



BSI Standards Publication

Generic smart grid requirements

Part 2-3: Resources connected to the grid domains

National foreword

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

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SYSTEMS REFERENCE DELIVERABLE



**Generic smart grid requirements –
Part 2-3: Resources connected to the grid domains**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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GENERIC SMART GRID REQUIREMENTS –**Part 2-3: Resources connected to the grid domains****FOREWORD**

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Draft SRD	Report on voting
SyCSmartEnergy/89/DTS	SyCSmartEnergy/98/RVDTS

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

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

A list of all parts in the IEC SRD 62913 series, published under the general title *Generic smart grid requirements*, 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 "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document 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- withdrawn,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.

INTRODUCTION

The IEC SRD 62913 series has been broken down into domains so as to provide a neutral term for document management purposes. Under the general title *Generic smart grid requirements*, the IEC SRD 62913 series consists of the following parts:

- *Part 1: Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach;*
- Part 2 is composed of 5 subparts which refer to the clusters that group several domains:
 - *Part 2-1: Grid related domains* – these include transmission grid management, distribution grid management, microgrids and smart substation automation;
 - *Part 2-2: Market related domain;*
 - *Part 2-3: Resources connected to the grid domains* – these include bulk generation, distributed energy resources, smart home/commercial/industrial/DR-customer energy management, and energy storage;
 - *Part 2-4: Electric transportation related domain;*

IEC SRD 62913 refers to 'clusters' of domains for its different parts so as to provide a neutral term for document management purposes simply because it is necessary to split in several documents the broad scope of smart energy.

The purpose of this document is to define the generic smart grid requirements of resources connected to the grid domains, i.e. distributed energy resources, smart home/commercial/industrial/DR-customer energy management, energy storage, and bulk generation domains, based on the methods and tools developed in IEC SRD 62913-1.

The document for each domain is composed as follows.

- Purpose and scope.
- The business analysis: to address domain's strategic goals and principles regarding its smart grid environment. It also lists business Use Cases and system Use Cases identified, their associated business roles and system roles (actors) and the simplified role model highlighting main interactions between actors.
- Generic smart grid requirements: extracted from Use Cases described in Annex B.
- Annex A lists links between domains, technical committees and gathered materials (existing standardization documents, user stories, Use Cases and functional architectures).
- Annex B includes a complete description of Use Cases per domain based on IEC 62559-2.
- Bibliography.

This document is based on the inputs from domain experts as well as existing materials in a smart grid environment.

GENERIC SMART GRID REQUIREMENTS –

Part 2-3: Resources connected to the grid domains

1 Scope

This part of IEC SRD 62913 initiates and illustrates the IEC's systems approach based on Use Cases and involving the identification of generic smart grid requirements for further standardization work for resources connected to the electric power systems – i.e. distributed energy resources, smart home/commercial/industrial/DR-customer energy management, energy storage, and bulk generation domains – based on the methods and tools developed in IEC SRD 62913-1.

This document captures possible "common and repeated usage" of a smart grid system, under the format of "Uses Cases" with a view to feeding further standardization activities. Use Cases can be described in different ways and can represent competing alternatives. From there, this document derives the common requirements to be considered by these further standardization activities in term of interfaces between actors interacting with the given system.

To this end, Use Case implementations are given for information purposes only. The interface requirements to be considered for later standardization activities are summarized (typically information pieces, communication services and specific non-functional requirements: performance level, security specification, etc.).

This analysis is based on the business input from domain experts as well as existing material on grid management in a smart grid environment when relevant. Table 1 highlights the domains and business Use Cases described in this document.

Electric vehicles are on one hand considered as a DER and normally should fit in IEC SRD 62913-2-3; but on the other hand, and for historical reasons, they are separated into two documents and covered in the IEC SRD 62913-2-4 electric transportation domain.

The document will be updated as new editions are published. Table 1 highlights the business areas covered in this document.

Table 1 – Content of IEC SRD 62913-2-3:2019

Domain	Content	Scope described
Distributed energy resources	Identified with 41 business Use Cases and 36 system Use Cases	Operation and monitoring of a DER
Smart home/commercial/industrial/DR-customer energy management	Described with 8 business Use Cases and 14 system Use Cases	Smart home, smart building, multi-building complexes
Energy storage	Described with 2 business Use Cases	EES services for grid users and system operators
Bulk generation	n/a	n/a

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

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

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

3.1.1

ancillary services

services necessary for the operation of an electric power system provided by the system operator and/or by power system users

Note 1 to entry: System ancillary services may include the participation in frequency regulation, reactive power regulation, active power reservation, etc.

