



BSI Standards Publication

Systems interface between customer energy management system and the power management system

Part 2: Use cases

National foreword

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TECHNICAL REPORT

**Systems interface between customer energy management system and the power management system -
Part 2: Use cases**



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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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**Systems interface between customer energy management system
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Part 2: Use cases**

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IEC TR 62746-2 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) The Architecture Model of the Smart Grid Coordination Group (Figure 6) has been replaced with the draft Architecture Model of TC57 in collaboration with SC23K and TC13;
- b) The use cases from Edition 1 (2015) with the following IDs have been removed from the current document: JWG2000, JWG2001, JWG2010, JWG202x, JWG2041, JWG2042, JWG1111, WGSP2120, JWG30xx;

- c) The use cases from Edition 1 (2015) with the following IDs: JWG1100, JWG1101, JWG-SPUC1102, and JWG1103 have been replaced with the use case JWG1100;
- d) The following use cases have been added to the current document: JWG3000, JWG3001, JWG3002, JWG3003, JWG3004, JWG3005, JWG3006, JWG4000.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
57/2803/DTR	57/2847/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 62746 series, published under the general title *Systems interface between customer energy management system and the power management system*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

Intelligent, integrated energy systems for smart environments

NOTE This Introduction is an extract from the "Demand – Response – White Paper, Siemens AG, 2010 [1]¹.

In 2007, the number of people living in conurbations around the world surpassed that of those living in rural areas. Today, large cities worldwide account for 75 per cent of energy demand and generate a large percentage of total carbon dioxide emissions. For this reason, a number of cities and metropolitan areas have set themselves ambitious goals towards reducing emissions by increasing the efficiency of their infrastructures. These goals aim to have a positive impact on the environment, while continuing to enhance the quality of life of growing urban populations.

The transition to a new "electrical era" in which electricity is becoming the preferred energy source for most everyday applications is currently taking place. This is governed by three key factors: demographic change, scarcity of resources, and climate change. In the meantime, two development trends are of particular interest:

- the demand for electricity is continuing to grow.
- the energy system is subject to dramatic changes.

The experienced changes to the energy system can vary, based on whether they are nationally or cross-nationally observed. Some of the changes are caused by electricity production and fluctuating power supply sources.

Until recently, load dictated production, a method which influenced how interconnected power systems were designed. Power generation was centralized, controllable, and above all, reliable. The load was statistically predictable, and energy flow was unidirectional, that is from producer to consumer.

These aspects of power generation are changing. Firstly, the rising percentage of fluctuating production within the energy mix brought about by renewables reduces the level of power generation control available. Secondly, the energy flow is no longer unidirectionally sent from producer to consumer; now the consumer is slowly turning into a "prosumer," a term which denotes a person who produces and consumes energy. More and more consumers are installing their own renewable energy products to increase energy efficiency. These prosumers are cogenerating heat and power with their own solar panels or microCHPs, for example. This trend is set to continue, as government bodies continue to provide incentives to domestic users to become "prosumers" as part of their increased energy efficiency policies.

Managing reactive power in relation with power system voltage control will become more important in situation and regions where distributed generation and power storage is or will become a substantial part of the total power demand of that region. The total power demand in the region will be generated partly by the central power stations that are connected to the transmission system and the power generated locally by generators and storage facilities connected to the distribution networks in that region. It will not be sufficient to switch distributed generators and/or storage facilities of premises off during emergency situations in the power system. In future it will be thinkable, and it already happens that in certain regions distributed generation and storage will support power system restoration in emergency situations in the network. Voltage and frequency will not only be controlled by central power stations and dispatch centers, a more advanced control will be supported by appropriate energy market arrangements (contracts and transparent arrangements between different parties involved).

¹ Numbers in square brackets refer to the Bibliography.

Ultimately, the way of the future will have to be that, up to a certain extent, the load follows the energy availability.

The way in which loads (being demand or local generation) at the consumer side can be managed, is through the mechanisms of Demand Response and Demand Side Management.

When referring to Demand Response and Demand Side Management, within this technical report the following definition of EURELECTRIC [2] in its paper "EURELECTRIC Views on Demand-Side Participation" is used:

- "Demand Side Management (DSM) or Load Management has been used in the (mainly still vertically integrated as opposed to unbundled) power industry over the last thirty years with the aim "to reduce energy consumption and improve overall electricity usage efficiency through the implementation of policies and methods that control electricity demand. Demand Side Management (DSM) is usually a task for power companies / utilities to reduce or remove peak load, hence defer the installations of new capacities and distribution facilities. The commonly used methods by utilities for demand side management are combination of high efficiency generation units, peak-load shaving, load shifting, and operating practices facilitating efficient usage of electricity, etc." Demand Side Management (DSM) is therefore characterized by a 'top-down' approach: the utility decides to implement measures on the demand side to increase its efficiency.
- Demand Response (DR), on the contrary, implies a 'bottom-up' approach: the customer becomes active in managing his/her consumption – in order to achieve efficiency gains and by this means monetary/economic benefits. Demand Response (DR) can be defined as "the changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time. Further, DR can be also defined as the incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized. DR includes all intentional modifications to consumption patterns of electricity of end use customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption". DR aims to reduce electricity consumption in times of high energy cost or network constraints by allowing customers to respond to price or quantity signals."

The intent of Demand Response and Demand Side Management programs is to motivate end users to make changes in electric use, lowering consumption when prices spike or when grid reliability is jeopardized. These concepts refer to all functions and processes applied to influence the behaviour of energy consumption or local production. This leads to a more efficient energy supply which enables the consumer to benefit from reduced overall energy costs.

In this context, the report focuses on the signals exchanged between the grid and the premise, which goes from simple signalling to integrated load management.

Since many components are integrated to interface within a demand response solution, a suitable communication infrastructure is of paramount importance.

There is a variety of equipment connected to the grid, which can be included in a demand response solution. Such devices can act as an energy source or load. Some devices can act as both an energy source and a load alternately, depending on the operation mode selected. In response to load peaks or shortages, selected generation sources can be switched on, loads switched off, and storages discharged. In addition, loads with buffer or storage capacity can be switched on to make use of preferred energy generation when available.

As shown in the examples in Figure 1, some device types provide storage or buffer capability for energy. A storage device can give back the energy in the same type as it was filled. An example of this is a battery. A buffer device, however, can store energy only in a converted form, in the way that a boiler stores energy by heating up water; it is only capable of load-shifting. Devices capable of storage, however, can be utilized fully for energy balancing within the electrical grid.

Table: Demand response communication infrastructure				
Device type	Influenceable		Storage/ buffer	Comment
	Generation	Consumption		
Wind turbine	■			Only reduction of actual generation
Photovoltaic generation	■			Only reduction of actual generation
Backup generators	■			
Solar water radiators		■	B	Additional electrical heating in boiler required
Combined heat and power	■	■	B	Additional electrical heating in boiler required
Heat pump with boiler		■	B	
Electric radiators		■		
Central air-conditioning		■	B	
Decentral air-conditioning		■		
Drives for ventilation		■		
Drives for water pumps		■	B	Requires water tanks on top of buildings
Other drives		■		Elevators, escalators, etc.
Household appliances		■		Washing machines, tumble dryers, dishwashers, etc.
Industrial processes		■	S/B	Storage/buffer capability depends on process type
Batteries and supercaps	■	■	S	
E-cars (home charging)	■	■	S/B	Feedback is currently only future option
+ E-cars (public charging)		■		

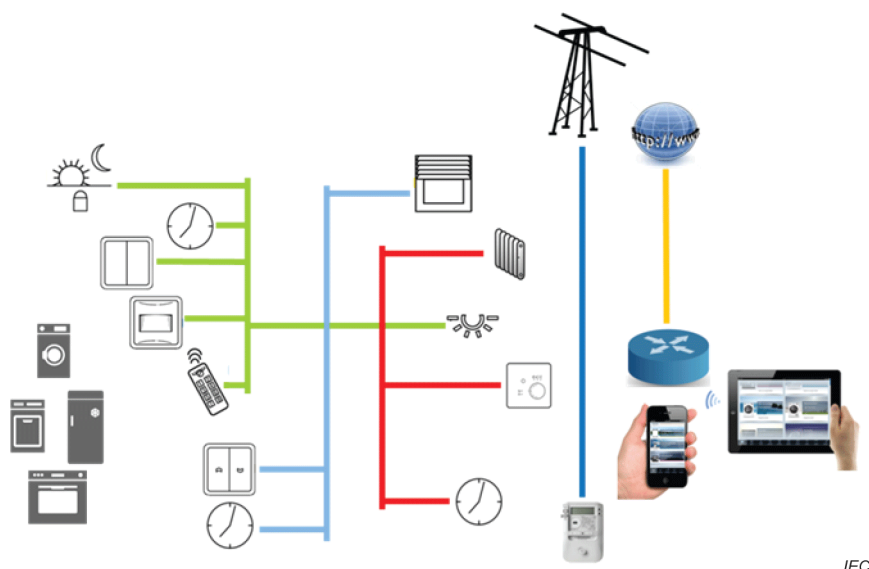
SOURCE: Siemens AG [1]

Figure 1 – Examples of demand response capabilities

1 Scope

The success of the Smart Grid and Smart Home/Building/Industrial approach is very much related to interoperability, which means that Smart Grid and all smart devices in a Home/Building/Industrial environment have a common understanding of messages and data in a defined interoperability area (in a broader perspective, it does not matter if it has an energy related message, a management message or an informative message).

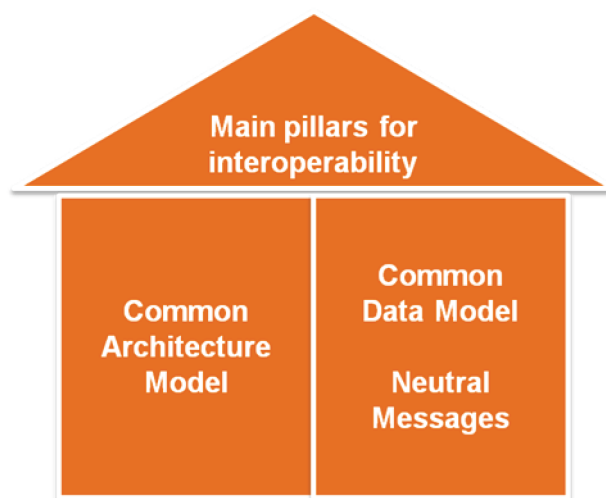
In contradiction, today's premises are covered by different networks and standalone devices (see Figure 2).



IEC

Figure 2 – Smart environment as of today

The scope of this part of IEC 62746, which is a technical report, is to describe the main pillars of interoperability to assist different IEC Technical Committees in defining their interfaces and messages covering the whole chain between a Smart Grid and Smart Home/Building/Industrial area (see Figure 3).



IEC

Figure 3 – Criteria for interoperability

The main topics of this document are:

- To describe an architecture model from a logical point of view;
- To describe a set of user stories that describe a number of situations related to energy flexibility and demand side management as well as an outline of potential upcoming Smart Building and Smart Home scenarios. The set of user stories does not have the ambition to list all home and building (energy) management possibilities, but is meant as a set of examples that are used as input in use cases and to check that the set of use cases is complete;
- To describe a set of use cases based on the user stories and architecture. The use cases describe scenarios in which the communication between elements of the architecture are identified;
- To further detail the communication, identified in the use cases, by describing the messages and information to be exchanged.

This document can also be used as a blueprint for further smart home solutions like remote control, remote monitoring, ambient assistant living and so forth.

This technical report will be regularly revised by introducing new use cases and updating the current use cases. The use cases presented in this document are not going to be included in the IEC Use Case Management Repository (UCMR). The data models of some use cases presented here are defined in the second edition of IEC 62746-4². The smart grid architecture model presented in this document is created in coordination with IEC TC13, SC23, and TC57.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

use case

class specification of a sequence of actions, including variants, that a system (or other entity) can perform, interacting with actors of the system

[SOURCE: IEC 62559:2008, IEC 62390:2005]

3.1.2

use case template

form which allows the structured description of a use case in predefined fields

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

² Under consideration.

