the Smart Grid, and part of the plan for accomplishing this was to establish the SGIP. NIST and SGIP members identified a facility Smart Grid information model that would become the basis for a family of protocol specific standards for automation and control networks in residential, commercial, institutional, and industrial facilities as one of the highest priority standards needs.

D.2.6.4 Applications (use cases)

The draft standard is intended to be able to represent all of the information that a facility manager needs to control generating resources and loads in a facility. This includes both information exchanged with an energy provider and information that is known only within the facility. A number of use cases have been developed and reviews by contributors to PAP 17 and the SPC 201P committee.

http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP17Deliverable1

D.2.6.5 Communication/transport architecture (actors and networks)

The use cases identify a number of actors and example transactions but the standard is an information model. It does not assume a particular communication protocol or architecture.

D.2.6.6 Information model

The FSGIM contains four main components (generator, load, energy manager, meter) that can be aggregated or combined in ways to represent the characteristics of real devices. The model is developed and documented in Universal Modelling Language (UML). The UML description is normative and the text of the standard is derived from the formal model.

D.2.6.7 Communication protocols

The FSGIM is protocol independent. The intention is that the FSGIM will drive revisions to protocol specific standards that already serve various types of facilities. It is expected that protocol standards and control technology used in residences, commercial buildings, and industrial facilities will vary but all will be adapted to represent and convey the information represented by the FSGIM.

D.2.7 Standard: ANSI/CEA-2045: Modular Communication Interface

D.2.7.1 Development status

The Modular Communication Interface (MCI) standard originated in the NIST Home-to-Grid Domain Expert Working Group (H2G DEWG) and was adopted by the Consumer Electronics Association in late 2011. The development is handled in the CEA R07.8 Working Group within the R07 Home Networks Committee. This standard has been approved and was published as an American National Standard in January 2013. The ANSI/CEA-2045 document is available at: http://webstore.ansi.org/RecordDetail.aspx?sku=CEA+2045-2013+(ANSI).

D.2.7.2 Standard scope and references

This document is a specification for a modular communication interface. The specification details the mechanical, electrical, and logical characteristics of a socket interface that allows communication devices to be separated from end devices. Although the potential applications of this technology are wide-ranging, it is intended at a minimum to provide a means by which residential products may be able to work with any load management system through user installable plug-in communication modules. This specification identifies the physical and data link characteristics of the interface, along with certain network and application layer elements as needed to assure interoperability over a broad range of device capabilities. In addition, it defines a mechanism through which application layer messages (defined in other standards) may be passed across the interface.

D.2.7.3 Policy goals

The U.S. Congress gave NIST the responsibility to coordinate the development of interoperability standards for the Smart Grid, and part of the plan for accomplishing this was to establish the SGIP. The H2G DEWG identified this interface as a priority need.

D.2.7.4 Applications (use cases)

The residential devices to use an MCI are not specified. For energy management the choice depends on the system and the network topology. If a hub topology is chosen, the MCI may be located on the hub.

The MCI is intended to:

- Support a broad range of technologies, both legacy, evolving, and new.
- Facilitate interoperability among products and systems.
- Allow easy product upgrades.
- Offer developers flexibility in product design.

The MCI specifies a physical wired connection to residential devices and a communications protocol with OSI (Open System Interconnection) layer specifications including application layer messaging. An optional translation function is specified for connection to another communications medium. Examples include power line carrier or radio (RF), depending on the home area network installed or the connection to an energy management system access-network supplied by a service provider. This second medium is outside the scope of this standard.

The specification details the mechanical, electrical, and logical characteristics of a socket interface that allows communication devices to be separated from end devices. Although the potential applications of this technology are wide-ranging, it is intended at a minimum to provide a means by which residential products may be able to work with any load management system through user installable plug-in communication modules.

D.2.7.5 Communication/transport architecture (actors and networks)

ANSI/CEA-2045 defines a direct local serial communication connection between a communication module (UCM) and an end-device (SGD) as illustrated in Figure D.4. The nature and variety of communication networks that might be supported by such an approach are unlimited. The UCM is an engineered part of the communication system (e.g. it is a cellular radio, a PLC transceiver, a HAN/LAN radio) and is universal in the sense that it can plug into and work on any end device.