[SOURCE: IEC 60050-617:2009, 617-03-09]

3.1.2

automated control

aggregate of operations aimed at sustaining or/and improving the functioning of a controlled object without direct human participation and in accordance with a prescribed control objective

EXAMPLE Automatic response to signals such as dynamic peak period notifications, price period changes or flexibility requests.

Note 1 to entry: The automated control is configured and tuned by the client/resident and the client/resident can override it if needed.

3.1.3

capacity firming

method that uses storage to control the ramp rate (MW/min), smooth and mitigate rapid output changes from renewable generation due to different natural parameters such as wind speed variability affecting wind generation or shading of solar generation due to clouds

Note 1 to entry: It is important because these rapid output changes must be offset by other "dispatchable" generation.

[SOURCE: DOE Global energy storage database, Glossary]

3.1.4

congestion

<electric power system> situation in a transmission or distribution network requiring, in parts of an electric power system, a limitation of load flow

[SOURCE: IEC 60050-617:2009, 617-03-04]

3.1.5

congestion mitigation

set of one or more actions set up to avoid grid congestions by means such as by increasing the transfer capacity of the grid, by curtailing demand connected to the grid or by curtailing generation units

Note 1 to entry: Congestion in transmission and distribution grids refers to a situation in which the demand for power transfer exceeds the transfer capability of a grid.

3.1.6**dispatchable generation source**

source of electricity that can be dispatched at the request of power grid operators or of the plant owner

Note 1 to entry: That is, generating plants that can be turned on or off, or can adjust their power output according to an order.

3.1.7**flexible load**

load of consumers (in kW) which can be reduced or increased for a limited period of time at the request of an external actor according to contractual arrangements

Note 1 to entry: The control is automatic and based on technology or devices operated remotely due to the volume of consumers participating – such as residential consumers.

Note 2 to entry: The control may target specific appliances, such as space-heaters for instance.

3.1.8**distributed energy resource****DER**

distributed set of one or more energy service resources, including generators, energy storage, controllable load and ancillary services

3.1.9**dynamic peak period****DPP**

superseding calendar which replaces the initial price schedule during a short period of time when facing a peak demand

3.1.10**electric power system****EPS**

network of electrical components deployed to supply and transfer electric power to a load

Note 1 to entry: The EPS may include generation units.

3.1.11**electrical energy storage****EES**

process which consists in using various forms of energy such as mechanical, chemical, electrochemical, electrical, or thermal energy to store energy that will later be converted to electricity

Note 1 to entry: This domain report covers any type of EES which can charge electricity to and discharge electricity from any source.

3.1.12**electrical energy storage management**

collection of methods used to manage EES with software, hardware, and services associated with the intelligent monitoring, management, and control of EES, for the specific purposes such as the enhancement of a system's efficiency, cost reduction or optimization of energy utilization to meet EES users' needs

3.1.13**electrical connection point****ECP**

point of electrical connection between the DER source or sink of energy and any EPS

Note 1 to entry: Each DER unit has an ECP connecting it to its local power system; groups of DER units have an ECP where they interconnect to the power system at a specific site or plant; a group of DER units plus local loads have an ECP where they are interconnected to the utility power system.

Note 2 to entry: For those ECPs between a utility EPS and a plant or site EPS, this point is identical to the point of common coupling (PCC) in IEEE Std 1547, *Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*.

3.1.14

electricity data

electricity-related data, either generation or consumption, coming from the electricity meter or from electrical devices

3.1.15

energy meter

instrument intended to measure electrical energy by integrating power with respect to time

[SOURCE: IEC 60050-313:2001, 313-01-35]

3.1.16

energy shifting

principle of shifting the timing of energy use by, for example, charging electricity during off-peak time and by discharging it during peak hours to reduce the cost to purchase electricity

3.1.17

flexibility

modification of electricity injection and/or extraction, on an individual or aggregated level, in reaction to an external signal in order to provide a service within the energy system

Note 1 to entry: Definition based on EURELECTRIC, Active Distribution System Management. A key tool for the smooth integration of Distributed Generation, 2013]

3.1.18

frequency regulation

ability of a balancing authority to help the interconnection maintain scheduled frequency

Note 1 to entry: This assistance can include both turbine governor response and automatic generation control.