3.1.3**cluster**

group of use cases with a similar background or belonging to one system or one conceptual description

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.4**high level use case**

use case which describes idea or concept independently from a specific technical realization like an architectural solution

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.5**primary use case**

use cases which describe in detail the functionality of (a part of) a business process

Note 1 to entry: Primary use cases can be related to a primary goal or function which can be mapped to one architectural solution.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.6**generic use case**

use case which is broadly accepted for standardization, usually collecting and harmonizing different real use cases without being based on a project or technological specific solution

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.7**specialized use case**

use case which is using specific technological solutions / implementations

EXAMPLE Use case with a specific interface protocol.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.8**scenario**

possible sequence of interactions

Note 1 to entry: Scenario is used in the use case template defining one of several possible routes in the detailed description of sequences.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.9**repository**

place where information like use cases can be stored (Use Case Management Repository)

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.10**Use Case Management Repository**

database for editing, maintenance and administration of use cases which are based on a given use cases template

Note 1 to entry: The UCMR is designed as collaborative platform for standardization committees, inter alia equipped with export functionalities as UML model or text template.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.11**actor**

entity that communicates and interacts

Note 1 to entry: These actors can include people, software applications, systems, databases, and even the power system itself.

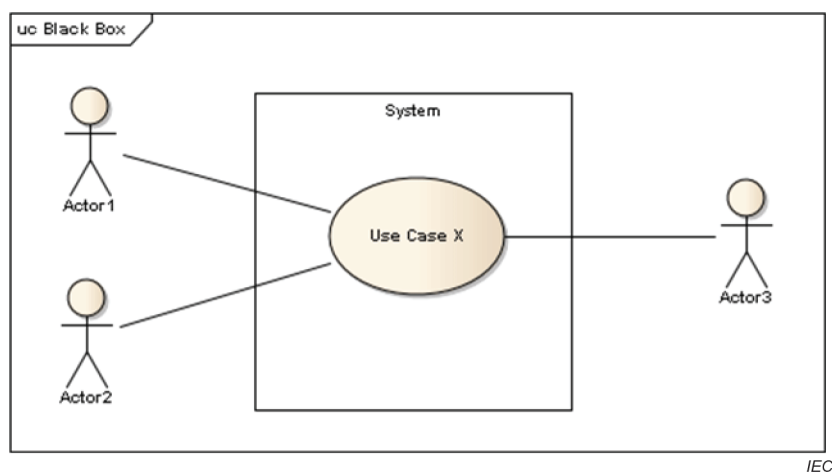
Note 2 to entry: In the actor list the European Harmonised electricity market role model", generic actors and technical system actors are considered.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.12**actor (external)**

entity having behavior and interacting with the system under discussion (system as 'black box') to achieve a specific goal (see Figure 4)

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]



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Figure 4 – External actor definition

3.1.13**actor (internal)**

entity acting within the system under discussion (actor within the system; system as 'white box') to achieve a specific goal (see Figure 5)

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

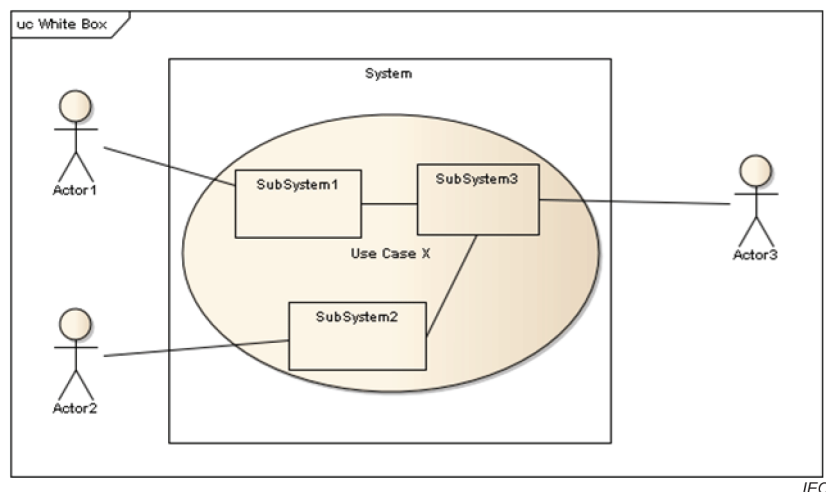


Figure 5 – Internal actor definition

3.1.14**role**

role played by an actor in interaction with the system under discussion

Note 1 to entry: Legally or generically defined external actors can be named and identified by their roles.

3.1.15**architecture**

fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.16**system**

typical industry arrangement of components and systems, based on a single architecture, serving a specific set of use cases

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.17**flexibility**

general concept of elasticity of resource deployment (demand, storage, generation) providing ancillary services for the grid stability and / or market optimization (change of power consumption, reduction of power feed-in, reactive power supply, etc.)

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.18**flexibility offer**

offer issued by roles connected to the grid and providing flexibility profiles in a fine-grained manner dynamically scheduled in near real-time, e.g. in case when the energy production from renewable energy sources deviates from the forecasted production of the energy system

Note 1 to entry: Flexibility offer starts a negotiation process.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.19**flexibility service provider**

role that offers flexibility services based on acquired (aggregated) resources

[SOURCE: HARMONISED ELECTRICITY MARKET ROLE MODEL: 2023-1]

3.1.20**market**

open platform operated by a market operator trading energy and power on requests of market participants placing orders and offers, where accepted offers are decided in a clearing process, usually by the market operator

EXAMPLES Energy, balancing power / energy, capacities or in general ancillary services.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.21**Smart Grid Connection Point****SG CP**

borderline between the area of grid and markets towards the role customer (e.g. households, building, industry)

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.22**Customer Energy Manager****CEM**

internal automation function of the role customer for optimizations according to the preferences of the customer, based on signals from outside and internal flexibilities

CEM includes a semantic mapping for received and sent messages between CEM-connected devices

EXAMPLE A demand response approach uses variable tariffs to motivate the customer to shift consumption in a different time horizon (i.e. load shifting). On customer side the signals are automatically evaluated according to the preset customer preferences like cost optimization or CO2 savings and appropriate functions of one or more connected devices are initiated.

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.23**smart device**

device which is capable to interact with a CEM and is able to be managed in an overall energy efficiency optimization according to its capabilities

3.1.24

traffic light concept

on one hand a concept which describes the relation between the use of flexibilities on the grid side (red phase) and the market side (green phase) and the interrelation between both (yellow phase), on the other hand a use case which evaluate the grid status (red, yellow, green) and provides the information towards the relevant market roles

[SOURCE: SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.25

demand side management (DSM)

load management

process that is intended to influence the quantity or patterns of use of electric energy consumed by end-use customers

[SOURCE: IEC 60050-617:2009, 617-04-15, SG-CG/M490/E_Smart Grid Use Case Management Process:2012 [9]]

3.1.26

demand response

DR

3.1.26.1

demand response

DR

action resulting from management of the electricity demand in response to supply conditions

[SOURCE: IEC 60050-617:2009, 617-04-15]

3.1.27

function specific profile

set of data on the structure and type of data

Note 1 to entry: This contains a description of the information carried by the profile such that a mapping between different instantiations of that profile is possible with a minimum of semantic loss.

3.1.28

quantity

magnitude that is expressed as a value and reference (e.g. unit)

3.1.29

value

dimensionless number

3.1.30

unit

name of relative or absolute measurement unit from a system of units preceded by a conversion multiplier for the value

3.2 Abbreviated terms

AAL	Ambient Assistant Living
BAS	Building Automation System
BMS	Building Management System
BRP	Balance Responsible Party
BSP	Balance Service Provider
CEM	Customer Energy Manager
CEMS	Customer Energy Management System
CEP	Community Energy saving Service Provider
CES	Community Energy Supplier
DER	Distributed Energy Resources
DF	Delivery Fee
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
D-SPEM	District Service Provider EMS
EMS	Energy Management System
ESP	Energy Service Provider
FSP	Flexibility Service Provider
G-CEM	Groups of Building EMS
GW	Gateway
HES	AMI Head End System
I/F	Interface
JWG	Joint Working Group
LNA	Local Network Access Point
MDM	Meter Data Management
MID	Measuring Instruments Directive
NN	Neighborhood Network
NNAP	Neighborhood Network Access Point
PoE	Price of Energy
PSCBA	Peak Shift Contribution of Battery Aggregation
PV	Photovoltaic
RM	Resource Manager
SCADA	Supervisory Control and Data Acquisition
SD	Smart Device
SG CP	Smart Grid Connection Point
TLC	Traffic Light Concept
TSO	Transmission System Operator
UCMR	Use Case Management Repository
VEE	Validation, Estimation and Edit
VPP	Virtual Power Plant
WGSP	Working Group Sustainable Processes

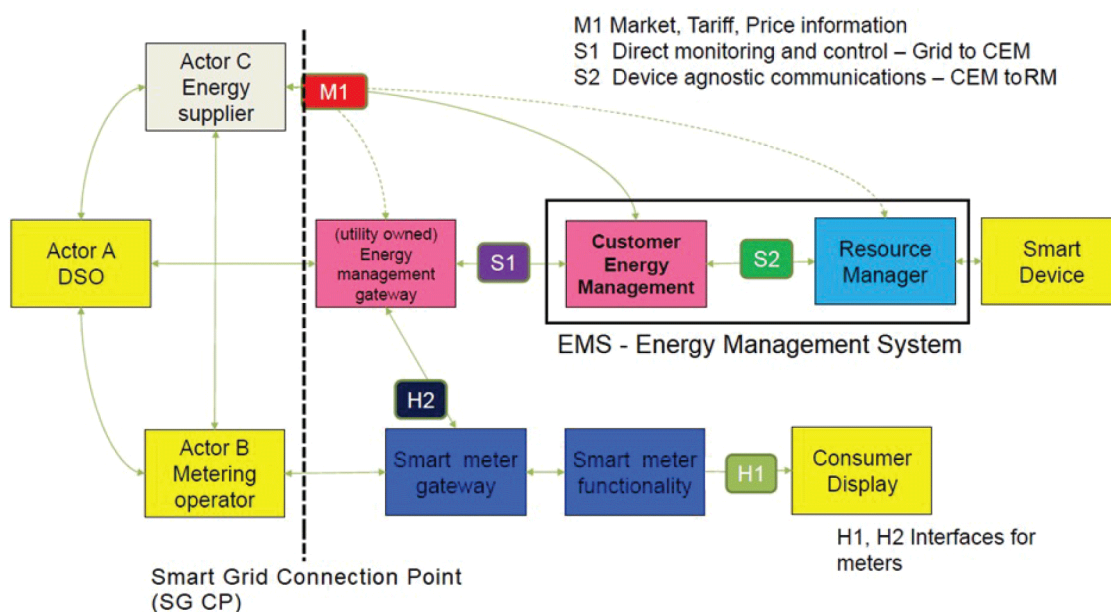
4 Guidelines

4.1 Common architecture model – Architectural criteria

The architecture in this document, which is used for analysing criteria for messages and information models, focuses on in-premises architectural criteria, whereas other parts of IEC 62746 describe the architecture on the grid side.

The architecture shown in Figure 6 is the functional reference diagram that will be used in this document. In this logical architecture the Smart Grid Connection Point (SG CP) represents the interface from the Grid into the premises. The Customer Energy Manager (CEM) provides the flexibility by managing power consumption/generation of connected smart devices, while the smart metering and the simple consumer display provide a number of functionalities which are described in more detail in work of the Smart Meters Coordination Group. It is to be noted that this reference architecture is currently being revised and a coordination work is also taking place in a joint task force between IEC SC23K and IEC TC13 in order to enable control of smart devices by the smart metering channel in simpler scenarios and in order to align with existing practices. The energy management gateway communicates with the metering channel and the smart metering through the Smart Metering Gateway. The gateways in this architecture split different networks (Wide Area Network, Neighborhood Area Network and Local Area Network) and can be, as further described below, integrated with other functional entities. A detailed discussion can be found in 4.2.

The Energy Management System (EMS) is the central managing function. It decides and manages based on information coming from the grid and/or from the smart devices via the resource manager. In a typical home or building environment this manager will likely manage all kinds of future service and management scenarios and will be the basis for AAL (Ambient Assistant Living) and other future User Scenarios. The resource manager (RM) is a logical component that exclusively represents a group of devices or a single smart device and is responsible for sending unambiguous instructions.



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Figure 6 – Smart Grid Functional Architecture Model

NOTE 1 Figure 6 is a draft model and still under discussion with IEC TC13, SC23 and TC57.

NOTE 2 The actors in the above architecture are functional entities, which means that some of them can be part of the same physical device (e.g., CEM functionality can be part of a smart device, the smart meter can also encompass the smart metering gateway and CEM, etc.). This will be detailed via further examples.

The external actors A, B, and C, identified in this functional architecture, represent (systems of) market roles that communicate through the Smart Grid Connection Point (SG CP). Examples of these roles are Grid operator, meter data collector, meter operator, aggregator, supplier, flexibility service provider, etc.

The actual role of actor A, B, or C depends on the local market organization in a member state and competition. In the scope of this report, actor A is defined as the DSO while actor B is defined as the external actor communicating with the smart metering gateway, and actor C as the energy supplier.