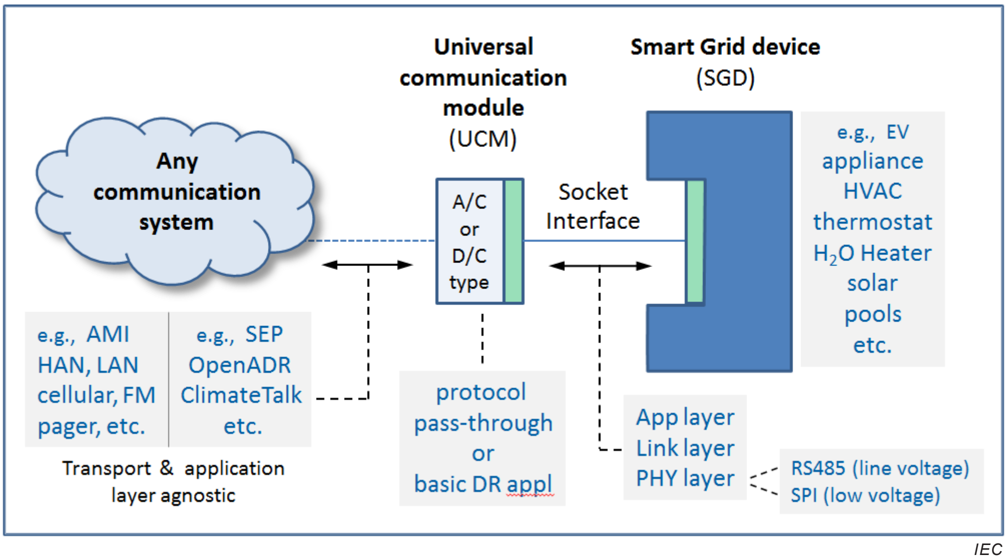


Figure D.4 – Modular interface concept

The communication systems presently used for load management are diverse, including two-way and one-way messaging. Information that may be sent from the utility or load serving entity to the SGD can inform the SGD of a range of grid conditions, including energy price and curtailment events, to serve a wide range of use cases. Information that may be sent from the SGD to the utility can convey the SGD state, status, and power consumption to verify demand responses for a variety of use cases.

D.2.7.6 Information model

ANSI/CEA-2045 supports the pass-through of industry standard application protocols, each of which may be based upon an existing common information model. The range of protocols, one of which includes a simple mechanism defined in the ANSI/CEA-2045 standard, were identified by stakeholders during the development of the standard. These application protocols support all complexity levels of end devices (from the simplest to the most advanced) and communication systems. For simple devices, the information model may be the short list of fixed data points documented within ANSI/CEA-2045. For more capable devices, the model may be based on the IEC 61968/IEC 61970 Common Information Model.

D.2.7.7 Communication protocols

Figure D.5 illustrates the communication layers associated with communications across the ANSI/CEA-2045 interface. The color-coding in the figure indicates which elements are specified in this standard.

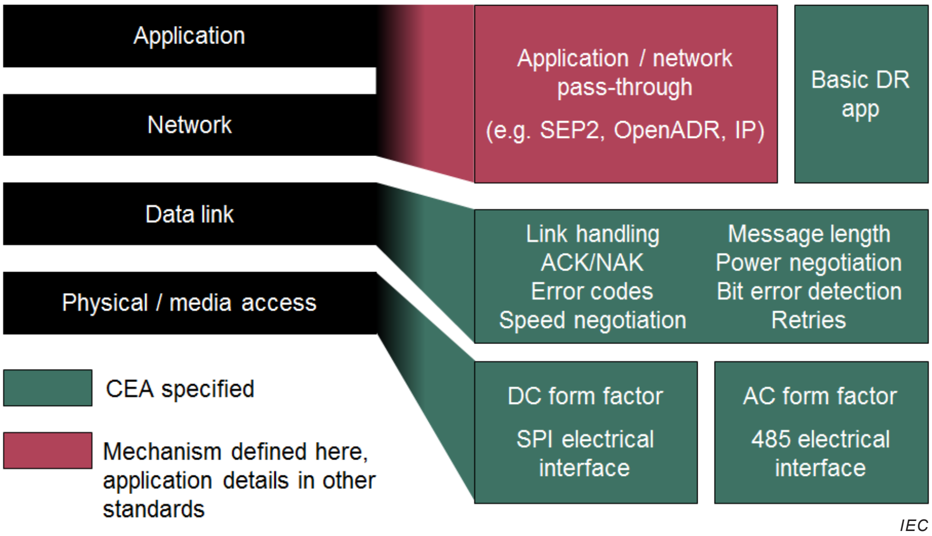


Figure D.5 – CEA-2045 modular interface layers

The protocol uses the OSI communications layering model of ISO 7498. A set of link-layer commands enables negotiation of various packet size limits and bit rates so that default values accommodate limited devices, and yet more advanced devices have the ability to raise the performance to higher levels.