3.1.19

grid stabilization

process requisite to stabilize power transmission and distribution networks with the operation of power plants

Note 1 to entry: Grid stabilization can be achieved, for example, by stabilizing the frequency of electric power produced on an island and by stabilizing voltage at the end of a long transmission line.

3.1.20

historian

software service which accumulates time-stamped data, events and alarms in a database which can be queried or used for further actions

3.1.21

home area network

HAN

in-house local area network which interconnects domestic equipment and can be used for energy management purposes

[SOURCE: CEN/CLC/ETSI TR 50572:2011]

Note 1 to entry: There can be multiple HANs inside a customer's premises.

3.1.22

islanding

process whereby a power system is split into two or more islands

[SOURCE: IEC 60050-603:1986, 603-04-31]

Note 1 to entry: Islanding is either a deliberate emergency measure, or the result of automatic protection or control action, or the result of human error.

Note 2 to entry: In this document, islanding refers to a measure to avoid load shedding in an area by immediately supplying power to the area from EES, and temporarily form an islanding status after the power supply from grids fails due to, for instance, a contingency.

3.1.23

load following

adjusting the output of power generation plants to meet the electricity demands which vary in a particular period

3.1.24

manual control

mode that allows clients or residents to directly control their consumptions depending on information provided by the energy market player(s) they have contracted with

Note 1 to entry: Sometimes this manual control mode is the only one available when technology or the electrical devices are not able to respond automatically to dynamic peak period notifications, price period changes or flexible requests.

3.1.25

operating reserves

all resources, generation or consumption, available to the system operator within a short interval of time to provide for frequency regulation or balancing purposes

Note 1 to entry: Operating reserves consist of spinning reserve, the increasing power output of generators that are already connected to the power grids, and non-spinning reserve, the extra generating capacity that is not currently connected to the system but can be brought online after a short delay.

[SOURCE: ENTSO-E: System operation guideline]

3.1.26

peak shaving

process needed to reduce peak demand by storing energy when demand is low and releasing energy when demand is high to level out electricity load throughout the day

3.1.27

price-based management

management method based on the fact that in order to modulate clients' consumptions during a day, a week or a peak period, the electricity supplier can offer temporarily higher electricity prices in order to tempt clients to erase or postpone the use of some of their electric devices

Note 1 to entry: Price-based control therefore combines variable electricity prices and the sending of price incentives to clients for them to be able to control manually or automatically the use of their electric devices.

3.1.28

quality of service

collective effect of service performance which determines the degree of satisfaction of a user of the service

Note 1 to entry: The quality of service is characterized by the combined aspects of service support performance, service operability performance, severability performance, service integrity and other factors specific to each service.

[SOURCE: IEC 60050-191:1990/AMD1:1999, 191-19-01]

3.1.29

remote customer information

RCI

data and signals communicated toward the smart home through the internal smart metering gateway

Note 1 to entry: This data can be tariff signals, flexibility requests or technical data.

3.1.30

security

<of an electric power system> ability of an electric power system to operate in such a way that credible events do not give rise to loss of load, stresses of system components beyond their ratings, bus voltages or system frequency outside tolerances, instability, voltage collapse, or cascading

[SOURCE: IEC 60050-191:1999, 191-21-03]

Note 1 to entry: In the context of smart grid the term 'security' may be too vague. In this document, it may be replaced by 'operational reliability' or 'operational security' to reflect the real practices of, for example, NERC or ENTSO-E.

3.1.31

self-consumption

act of consuming energy which is produced by a power generation system installed at the consumption site

3.1.32

smart home

house or apartment equipped with a communicating (electricity, telecoms) and structured home area network (HAN)

Note 1 to entry: Clients or residents are able to remotely control and/or programme home electrical devices by activating or enabling and/or disabling internal controls and/or external events (excluding emergency signals). Then, smart home devices can adapt their operations without any resident intervention.

3.1.33

smart home flexibility

ability of a smart home to adjust up or down its consumption or generation depending on signals in order to modify the load curve

3.1.34

smart site

site equipped with a communicating (electricity, telecoms) and structured home area network (HAN)

Note 1 to entry: Clients, residents or operations staff are able to remotely control and/or programme home electrical devices by activating or enabling and/or disabling internal controls and/or external events (excluding emergency signals). Then, smart home devices can adapt their operations without any resident intervention.