NOTE 3 The value of a flexibility service will depend on the guarantee given to the beneficiary of the service. Thus, the DSO metering data for the certification of flexibilities can be used.

For the sake of simplicity, the use cases in this document do not represent the energy management gateway and the smart metering gateway – when developing the use cases, it was assumed that the gateways do not provide functionalities contributing towards the goals of the use cases. These do however provide functionality in terms of routing information, translation of protocols, device management, security and service capabilities.

Within this architecture model, five main different interfaces are necessary to support Interoperability between:

- a) M1: Market, tariff, and price information: between actor C and Energy management gateway, or CEM, or RM.
- b) S1: Direct monitoring and control: between energy management gateway and CEM.
- c) S2: Device agnostic communication: between CEM and RM.
- d) H1: Local connection to simple external consumer display.
- e) H2: Connection between the energy management gateway and smart meter gateway.

NOTE 4 A smart device can be in a range of very simple up to very complex devices.

The main target of this document is to enable technical committees to define messages and information exchange necessary to ensure interoperability between Smart Grid, EMS, and smart devices.

These messages and information exchange are defined on a neutral basis (based on a technology independent neutral interface). This implies that we are talking about application level and do not describe specific protocol relevant messages on lower ISO/OSI levels.

Therefore, this technical report neither intends to define the mapping onto domain-specific transmission technologies nor requests specific technologies for in-premises connectivity. Mappings are the responsibility of domain specific protocol owners. However, this also implies that messages are transferred to mappings (types of devices, supported by domain specific protocols).

Figure 7, Figure 8 and Figure 9 describe the end-point architecture.

NOTE 5 The equipment, messages and mapping of messages shown in the following diagrams (Figure 8 to Figure 10) are examples.

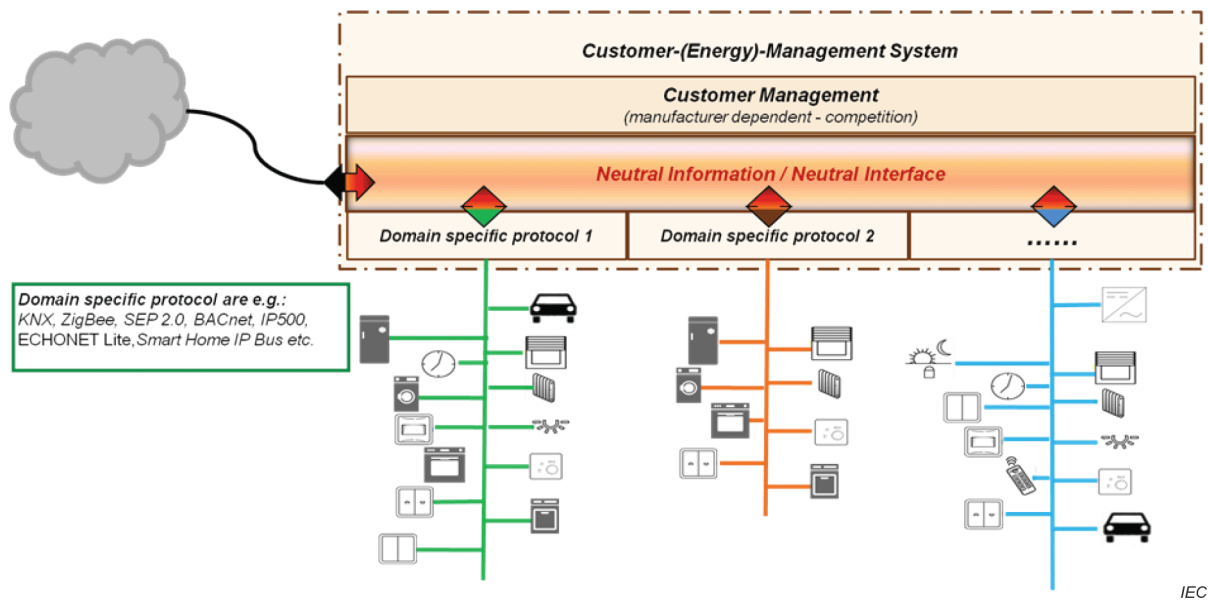


Figure 7 – Neutral interfaces

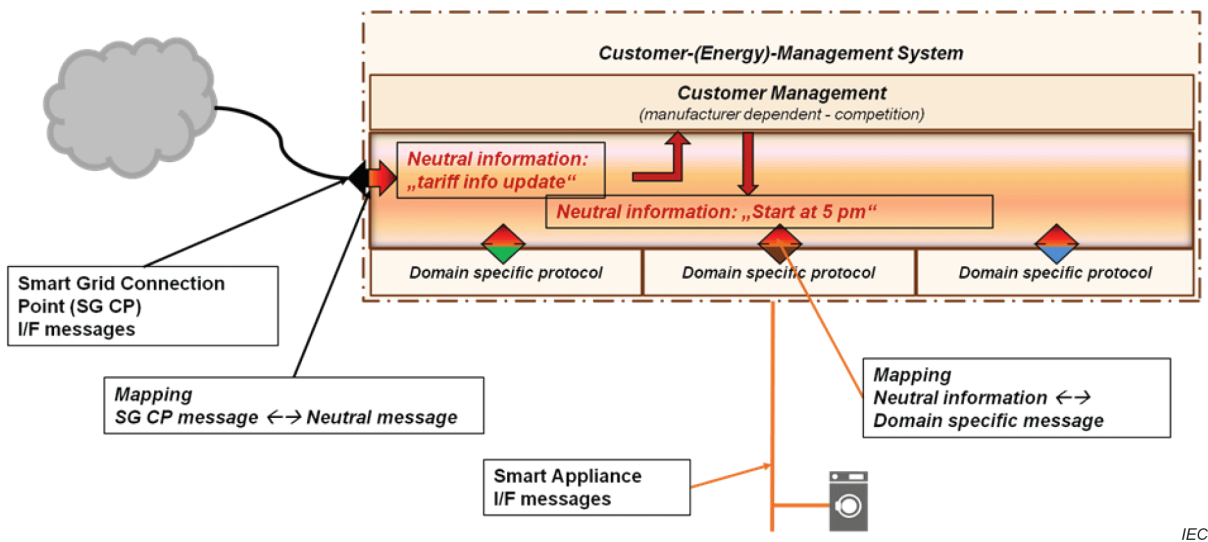


Figure 8 – Mapping Interface (I/F) structure

In this context the CEM can use a different set of messages and information exchange to manage smart devices as for the exchange with the grid (see Figure 10).

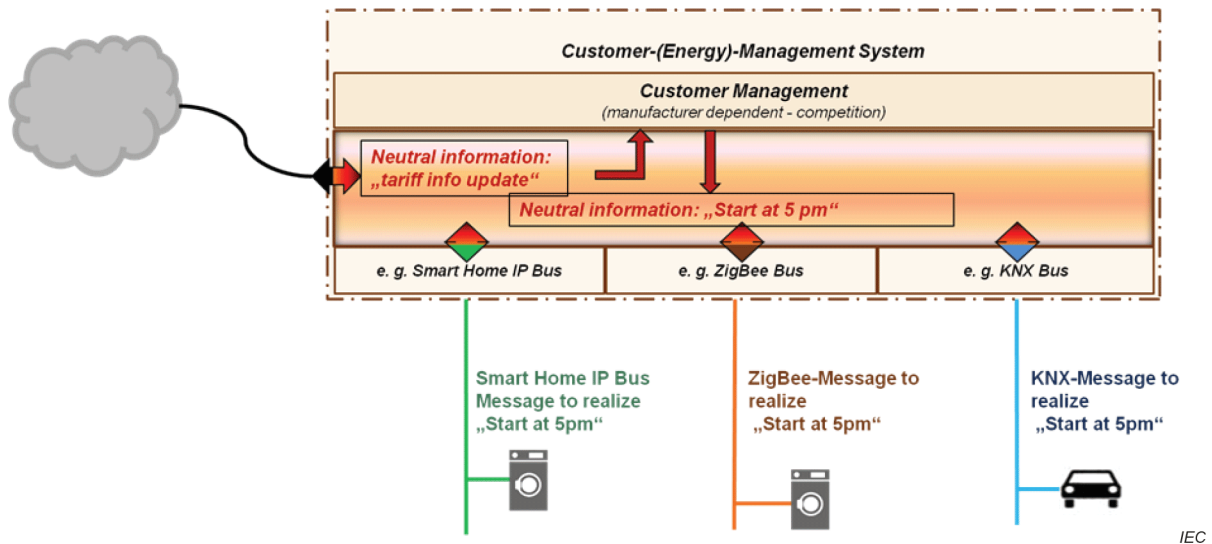


Figure 9 – Example of a mapping of messages

As mentioned above, the CEM can act as a central management system, while parallel working CEMs can also coexist, as shown in Figure 10.

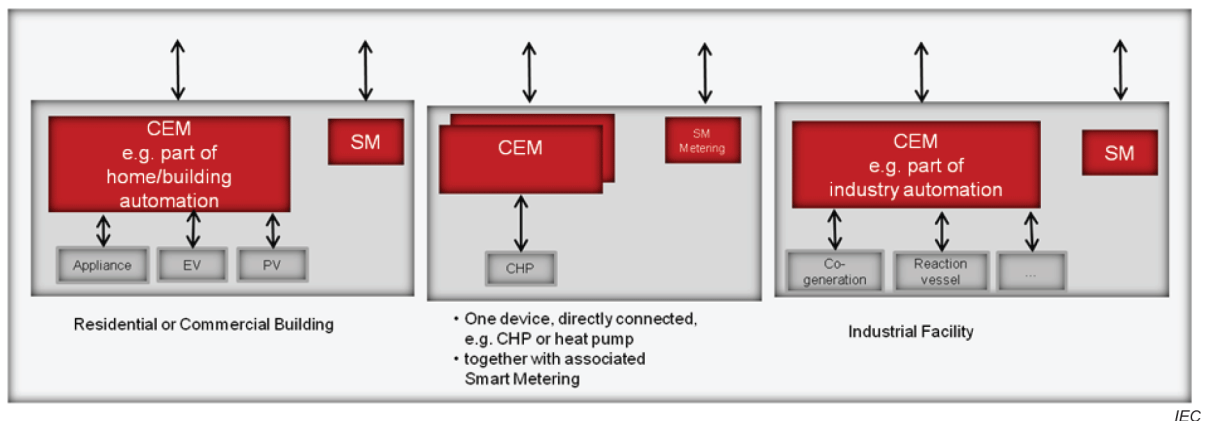


Figure 10 – Different CEM configurations see SG-CG/M490 [5] to [9]

NOTE 6 Based on the SG CG picture [5] to [9], this figure also covers industrial applications.

NOTE 7 In all figures of this document, it is assumed that smart devices are communicating to the energy management system through the resource manager.

Figure 11 lists example mappings of "logical boxes" to physical device combinations.



Interfaces between CEM and CEM Aggregator as well as CEM Aggregator and power plant are to be defined in other parts of IEC 62746-x. In addition, cascaded CEM structures inside premises (CEM – Sub CEM) are part of further discussion and can become part of upcoming versions of IEC 62746-2.

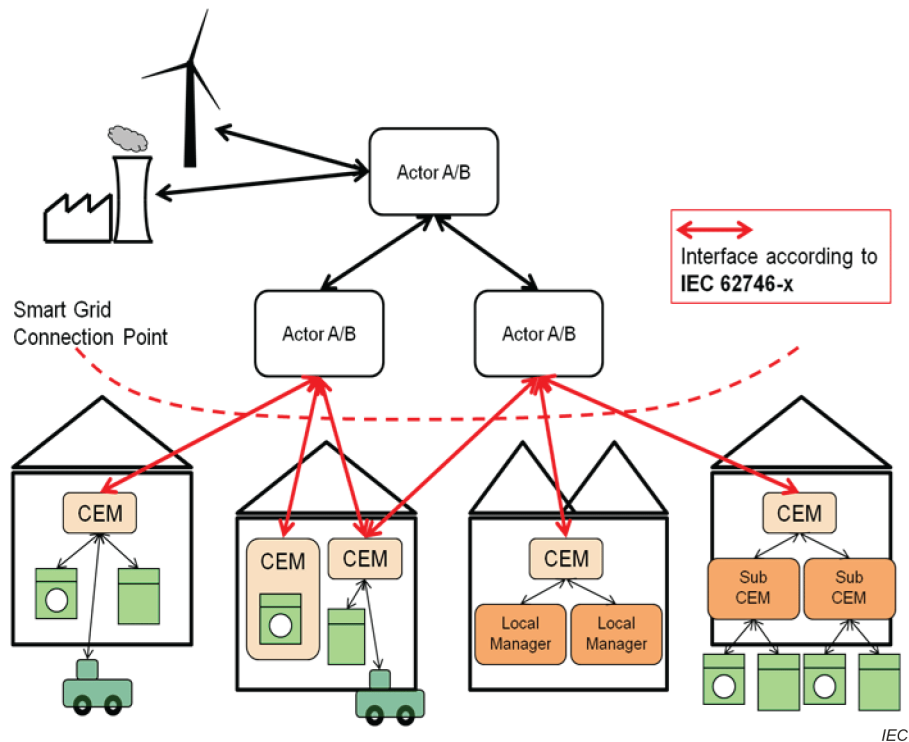


Figure 12 – Examples of CEM architecture

4.2 SG CP (Smart Grid Connection Point)

4.2.1 Overview

This subclause considers the interface between the "Group of Energy Supplier domains" and the "Group of Customer domains" as shown in Figure 13. Both domains are as defined in the Smart Grid Conceptual Model (see e.g., NIST Smart Grid Conceptual Model [3]).