A UCM may utilize an industry standard application layer message, such as SEP or OpenADR to communicate across the serial interface to end devices that are capable of receiving these messages. When used, these messages are encapsulated in the payload of the serial data link frame. Such protocols may be used if supported by both the UCM and the SGD. Whenever one or both of the devices is limited and cannot support these protocols, basic demand responsiveness is still guaranteed by using the default required messages of ANSI/CEA-2045.

Bibliography

[1] IEC 62056-1-0, *Electricity metering data exchange – The DLMS/COSEM suite – Part 1-0: Smart metering standardisation framework* [11]

[2] SGIP Energy Services Interface white paper, v1.0, 2012, available at: http://collaborate.nist.gov/twiki-sggrid/pub/SmartGrid/EnergyServicesInterface/EnergyServicesInterfaceWhitePaper_V1_0.pdf

[3] ISO/IEC 15045 (all parts), *Information technology – Home Electronic System (HES) gateway*

[4] ISO/IEC 15067-3:2012, *Information technology – Home Electronic System (HES) application model – Part 3: Model of a demand-response energy management system for HES*

[5] DOE GridWise Architectural Council, GridWise Interoperability Context-Setting Framework, http://www.gridwiseac.org/pdfs/interopframework_v1.pdf.

[6] Denning, P, R. Hayes-Roth, ―Decision Making in Very Large Networks,‖ Communications of the ACM, November 2006, pp 19-23

[7] Hayek, F., ―The Use of Knowledge in Society,‖ American Economic Review, XXXV, No. 4, September, 1945, pp 519-530

[8] European Industry Association, Information Systems Communication Technologies Consumer Electronics, ―EICTA Interoperability White Paper, 21 June 2004

[9] CEN-CENELEC-ETSI Smart Grid Coordination Group –Sustainable Processes WG

[10] NIST Smart Grid Framework and Roadmap v1.0, section 5.5, p.83

[11] IEC 60050-617, *International Electrotechnical Vocabulary – Part 617: Organization/Market of electricity*, available at: http://www.electropedia.org/.

[12] NISTIR 7628 "Guidelines for Smart Grid Cybersecurity v1.0", available at: http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/CyberSecurityCTG#NISTIR_7628_v1_0_and_Related_Doc.

[13] IEC 62746 (all parts), *Systems interface between customer energy management system and the power management system* (to be published)

[14] EN 50491-12, *Smart Grid interface and framework for Customer Energy Management*

[15] IEC TR 61850-90-8, *IEC 61850 object models for electric mobility* (to be published)

[16] OASIS Common Alerting Protocol (CAP), http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html

[17] OASIS Emergency Data Exchange Language (EDXL), http://docs.oasis-open.org/emergency/edxl-de/v1.0/EDXL-DE_Spec_v1.0.pdf

---

[11] To be published.

[18] Edward Barkmeyer, et.al., "Concepts for Automating Systems Integration," National Institute of Standards and Technologies, Gaithersburg, MD, NISTIR 6928, February 2003

[19] Mandate M/441 Smart Meters Coordination Group prTR50xxx Functional reference architecture for smart metering systems, Draft v0.4.3

[20] OASIS Energy Interoperation 1.0 http://docs.oasis-open.org/energyinterop/ei/v1.0/energyinterop-v1.0.html

[21] OASIS EMIX 1.0, http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html

[22] OASIS WS-Calendar 1.0, http://docs.oasis-open.org/ws-calendar/ws-calendar-spec/v1.0/cs01/ws-calendar-spec-v1.0-cs01.html.

[23] OpenADR 1.0 Specifications: Piette, Mary Ann, Girish Ghatikar, Sila Kiliccote, Ed Koch, Dan Hennage, Peter Palensky, and Charles McParland. 2009. Open Automated Demand Response Communications Specification (Version 1.0). LBNL and CEC PIER Program. CEC-500-2009-063 (http://openadr.lbl.gov/pdf/cec-500-2009-063.pdf)

[24] Transactional Energy Market Information Exchange (TeMIX): An Information Model for Energy Transactions in the Smart Grid. OASIS EMIX Technical Committee, May, 2010. https://www.oasis-open.org/committees/download.php/37821/Transactional%20Energy%20White%20Paper%20Draft%20010.pdf

[25] NAESB Standard REQ.21 Energy Services Provider Interface (ESPI) -- http://www.naesb.org/ESPI_Standards.asp

[26] U.S. Blueprint for a Secure Energy Future, March 2011. http://www.whitehouse.gov/sites/default/files/blueprint_secure_energy_future.pdf

[27] U.S. Policy Framework for the 21st Century Grid, June 2011. http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf

---

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™