3.1.35

traffic light concept

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), and which evaluates the grid status (red, yellow, green) and provides the information towards the relevant market roles

3.1.36

virtual power plant

collection of small and very small decentralized generation units that is monitored and controlled by a super-ordinated energy management system

[SOURCE: IEC smart grid Standardization Roadmap, 2010]

3.1.37

virtual resource

set of one or more energy service resources, including generators, energy storage, controllable load, and ancillary services

3.1.38

voltage support

ability to cope with the effects on grid voltage profiles when, for example, heavy power flows occur, to allow more installed photovoltaic capacity, while meeting the power quality requirements without grid reinforcement and power curtailment

3.1.39

wide area network

WAN

network that provides communication services to a geographic area larger than a single urban area

Note 1 to entry: Typically a wide area network covers a single country.

[SOURCE: IEC 60050-732:2010, 732-01-07]

3.2 Abbreviated terms

AMI	advanced metering infrastructure
CHP	combined heat and power
EES	electric energy storage
EHV	extremely high voltage
EPS	electric power system
ESP	electric services provider
ESR	electric services retailer
EV	electric vehicle
DER	distributed energy resource
DMS	distribution management system
DR	demand-response
DSO	distribution system operator
FDEMS	facility DER energy management system
FCR	frequency control reserve
FRR	frequency restoration reserve
HAN	home area network
HV	high voltage
HVDC	high voltage direct current
ICT	information and communication technologies
ISO	independent system operator
LAN	local area network
LV	low voltage
MV	medium voltage
PV	photovoltaic systems
RR	restoration reserve

RTO	regional transmission organizations
SCADA	supervisory control and data acquisition system
SGAM	smart grid architecture model
TSO	transmission system operator
WAN	wide area network

4 Distributed energy resources

4.1 Purpose and scope

4.1.1 Purpose: business analysis of DERs

The purpose of Clause 4 is to address a business analysis of distributed energy resources (DERs), and further describe the requirements of the domain in smart grid through the Use Case approach defined in IEC SRD 62913-1.

This analysis is based on the inputs from domain experts as well as existing materials in a smart grid environment. It is understood that different countries and regions in the world may have different regulatory and market structures for DERs, and these differences can even be within countries. Therefore the use cases contained in this document may or may not apply to all regions. However, DER regulations and markets are rapidly evolving so that even if certain use cases are not currently applicable to a particular region, this may change in the near future. Therefore, no attempt has been made to correlate specific use cases with specific regions.

4.1.2 Scope: DERs as sources of generation

DERs can be defined as a distributed set of one or more energy service resources, including generators, energy storage and controllable load, that are connected at the medium or low voltage levels (distribution power system). Some DERs are considered as sources of renewable energy, while others are fossil fuel based, or a combination of different types. They may provide energy as well as ancillary services.

Some typical types of DER include:

- battery based energy storage systems;
- biomass plants;
- combined heat and power (CHPs);
- cold storage and heat accumulation;
- electric vehicles (EVs) and their chargers: electric vehicle service elements (EVSE);
- fuel cells;
- gas turbines;
- geothermic power plants;
- hydro plants;
- photovoltaic systems (PV) and PV plants;
- pumped water storage systems;
- PV plus battery storage;
- tidal energy;
- wind turbines and wind power plants;
- wood chip boilers.

Because the scope of Clause 4 only includes generation, only the generation capabilities of DERs are discussed. DER generation can be defined as "the production of electric energy by multiple sources which are connected to the power distribution system". The terms commonly used for DER generation include on-site generation, distributed resources (DR), embedded generation, dispersed generation (DG), or dispersed power (DP).

All aspects of energy storage and batteries are out of the scope of Clause 4, as they are covered in the energy storage domain, although it is understood that both electric vehicles (EV) and electric energy storage (EES) can also sometimes provide distributed generation.

Installation rules are out of the scope of this document, as they are covered in the HV/LV installation domains in IEC SRD 62913-2-1.