NOTE In this document the NIST model is used as an example for the Smart Grid Connection Point although there are other models such as the European "Harmonised electricity market role model".

Those actors of the Customer domain, such as DER, that have energy supply functions here belong to the "Group of Customer domains".



4.2.2 Definition of SG CP (Smart Grid Connection Point)

In the case of an interruption of the electrical power supply from an energy supplier, e.g., switching of supplier, power outage, or scheduled load shedding, the control of demand / supply power is realized with the cooperation between the service provider and the customers through the grid. In this, the information for the control of demand / supply power is sent and received via the SG CP.

The purpose of defining SG CP is to clarify "the point of the interface for the demand / supply control of power between actors" and "the sending and receiving of information via the point of the interface".

4.2.4 Target of demand / supply of power and information that is sent and received

On the control of demand / supply power between the "Group of Energy Supplier domains" and the "Group of Customer domain", "the functions of the supplier and the customer that are implemented through the SG CP" realize "the marketing of power, the demand / supply adjustment of power, the power system stabilization (the ancillary service), the power optimum usage of the customer, the reduction of the greenhouse gas effect for environmental conservation, the acceleration of producing power by renewable sources of power, the disaster recovery, and so on."

In order to realize those functions relevant to the demand and supply of power, information that is sent and received via the SG CP could include "the time-series data of the electrical energy, the demand (e.g. predictive values, results), the supply (e.g. supply capacity), the price, the amount of the emission of the greenhouse gas effect, the utility grid stability (e.g. transmission capacity, voltage, frequency), and so on. This information is defined both logically and functionally so that the control of demand / supply can be realized under the system structure and devices in the Domains mentioned above.

4.2.5 Functional criteria of SG CP (Smart Grid Connection Point)

The SG CP implies functional criteria as shown below.

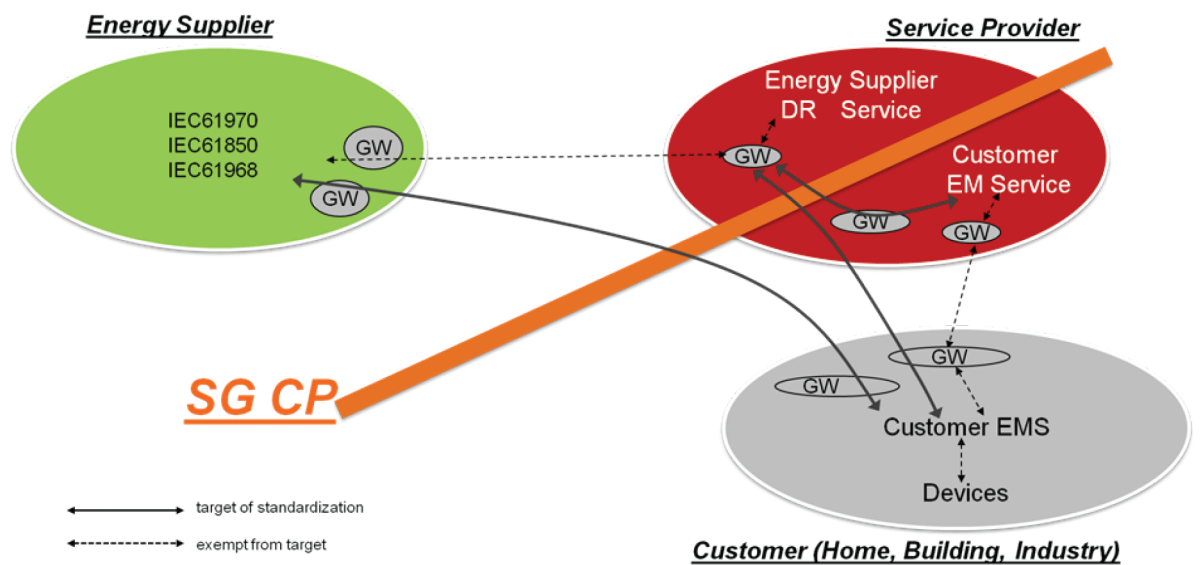
The SG CP is the functional and logical point of the interface that realizes control of demand / supply power between the "Group of Energy Supplier domains" and the "Group of Customer domains". The SG CP is independent of the function and physical structure of each actor. The SG CP is not for monitor control which is dependent on physical systems / devices (e.g. the start command, the stop command, the setting of command to control devices directly).

If the demand / supply control is realized by the energy supplier and the customer via the service provider, then the SG CP does not always correspond to the physical connection point for the power transmitting / receiving. In a such situation, the identification and localization by the DSO of the activated flexibility are still operational in order to ensure the Traffic Light Concept operation.

While responsibility for providing electrical power, services, and ownership of devices varies between countries, "the information that is sent and received via SG CP for the demand / supply control of power" is constant.

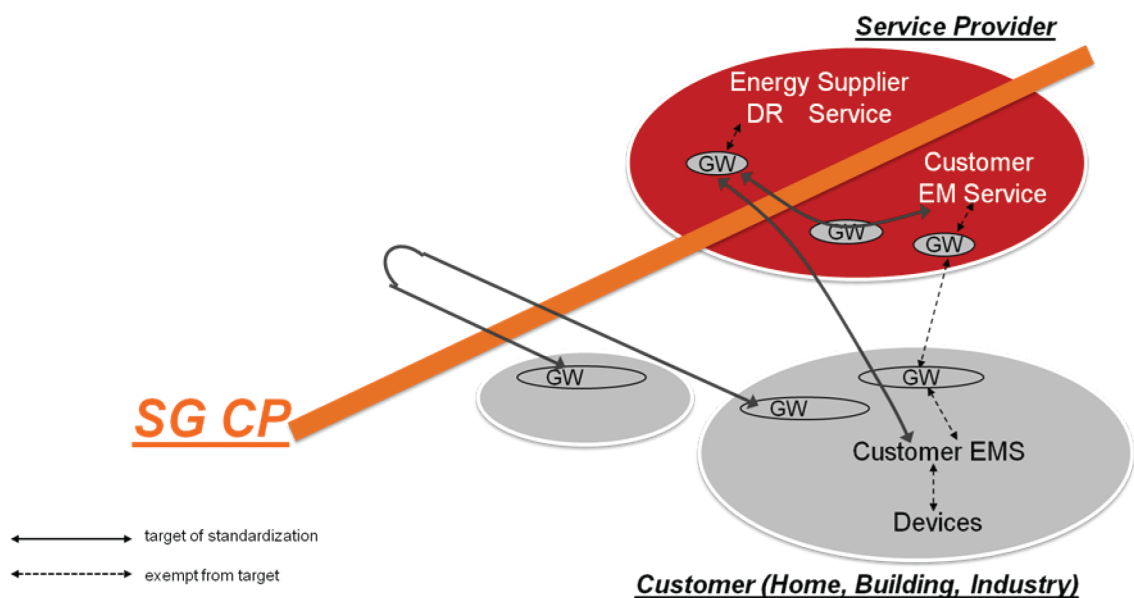
"The device that consumes power, stores power or supplies power" can be integrated into the CEM (Customer Energy Manager). The device can receive message from the "group of the energy supplier domains" and send message to the "group of the energy supplier domains" via the CEM.

If the customer with a power supply device wants to communicate with other customers (e.g. in the case of interruption of electrical power supply from energy supplier, see Figure 15), then the customer communicates with other customers via the SG CP.



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Figure 14 – Smart Grid Connection Point SG CP



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Figure 15 – SG CP (in the case of interruption of electrical power supply from energy supplier)

4.3 The Communication of the Smart Grid and the Smart Grid Connection Point (interface into the premises)

The communication system and protocol on the grid side for connecting smart customers include the following criteria:

- Many customers (resources) can be connected in parallel to a server (> 1 million).
- The system optimizes for a high volume of small data packets.
- Information about network availability (presence).
- Notifications and messages are "just-in-time" (within seconds) without store-and-forward or continually polling.
- Resources have a unique, trusted identity. This identity is used as a logical address for communications.

- Communication is encrypted and authenticated from both sides (trusted entities).
- The communication network is decentralized with straightforward federation.
- Server-host to server-host communication is supported.
- Message content based on e.g., XML, JSON, AVRO, etc., is extensible. If a message contains additional information not understood by a device, it will be ignored, and the sender realizes and accommodates for this fact. New payload types are defined without disrupting existing interfaces.
- Resources are not required to accept inbound connections, where there is not the need to open ports in firewalls to enable them to communicate over the internet. Resources will only make outbound connections to the communication infrastructure using their credentials.
- Resources are able to receive messages asynchronously, without the need to poll a controller.
- It is possible to address a message to a specific endpoint, whether the destination be a device that controls a resource or application software used to manage resources.
- Group communications (multi-party interactions) are supported, where a controller can address a message to all members of a group. Devices have membership in zero or more groups. This means that each message has a single source, but potentially many destinations addresses where a destination address can be a group address that is maintained and managed by the communication infrastructure.
- The protocol supports publish and subscribe.
- The protocol supports service discovery.
- The communication system supports redundancy.
- The communication system protects against denial-of-service attacks and other types of attacks as appropriate for the communication mechanisms.

4.4 Common messages – information to be exchanged

4.4.1 General

As already mentioned, the main intention of this document is to define criteria for the communication between grid side actors and CEM as well as between CEM and smart devices within premises. Common messages are the vehicle to understand each other. This subclause collects relevant information-criteria for these messages and describes the process used. Annex A gives further information.

4.4.2 Intention of user stories and use cases

Why user stories and use cases? Standardization does not standardize user stories. The user can use different ways to get to a target or the manufacturer can implement different solutions, means different interpretations of use cases. However, the definition of data and information exchanged between the different stake holders is essential to ensure interoperability. Use cases for this technical report do not exclude any stakeholder but define the information which can be exchanged to accomplish a certain task without favouring any specific stakeholder.

Use cases help to collect a guideline for necessary information by describing possible scenarios.

This document defines a minimum set of information which is necessary to ensure interoperability. It also defines the criteria for this information exchange as well as a description of the functionality and information flow.

It is then up to the specific technical specification (e.g. IEC 62746-4) to standardize the data models and the structure with its content.

As Smart Grid, Smart Building and Smart Home are overlapping areas, this technical report describes the whole chain from the grid interface into the premises via in-home/-building distribution until the smart (end) devices and vice versa.

Figure 16 describes the process to define messages and data models structures while this technical report ends with the information criteria and concepts.

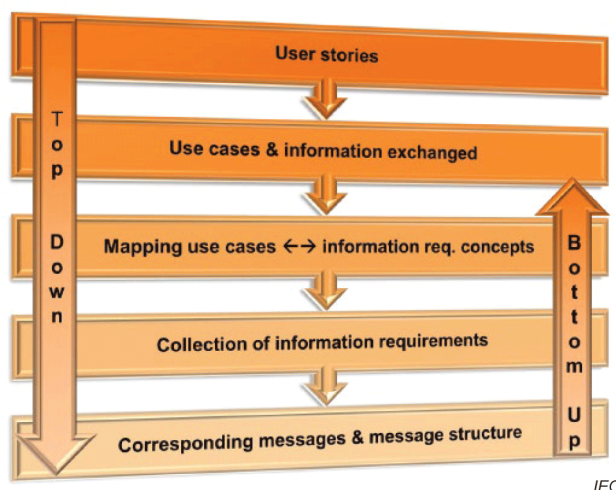


Figure 16 – User stories and use cases process

In order to define criteria for messages and related information to be exchanged, we have chosen a process described below.

The first step of the process is collecting "user stories". Each "user story" is a description of a specific scenario that a consumer can experience with Smart Grid and in the Smart Home/Building area. The user stories are derived from stakeholder brainstorming sessions. They do not follow a specific standardized format, use cases on the other hand compile information in a standardized format. They had been created out of these user stories or were taken from other sources, e.g., IEC Technical Committee 8. There are other standardization committees also working on use cases relevant to this technical report. Each user story is made from the consumer perspective and describes how consumers interact with Smart Grid and/or Smart Home/Building related scenarios in their premises.

The second step of the process is harmonization of use cases. Each use case as defined could not fit into the overall architecture and are extended or slightly modified. It could also be possible to touch upon existing use cases and integrate them as a new one for this activity. A single use case can realize one service or multiple services described in user stories. Use cases include messages transmitted between a smart device, a CEM and /or an actor on the power grid side through the Smart Grid Connection Point (SG CP). The SG CP is the information access point but does not consider the electrical grid connection point to the customer premises.

The last part of this step of the process is a verification step, checking the exhaustiveness of use cases with all user stories.

After confirming exhaustiveness of use cases, the consolidated information exchanged list shows the minimum criteria applicable to the selected user stories. The criteria for data for the messages are examined as the third and fourth step. This step of the process also ends with a verification step by checking the exhaustiveness of messages covering all use cases. The last step of this process is carried out by the technical specifications on the information exchange in the building (CEM to smart device) and on the information exchange between grid actors and the CEM.

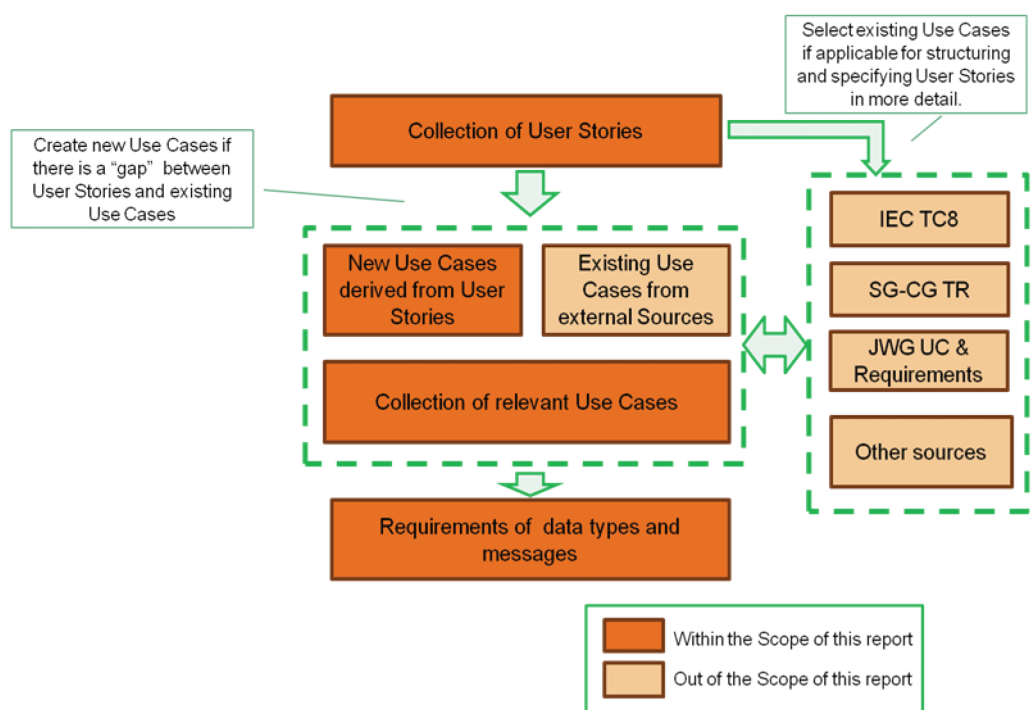
4.4.3 Relationship of user stories and use cases

This document provides descriptions of user stories and use cases.

User stories are produced from the consumer or grid side perspective and describe typical scenarios that can be experienced in an unstructured way. The list of user stories is not exhaustive and represents the scenarios which had been considered for this technical report. Since user stories do not have a standardized format and do not structure its content, they are mapped to structured use cases. These use cases use a standardized template format to compile the information needed for the scenarios described in user stories. It could be possible that one user story utilizes multiple use cases to accomplish a given task.

Depending on the level of detail and the content, use cases can be classified into various categories. The use case collection for this technical report makes usage of high level use cases and specialized use cases according to IEC specifications.

This is depicted in Figure 17.



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Figure 17 – Relationship user stories and use cases

4.4.4 Criteria for information exchange

According to the process described in 4.4.2, use cases are the basis for a collection of a numerous number of information to be exchanged between actors. Figure 18 lists high level examples for the interface between

- Smart Grid (Actor A, B, and C) and CEM
- Smart device and CEM

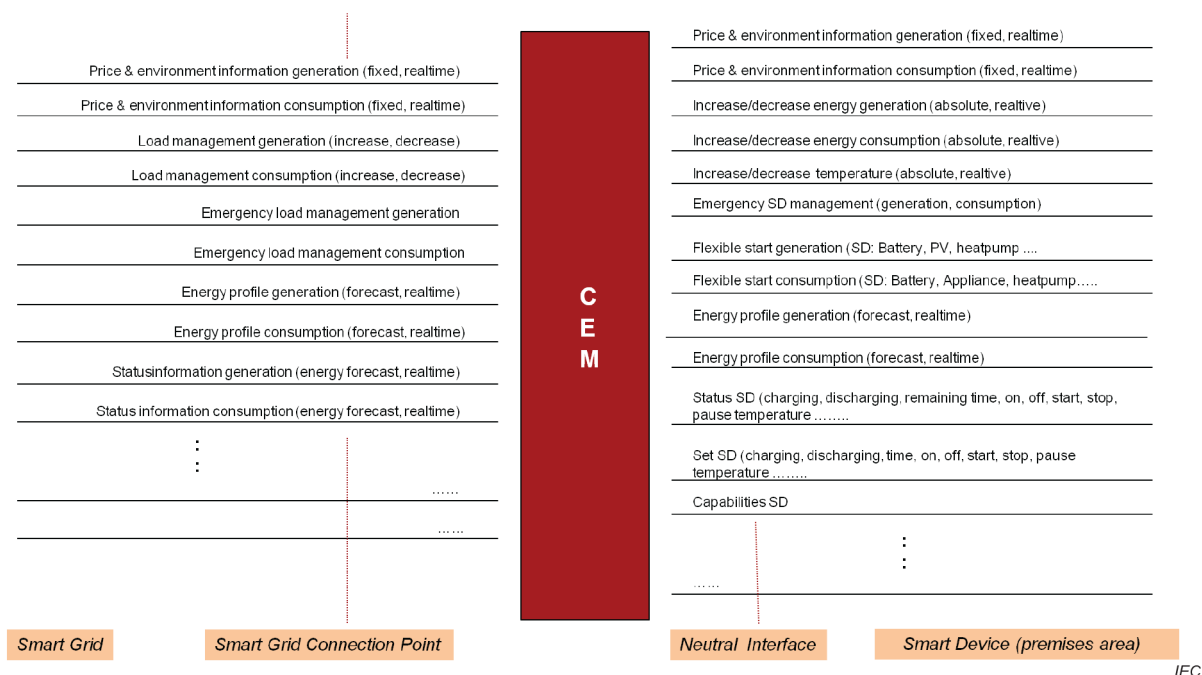


Figure 18 – Examples of information to be exchanged

As already described in 4.1, the CEM functions like an intelligent home or premises managing and mapping system between Smart Grid and smart devices.

The following example can help to understand the meaning of messages and behaviour of the CEM. Please refer to the user story Charging of an electric vehicle: A.1.3.

In this user story the user wants to drive a certain distance next morning (8 a.m.) and advises the car to take care of charging the battery until 8 a.m. The user has already programmed the CEM to use the cheapest price of electrical energy.

The car calculates the amount of lacking energy and asks the CEM to manage a flexible start. Attached parameters are in this case battery charging capacity, earliest starting time (e.g. now), latest end time (= 8 a.m.).

The optimization algorithms of CEM are not the subject of this report as it affects competition. This technical report only focuses on the relevant messages and information to be exchanged between Smart Grid, CEM and smart devices.

The next level of detailed criteria is summarized in Table 1. Three types of categorizations are considered: Customer optimization, Grid Management (Direct Control), and Grid Management (Pricing Signals).

Table 1 – Information criteria collection

Information exchange	
Category	Description
Customer optimization	For flexible energy management within customer premises (with / or without grid request).
Grid Management (Direct Control)	For building responds to grid – Stability / Resilience / Reliability.
Grid Management (Pricing Signals)	For Market Participation – Day ahead, Intra-day, Capacity, etc.

Table 2 describes the mapping between user stories and categories described in Table 1.

Table 2 – Mapping user stories to categories

User stories	Subclause	Categories
Flex start washing machine	A.1.2	Customer optimization
Flex start EV charging	A.1.3	Customer optimization
Severe grid stability issues	A.1.4	Grid Management (Direct Control)
Power limitation PV	A.1.5	Grid Management (Direct Control)
CEM manages devices	A.1.6	Customer optimization
Customer sells flexibility	A.1.7	Grid Management (Pricing Signals)
Customer sells decentralized energy	A.1.8	Grid Management (Pricing Signals)
Grid-related emergency situations	A.1.9	Grid Management (Direct Control)
Customer connects new smart device	A.1.10	Customer optimization
Energy consumption information	A.1.11	Customer optimization
Unexpected disconnect	A.1.12	Customer optimization
Expected yearly costs of smart device	A.1.13	Customer optimization
Energy storage and feed in based on tariff	A.1.14	Grid Management (Direct Control)
Energy consumption management from external	A.1.15	Grid Management (Direct Control)
Manage in-premises battery system	A.1.16	Grid Management (Pricing Signals)
Manage DER	A.1.17	Grid Management (Pricing Signals)
Peak shift contribution by battery aggregation	A.1.18	Grid Management (Direct Control)
Control appliances based on price information	A.1.19	Grid Management (Pricing Signals)
Control appliances based on energy savings signal	A.1.20	Grid Management (Pricing Signals)
Control appliances before power cut	A.1.21	Grid Management (Direct Control)
Control appliances in case of natural disaster	A.1.22	Grid Management (Direct Control)
Bilateral DR-negawatt	A.1.23	Grid Management (Direct Control)
User story lighting	A.1.24	Customer optimization
Energy market flexibility management	A.1.25	Grid Management (Pricing Signals)
Japanese building scenarios on energy management	A.1.26	Grid Management (Pricing Signals)

Table 3 describes the mapping between use cases, and categories described in Table 2.

Table 3 – Mapping use cases to categories

Use Cases	Subclause	Categories	Information
Flexible start of a smart device (SD)	A.3.2	Customer optimization	Load and energy profile, start and end time
Control of Smart home appliances based on price information by time slot	A.3.3	Grid Management (Direct Control), Grid Management (Pricing Signals)	Tariff, Profile, Direct Control, Commands
Manage mixed energy system like heat pumps with pv, storage battery	A.3.4	Grid Management (Direct Control), Grid Management (Pricing Signals)	Tariff, Temperature, Profile, Direct Control, Battery, Commands
Log mixed energy system events of heat pumps with pv, storage battery	A.3.5	Customer optimization	Tariff, Temperature, Profile, Direct Control, Battery, commands
Provide local power managing capabilities	A.3.6	Grid Management (Direct Control)	Actual power, Direct Control, Commands
Provide local power managing capabilities	A.3.7	Grid Management (Direct Control)	Actual power, Direct Control, Commands
District Energy Management	A.3.8	Grid Management (Pricing Signals)	Price profile, Estimated power profile, Emergency power profile (load curtailment)
Limitation of Power Consumption	A.3.9	Grid Management (Direct Control)	Direct Control, Commands
Limitation of Power Production	A.3.10	Grid Management (Direct Control)	Direct Control, Commands
Monitoring of Grid Connection Point	A.3.11	Grid Management (Direct Control)	Actual power
Monitoring of Power Consumption	A.3.12	Grid Management (Direct Control)	Actual power
Time of use Tariff	A.3.13	Grid Management (Pricing Signals)	Tariffs
Power Demand Forecast	A.3.14	Grid Management (Pricing Signals)	Tariffs
Power Envelop	A.3.15	Grid Management (Direct Control), Grid Management (Pricing Signals)	Tariffs Direct Control, Commands
Residential Home Energy Management integrating DER flexibility aggregation	A.3.16	Grid Management (Direct Control), Grid Management (Pricing Signals)	Tariffs, Commands

4.4.5 Energy management concepts

4.4.5.1 Traffic Light Concept

A good example of energy management service is the Traffic Light Concept (TLC), described in the report WG Sustainable Processes – CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG) – Approval of SG-CG deliverables". EU Mandate M490, Dec. 2012, see SG-CG/M490/E_Smart Grid Use Case Management Process [9].