DERs are a type of resource connected to the grid. Their main purposes are to provide a source of active power and energy-related services – depending on legal and/or regulatory framework. In many cases, DERs are not connected directly to the grid but are part of prosumers' or consumers' installations, thus providing services "behind the meter" as well as to the utility grid. However, some DERs are connected within plants which have the express purpose of providing energy and ancillary services to the grid.

The DERs domain is strongly related to the following domains.

- Transmission grid management: DERs may provide (or even be required to provide in some systems) ancillary services to system operators to contribute to system security (reactive power and voltage control, load following, etc.).
- Distribution grid management: DERs connection to the grid and operations shall respect specific (legal and/or regulatory) technical requirements, so they do not undermine the reliability of the grid and quality of supply, ensured by grid operators.
- Metering management: DERs will use meters and metering services to measure and optimize use of the exported energy or associated services (certification).
- Market: DERs may (or are required to) participate in electricity markets, by trading the energy produced and/or energy-related services.

4.2 Business analysis of DER systems

4.2.1 Benefits and challenges of grid-connected DER systems

4.2.1.1 General

DER systems are providing many benefits as well as many challenges to the electric energy domain. Many countries and regions are promoting the development and support of DERs in general, and renewable energy sources in particular, with the goals of achieving a transition towards a free-carbon economy and guaranteeing a competitive energy market, while continuing to ensure the security and efficiency of supply. There is an expectation that renewable energy will eventually be able to provide 60 % to 80 % of all electric generation around the world, with a large portion of that renewable energy coming from distribution-connected DER systems and DER power plants.

4.2.1.2 Impacts of DERs on the grid

However, the increased penetration of DERs onto the grid, with the connection of many small-scale and even larger-scale power generation sources to low and medium voltage networks, is leading to new operational challenges for grid management. In particular, system and grid operators will need to assess DER interconnection requirements, to monitor the variable and uncertain renewable output of these large numbers of DERs, and to initiate control actions either through market-based requests or direct commands.

In the future, more and more DER systems will be connected to the distribution network and will affect the operation of the grid both positively and negatively. Distribution operators have

to embrace DER systems, manage their negative impacts, and take advantage of their capabilities to improve safety, reliability, and efficiency.

4.2.1.3 Regulations related to DERs

Interconnection of new DER systems typically is regulated by country, state, regional, or other regulatory body. In the USA, IEEE Std 1547 is often used as the basis for those regulations, while other countries develop their own interconnection regulations. In Europe, these regulations are defined in the ENTSO-E network code for "requirements for grid connection applicable to all generators" (RfG). In all of these regulations, DSOs are required to assess the impact of new DER systems and require them to provide certain functions such as anti-islanding, voltage ride-through, frequency ride-through and possibly other functions.

The conditions to which electricity produced by DERs can be traded on electricity markets also vary according to the different regulatory and/or legal frameworks. In some countries, renewable energy power purchase obligation mechanisms (feed-in tariffs) have been implemented in order to guarantee a competitive price for renewable energies and encourage investments in renewable energy sources.

In Europe, by law, the responsibility of the safety of the network as well as the stability of frequency is under the responsibility of TSOs. DSOs do not have the mission of maintaining the stability of frequency of their grid themselves: in the European interconnected network, the frequency cannot be different between TSOs and DSOs.