TLC does not imply any specific user stories and/or use cases. It only describes a concept with different types of situations in the Grid.

The energy management relevant user stories and use cases in this document support on a certain level the TLC (see Figure 19) even if this is not in any case a prerequisite nor user stories and use cases are complete and covering all phases. The use cases presented in this document are not going to be included in the IEC Use Case Management Repository (UCMR) [10].

Further TLC related user stories and use cases can be included in future versions of this document.

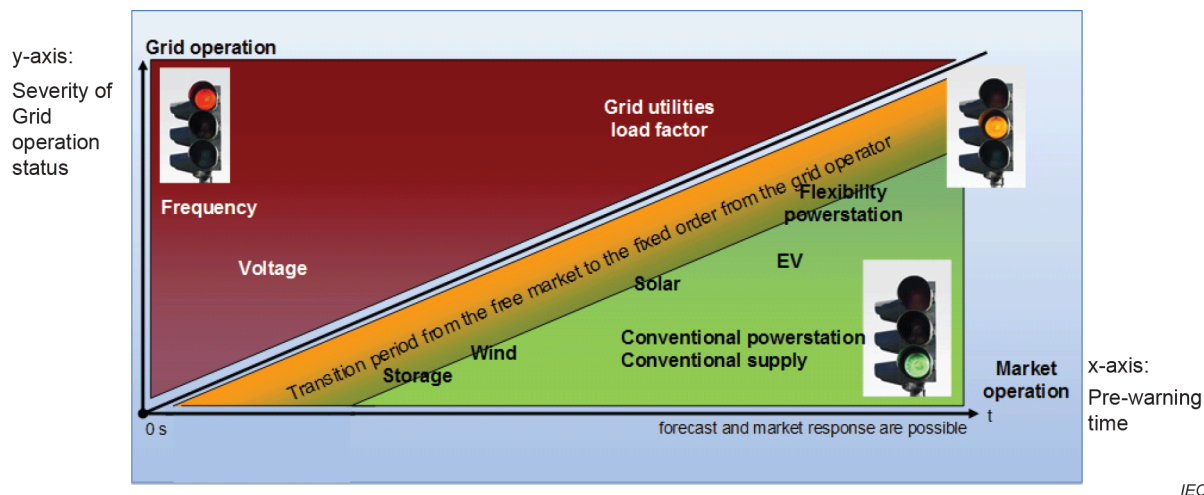


Figure 19 – Traffic Light Concept

NOTE 1 See BDEW Roadmap – Realistic steps for the implementation of smart grids in Germany [4].

NOTE 2 The devices in the graph show examples of resources that can be used to support mitigation on Grid issues.

NOTE 3 Please note that the interface between DSO and other entities (service provider, customer, market operator, etc.) could be unidirectional.

The TLC differentiates between three areas:

The **green shaded** region defines the region where the 'smart market' competitively operates freely; the DSO can or cannot interact with the market at this point. This is seen as the 'normal operating state.'

A typical function, used in this state, is "Flexibility or Demand Response", as described in 4.4.5.2.

The yellow state indicates the state where the DSO actively engages with the market in order to keep the system from becoming unstable, it is therefore a temporary state preventing the grid from entering the red state. This could be by executing pre-agreed contracts or by stepping in to procure in real time at market prices. This does not mean that the customer has to accept any situation where a third party (DSO) decides when they can use what is in their home or business premise. Instead intelligent solutions and economic incentives is provided to enable the customer to decide and accept some limits.

A typical function, used in this state, is "Load Management or Demand Side Management", as described in 4.4.5.3.

In the **red state** the DSO takes the control of market interactions in a certain area where the constraint has occurred. However, actions in this state are specific and well defined and are temporary in nature. In this situation the DSO can override contracts existing in the market, execute dedicated emergency actions through flexibility service provider, or execute direct controls over generation or demand in order to re-stabilize the system.

A typical function, used in this state, is "Emergency or Blackout prevention", as described in 4.4.5.4.

For details, please refer to the German Association of Energy and Water Industries (BDEW) Roadmap – Realistic Steps for the Implementation of Smart Grids in Germany [4].

4.4.5.2 Flexibility (demand response)

Flexibility is a typical functionality in the green area. The market offers flexible energy based on prices and / or environment. This can be amongst other scenarios the retailer, offering time separated tariffs but also using the own PV energy and combinations of that.

The customer offers flexibility by letting a smart device to be started, paused, etc. based on specific conditions like price ranges, or the availability of energy (green power etc.).

The smart device can be a consumer or producer of energy.

4.4.5.3 Load management (demand side management)

As already mentioned in the definition (see [2]), demand side management reflects the Top-Down approach. If the grid recognises stability issues like frequency is running out of bandwidth, the TSO and/or DSO can ask the attached CEMs for help. This can be a request to reduce or increase consumption or generation.

In case of a specific contract, load management can be seen as a management of Smart Devices, e.g., a heat pump is attached via an integrated CEM. In this case the message could be "increase/decrease to 100 % or 0 %".

4.4.5.4 Emergency / blackout prevention

Emergency or blackout prevention management can be seen as a specific load management case. In case a blackout is in front of the grid connection point, the message from the TSO or DSO could advise the CEM and smart devices to immediately go into a defined Standby Mode as a last chance to prevent the upcoming blackout.

4.4.6 Function-specific profiles

4.4.6.1 General

In order to create interoperable messages with the relevant information, specific concepts can be explained to become the basis for these messages and information to be exchanged. These information are listed in the corresponding Table 4 to Table 7.

4.4.6.2 Power profile

Irrespective of whether the smart device is a consumer or producer it announces a kind of expected energy consumption or generation (power profile – see Figure 20) to enable energy allocation within smart premises.

For example, a heat pump can ask for allocating two sequences per day, once in the morning, once in the afternoon, each sequence with different phases of power consumption.

Alternatively, a smart device can offer multiple sequences for the same time period, e.g. a battery pack can offer charging or discharging. The CEM can choose between these possibilities.

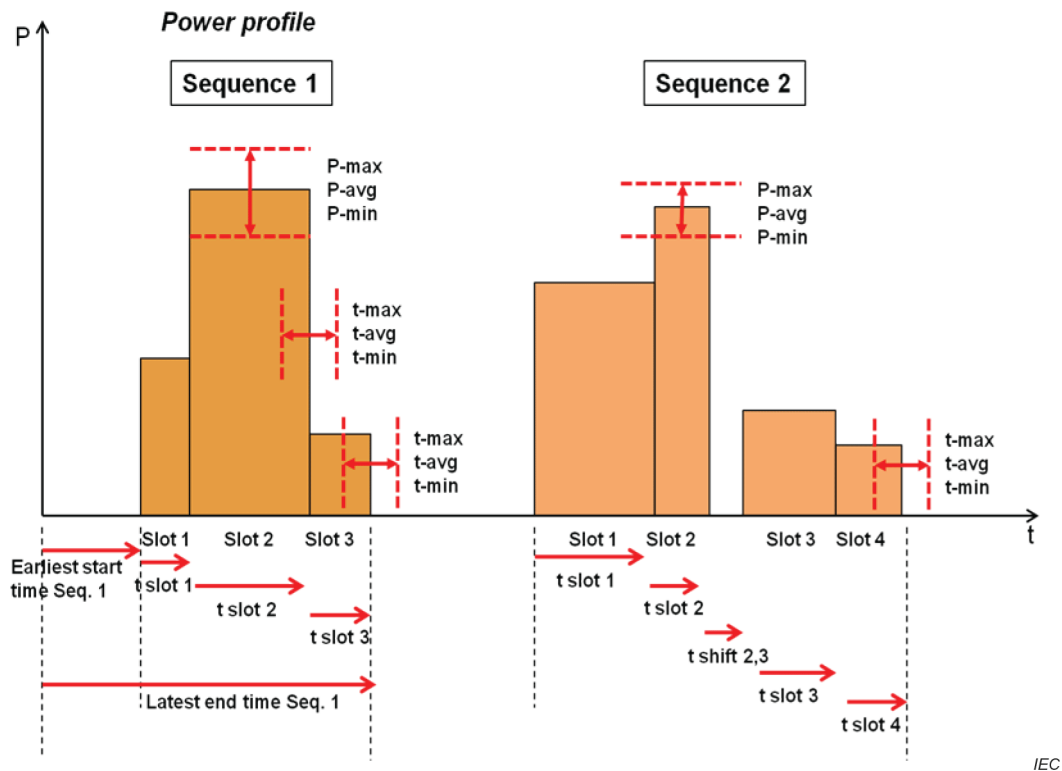


Figure 20 – Structure of a power profile

This power profile enables "generation" or "consumption" of energy to be distinguished. Figure 21 shows as example the energy direction of a storage battery during charging and discharging.

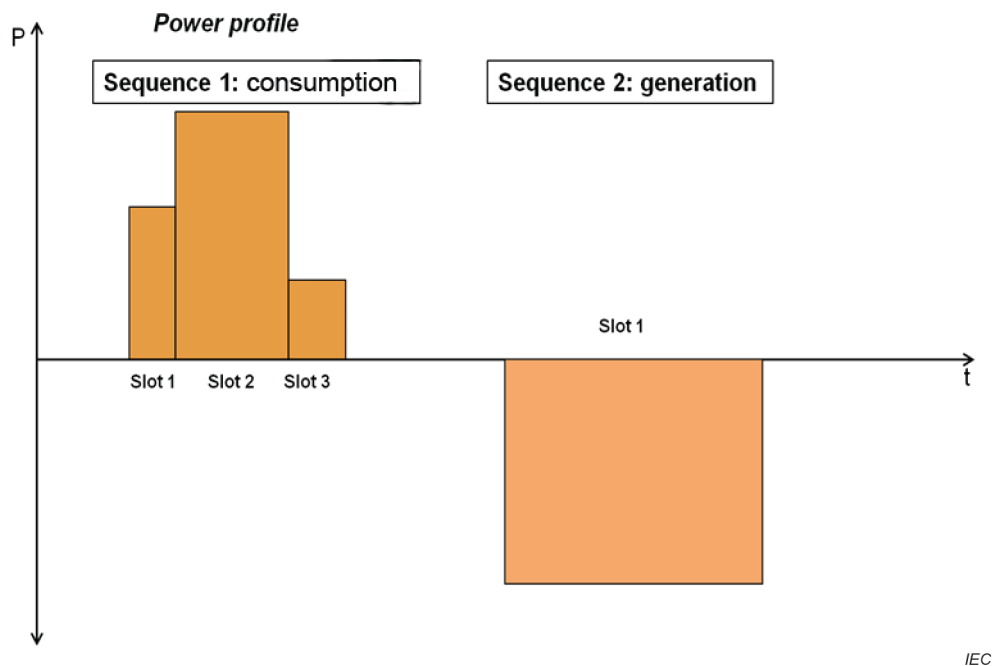


Figure 21 – Consumption and generation

The easiest way to express the expected energy consumption / generation is one sequence with one timeframe with one power value over timeslot (see Figure 22). Table 4 describes information guidelines for "Energy Profile".

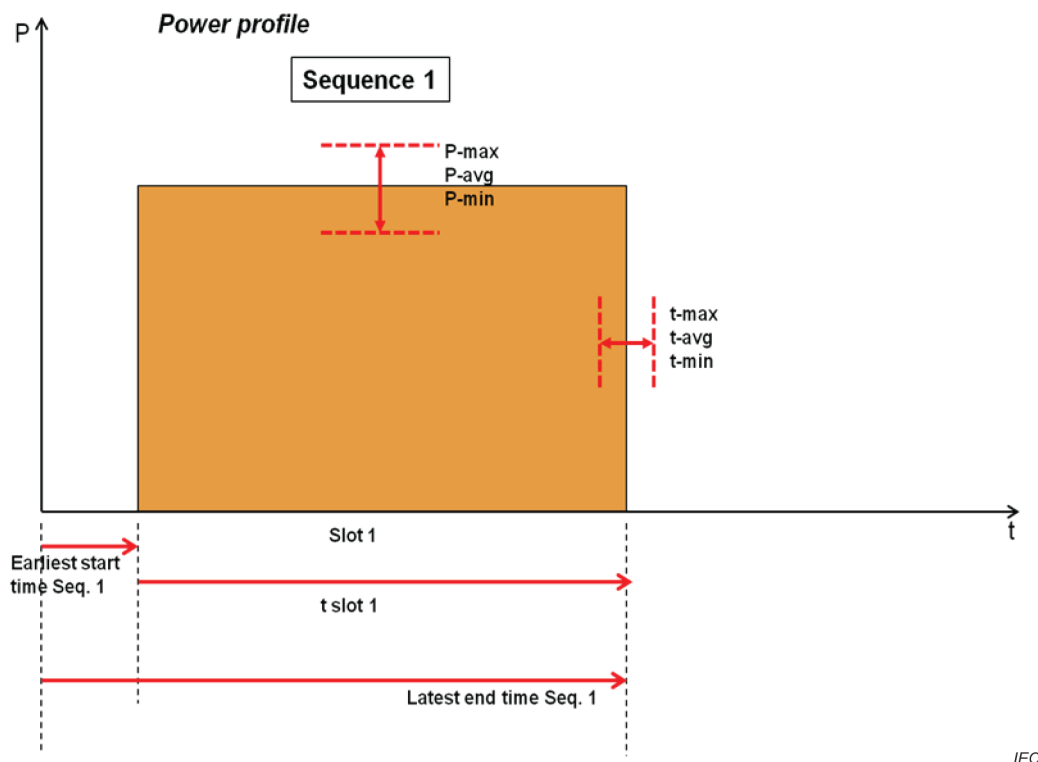


Figure 22 – Structure of an easy power profile

Table 4 – Information guidelines for "Energy Profile"

Name	Includes	UC references
power profile (power over time)		JWG1100, 1110, 120x, 212x, 3004, 3006 WGSP2110, 2111, 2112
	power quantity	
	type of energy sources and amount of energy from each source type	
	consumption / generation	
	time information (e.g. slots, actual time, start time, end time, ...)	
	date information (e.g. weekday, date, ...)	
	confidence level	
	devices	
instantaneous power information		JWG113x
	power quantity	
	time information (e.g. actual time, ...)	
	date information (e.g. weekday, date, ...)	
	confidence level	
	devices	

4.4.6.3 Price and environmental information profile (see Figure 23)

The price and environmental profile uses the same basic structure as shown in 4.4.6.2 within power profile. Herewith typical scenarios can be handled like the price table for certain time slots within a timeframe (e.g. the next 24 h).

Additionally benchmark conditions can be used to address more than one price per time-slot. The different price can be based on different conditions. Examples are:

- If energy consumption exceeds a certain amount of energy within the time-slot, the next price level will be activated.
- The price levels reflect benchmarks, e.g. types of energy like renewables, yellow energy, CO₂ footprint etc., from which the customer can select.

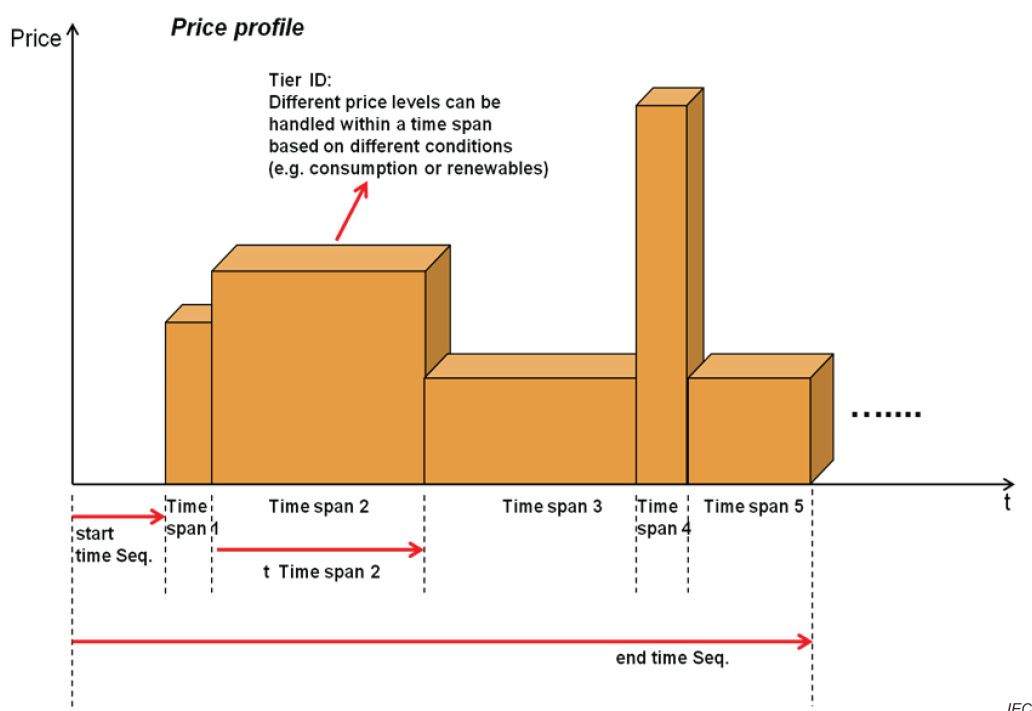


Figure 23 – Structure of a price profile

Table 5 describes information guidelines for "Price and Environment Profile".

Table 5 – Information guidelines "Price and Environment Profile"

Name	Includes	UC references
price & environment profile		JWG1100, 113x, 1110, 3004, 3005, 3006, 4000 WGSP 2110, 2111
	price quantity	
	environment description a/o quantity	
	variable price model (e.g. discount, quantity based etc.)	
	time information (e.g. slots, actual time, start time, end time, ...)	
	date information (e.g. weekday, date, ...)	
	binding level (connection strength and extent)	

4.4.6.4 Load / generation / storage management profile

Load/generation management is used for expressing the need and quantity of power adjustment. The actor A is signalling stability issues in the grid and is asking for help. If the customer has offered support (e.g., as part of the contract or as part of an incentive program) the CEM can evaluate capabilities to increase or reduce energy consumption or generation inside premises.

Examples are:

- lack of energy in the grid due to a breakdown of a power station with a certain time to ramp up another backup power station;
- energy overload due disproportional PV- and wind energy.

In these examples the actor A asks the CEM to reduce or increase power consumption for a specific time period.

Nevertheless, this load / generation management concept can also be used to manage specific CEM-smart devices directly (see Figure 24).

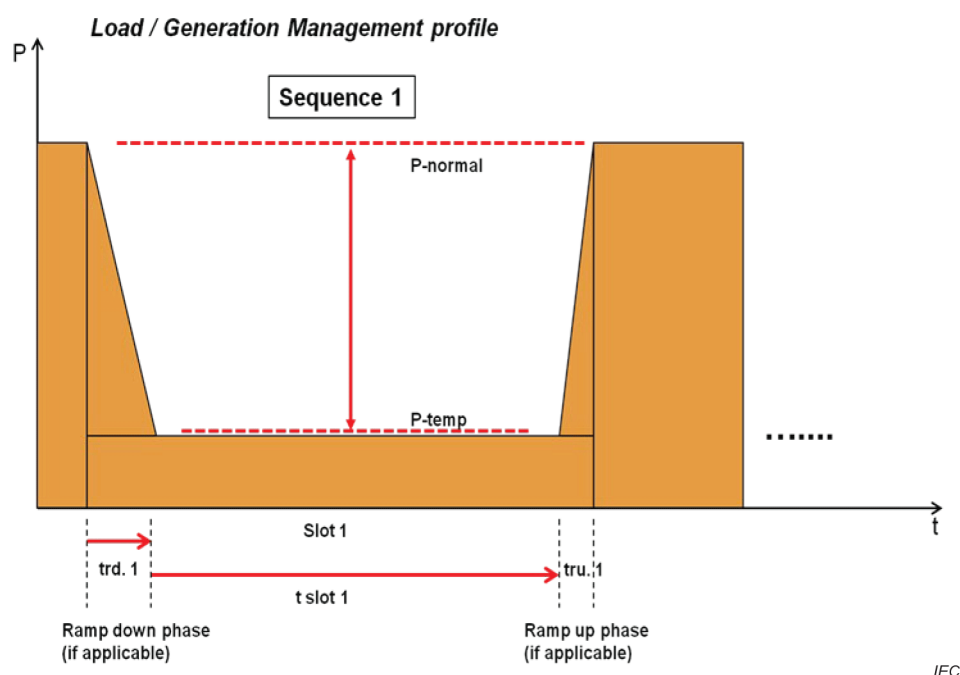


Figure 24 – Structure of a load / generation management profile

Table 6 describes information guidelines for "Direct Load / Generation Management Profile".

Table 6 – Information guidelines "Direct Load / Generation Management Profile"

Name	Includes	UC references
load / generation management profile		JWG113x, 112x, 1110, 120x, 121x, 2002, 3000, 3001, 3002, 3003 WGSP2121, 2114, 2111, 2112
	time information (e.g. slots, actual time, start time, end time, ramp up time, ramp down time, etc.)	
	date information (e.g. weekday, date, etc.)	
	power quantity during ramp up / down (absolute / relative)	
	Urgency / criticality	
	confidence level (0 indicates no confidence and 1 indicates complete confidence)	
	devices	

4.4.6.5 Emergencies / blackout prevention profile

Emergencies / blackout prevention management is a specific characteristic of load / generation management. The actor A is signalling an upcoming blackout situation in the grid. To prevent this blackout the actor A is advising the CEM to send all smart devices into a defined blackout prevention mode (minimal power consumption except safety relevant tasks).

The information exchange can be handled like the load / generation management profile.

4.4.6.6 Temperature profile

Instead of power management types, smart devices can also be managed by a temperature profile (see Figure 25). The concept behind is comparable with the power profile concept.

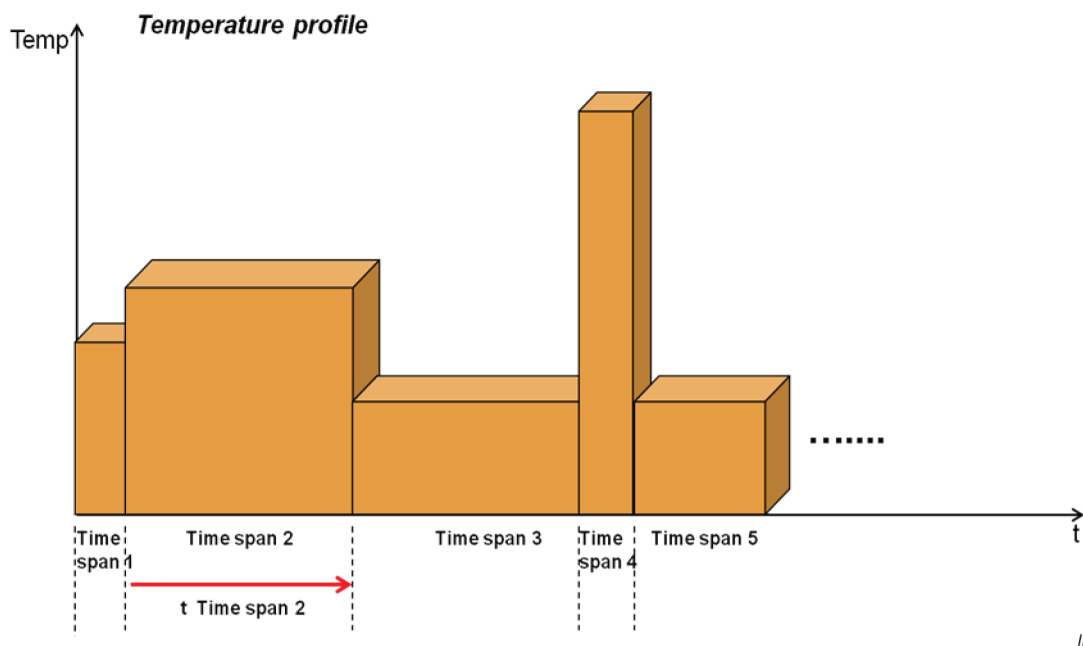
**Figure 25 – Structure of a temperature profile**

Table 7 describes information guidelines for "Temperature Profile".

Table 7 – Information guidelines "Temperature Profile"

Name	Includes	UC references
temperature profile		JWG120x, 121x, 1100, 1110, 1130x WGSP2112, 2121, 2114, 2111
	temperature quantity	
	time information (e.g. slots, actual time, start time, end time, etc.)	
	date information (e.g. weekday, date, etc.)	
	confidence level	
	devices	

4.4.7 Comfort, management and status information

Comfort, management and status information summarize information criteria for remote management as well as kinds of remote monitoring like notifications, alerts and status information.

The collection includes typical data like on, off, waiting for start, remaining time, pause, finished etc. The information to be exchanged is already referenced within Figure 18.

4.4.8 Upcoming profiles for new service criteria

The function specific profiles, information to be exchanged (as described in this document) and corresponding messages are set up in a manner to enable easy definition and smooth harmonization of upcoming services like further energy related criteria, AAL, security, healthcare, and so forth.

Annex A (informative)

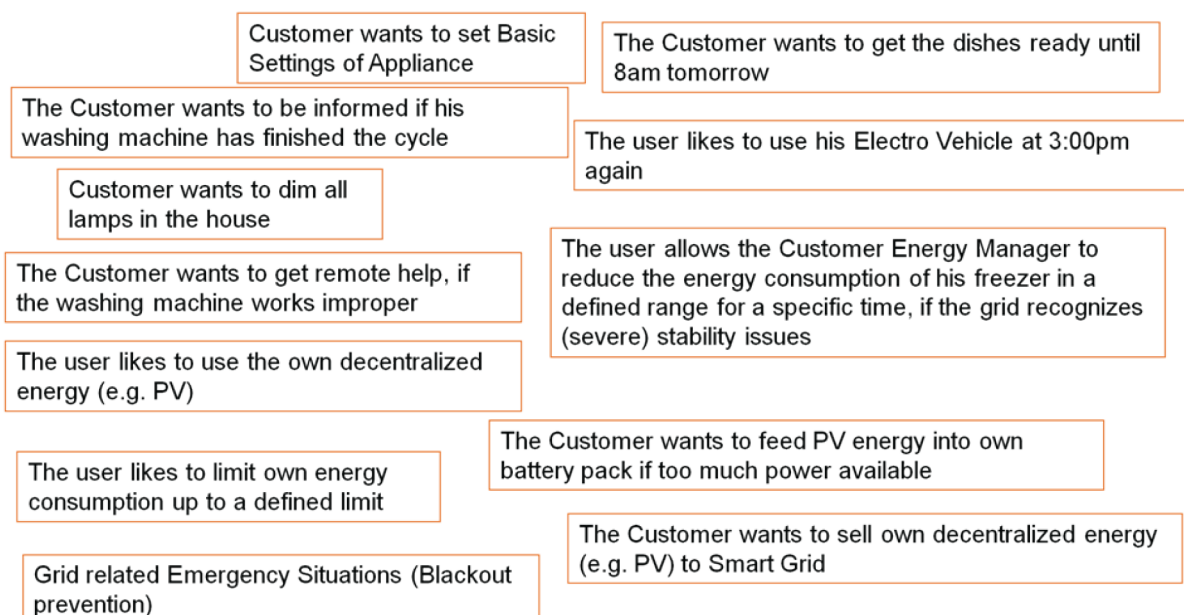
User stories and use cases collection

A.1 User stories

A.1.1 General

This annex describes a collection of user stories as a basis for necessary use cases. User stories describe the behaviour from the customers'/users' point of view. The main target of user stories is to narrate typical behaviors in own premises to validate the use cases used to accomplish the story. These user stories can apply to various scenarios and are not limited to specific home environments, building and industrial applications.

Figure A.1 lists typical user stories.



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Figure A.1 – Kinds of user stories

A.1.2 JWG1 Flex start washing machine

The user wants to get the laundry done by 8:00 p.m.

The user prepares the washing machine

Fills clothes Selects washing program

Pre-selects the end time (e.g. 8:00 p.m.)

Starts washing program

The washing machine now informs the CEM about

The start of the new program

The pre-selected end time

The expected power consumption profile with duration and (e.g. time related specific) energy consumption

The CEM calculates the operation plan and takes into account

- The pre-selected end time

- A pre-selected incentive program

- The expected power consumption profile with duration and (e.g. time related specific) energy consumption

- Tariff information

- Expected energy consumption of other smart devices

- Expected local energy generation

- Amount of locally stored energy

The CEM sends the calculated start time to the smart device (washing machine)

- In case the situation changed, a CEM can send an updated starting time unless the smart device started

The smart device starts the cycle based on the calculated start time

A.1.3 JWG2 Flex start EV charging

The user wants to have his electro vehicle charged by 8:00 a.m.

The user prepares the EV

- Selects charging level

- Pre-selects the end time (e.g. 8:00 a.m.)

- Can pre selects the incentive program (e.g. cheapest tariff, greenest power etc.)

- Starts charging cycle

The EV now informs the CEM about

- The start of the new charging cycle

- The pre-selected end time

- The pre-selected incentive program (if not already stored)

- The expected charging consumption profile with duration and (e.g. time related specific) energy consumption

The CEM calculates the operation plan and takes into account

- The pre-selected end time

- The pre-selected incentive program (if not already stored)

- Tariff information

- Decentralized Energy forecast, if applicable

- The expected power consumption profile of the requested EV charging

- Expected energy consumption of other smart devices

- Expected local energy generation

- Amount of locally stored energy

The CEM sends the calculated start time to the EV

- In case the situation changed, a CEM can send an updated starting time unless the smart device started

The EV starts the cycle based on the calculated start time

A.1.4 JWG3 Severe grid stability issues

The grid recognizes (severe) stability issues

The grid sends a load control message, requesting the CEM to adjust the load (by either increasing or decreasing consumption or generation). The load control message can include:

- An incentive value and/or time frame for answering to the request.
- An incentive value and/or time frame for acting on the request.

Depending on user configurations, several options are possible, e.g.:

- The user enables the CEM to adjust the load of some of his devices (e.g. of the freezer for a defined/maximum time). The support of these capabilities can usually be part of a contract between Energy Supplier and customer. After receiving the request from the grid, the CEM checks the status of attached smart devices checking on the possibility of e.g. reducing consumption by xW, x % of consumption or alternatives which leads into a change in consumption / generation. The smart device can react so and can respond with the achieved details.
- The CEM can send the response back to the grid.
The CEM checks the status and can recalculate (e.g. postpone) the starting time of already planned upcoming cycles. The CEM updates starting time of smart devices.
- CEM feeds own battery pack energy into own network or into the grid. The CEM checks status of battery pack. In case the battery pack can provide enough energy the CEM can decide to start feeding process.
- CEM stores additional energy from the grid into own battery pack. The CEM checks status of battery pack. In case the battery pack has enough capacity and if the energy price plus the incentive value is better than the average cost of stored energy, the CEM starts feeding process.

A.1.5 JWG4 Power limitation PV

The user wants to limit his consumption to his own local production (e.g. PV)

The user instructs the CEM to limit power consumption up to amount of own decentralized power. Along with this command, several additional parameters can be set, for example:

- At which time of the day this limit applies.
- Which devices are exempt from this limit.
- Etc.

The CEM is kept informed on total power consumption and generation through the smart meter.

When managing power consumption in the house, the CEM takes into account the above limits and parameters.

If the user wants to start a smart device, then the CEM is notified by the smart device and receives, amongst others, a load profile (see 4.1).

If, when based on the load profile and other parameters, the CEM concludes that the power limit will be exceeded, then it can send a warning message to the relevant device and to a display if one is available.

Based on the warning message, the user can decide to postpone his consumption or to manually overrule the power limit.

Furthermore, there is the possibility that premises go in isolated (island) operation from the distribution system. Such premises will be isolated or "switched off" by the network operator or by the premise's own control facilities based on appropriate monitoring arrangements. The ability of island operation comes from the fact that they are able to cover their own power demand by the premise's own "distributed" generator and/or storage facilities, i.e. batteries. In such situations the distribution network can be in operation or out of service due to emergency situations and/or planned maintenance and/or repair activities. Premises with their own generation and storage facilities can cover their total demand or at least part of their total demand controlled by a CEM with or without being connected to the distribution network. In normal situations the surplus of energy generated by the premises can be delivered back to the distribution system. Reconnecting the premises to the distribution system after a period of island operation has to be arranged in a safe and coordinated manner. That can be arranged by a synchronizing facility/unit with build-in monitoring and control arrangements; the latter can be part of the afore-mentioned CEM.

A.1.6 JWG5 CEM manages devices

Switch on/off devices, dim devices

Examples are turning on/off devices such as lighting, smart plugs and dimming lighting etc.

A.1.7 JWG6 Customer sells flexibility

The Customer wants to sell his flexibility to the grid

Based on information on:

- Current consumption (received from smart meter)
- Currently running devices and their load profiles
- Device assignments to be ran and their load profile
- Tariff information
- Information on power limitations

The CEM can identify opportunities for flexibility.

The user can have set constraints on the flexibility that can be offered to the grid. These constraints can be:

- Which loads (or generators) and user specified conditions are available for providing flexibility
- Start time of the flexibility (start time within a certain time period)
- Duration of the flexibility
- Amount of flexible power at a point in time
- Amount of flexible energy

The CEM proposes this flexibility to the grid, by providing the following information:

- Start time of the flexibility (start time within a certain time period)
- Duration of the flexibility
- Amount of flexible power at a point in time
- Amount of flexible energy

These offerings are negotiated by a process of offering, accepting, or rejecting, possibly. Reasons for accepting and rejecting include suitability of the offered flexibility (the expected value of the flexibility e.g. in a portfolio) and financial aspects.

If the grid wants to accept the offer, it sends a message indicating this and with the incentive that is related to the acceptance (this is the Flexibility Offer Acceptance).

A second message from the grid indicates how the flexibility is allocated. This message comes in the form of a load profile but stays within the constraints of the flexibility offer.

The CEM implements the flexibility allocation by adjusting the (time of the) consumption / generation of devices on the premise.

A.1.8 JWG7 Customer sells decentralized energy

The customer wants to sell own decentralized energy (e.g. PV) to Smart Grid

When the consumer wants to sell his own decentralized energy to the grid, several options are possible:

- Based on a price message or load/generation control message, CEM can instruct local generators / storage to adjust output.
- CEM offers to sell an amount of energy at a specified price. This corresponds to offering flexibility as described in user story JWG 6 Customer sells flexibility, see A.1.7

The CEM then releases stored energy and starts power generation if available.

A.1.9 JWG8 Grid-related emergency situations

Grid-related emergency situations (blackout prevention)

The grid is close to a black-out and will soon have to cut off sections of the grid.

As a means of preventing this by limiting the overall energy consumption to a certain minimum, the grid sends an emergency message to all connected households in order to instruct them to place their connected devices into "emergency connected off mode".

Assumption: The CEM and smart devices are pre-configured with an "emergency connected off mode" profile. This profile defines which connected devices enter "emergency connected off mode" and what that mode entails (on a device-by-device basis). This profile is agreed by both the consumer and the energy provider and is likely to be included in a contract.

The CEM receives an emergency message (some low consumption, essential devices like gas boilers that have a minimum of electricity to run, can be enabled to stay operational – this will be defined within the profile).

This message can include the duration of the emergency period.

The CEM sends a message to all connected smart devices to switch to "emergency connected off mode".

The devices switch to "emergency connected off mode".

When the emergency period has ended (either because the predetermined emergency time has passed or because the grid sent a message that the emergency has passed), the CEM instructs the devices that they can resume operations as normal.

A.1.10 JWG9 Customer connects new smart device**The Customer wants to connect a new smart device to the CEM**

Installer and/or "plug and play" consumer installation will be supported.

Discovery, authentication etc. are handled by lower layers and are out of scope of this document.

Communication messages and data used between the CEM and device concerning the capability (type and functionality) of the device are within the scope of this document.

A.1.11 JWG10 Energy consumption information**The consumer wants to be informed on their historic and forecasted energy use**

The consumer indicates on the CEM User Interface that they want information on their historic and forecasted energy use.

In case the CEM does not have the relevant historic information, it can request these data from the smart meter or other source.

Based on the information related to currently connected devices and their expected consumption and generation and based on the historic data, the CEM can build a short-term energy forecast and informs the user.

A.1.12 JWG11 Unexpected disconnect**A smart device disconnects unexpectedly (failure)**

The CEM and smart device exchange regular messages or status messages to keep each other informed of their connection (to the network) and of their operational status.

At a moment in time, the CEM does not receive such a message from a device when it expected one.

The CEM sends a status request to the device.

In case the CEM does not receive a response or when the device responds with an abnormal status, the CEM sends a warning message to an advanced display. The CEM can also send a warning to a third party (e.g. service provider) on the grid side.

A.1.13 JWG12 Expected Yearly Costs of Smart Device**The consumer wants to know an estimate of the yearly energy cost of a smart device**

(This user story assumes that the CEM or the device stores information on time-of-use consumption of individual devices and that the CEM has a historic record of time-of-use buckets and their related tariffs in the relevant currency).

The consumer indicates on the CEM User Interface that they want information on the yearly cost of a specific device.

The CEM collects information of individual device's consumption from its memory or requests this information from the device.