4.2.1.4 Benefits of DERs

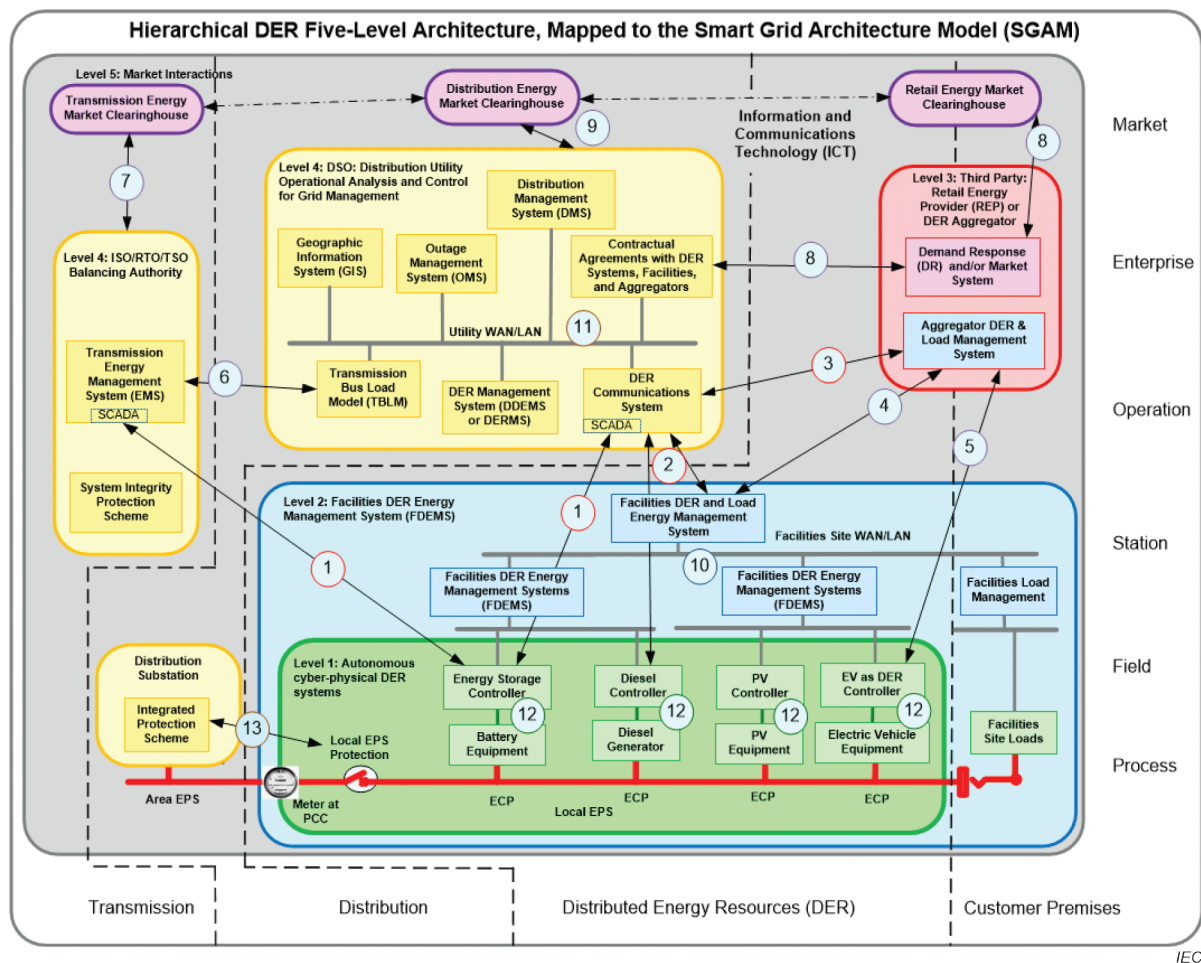
DERs can also provide both energy and ancillary services to the electric power system that benefit power grid operation, consumers, and society.

- DERs are able to help TSOs and DSOs improve the reliability and efficiency of the grid and maintain power quality through their smart converters and through management by facility DER energy management systems.
- DERs can provide consumers with less expensive energy over time even if they are not involved in retail energy markets.
- The integration of DERs involves the optimization of their contribution to the electric power system – through their participation in electricity markets and market mechanisms (balancing, capacity, ancillary services, ...).

Society benefits from the increased use of renewable resources and the consequent decrease in the production of greenhouse warming gases. According to the IEC smart grid standardization roadmap, "the generation of these types of energy near to the consumers offers economic and ecological benefits."

4.2.1.5 Architecture of DER systems

DER systems are expected to be managed through a hierarchy of stakeholders and systems. An example of a five-level hierarchy is shown in Figure 1. The diagram is described in A.1.3.



NOTE An explanation of this figure is given in A.1.3.

Figure 1 – Example of a hierarchical DER system five-level architecture

Most DER systems can or must operate autonomously in order to respond rapidly to changing power system conditions and meet power system safety, reliability, and efficiency criteria. At the local level, DER systems must manage their own generation and storage activities autonomously, based on local conditions, pre-established settings, and DER owner preferences. However, communications with utilities, facility energy management systems, and/or retail energy providers can support additional functions and provide updated functional parameters, so that the DERs can participate more effectively in the management of the area EPS. But direct control by utilities is not feasible for the thousands if not millions of DER systems connected to the distribution system, so a hierarchical approach is necessary for utilities to interact with most of these widely dispersed DER systems.

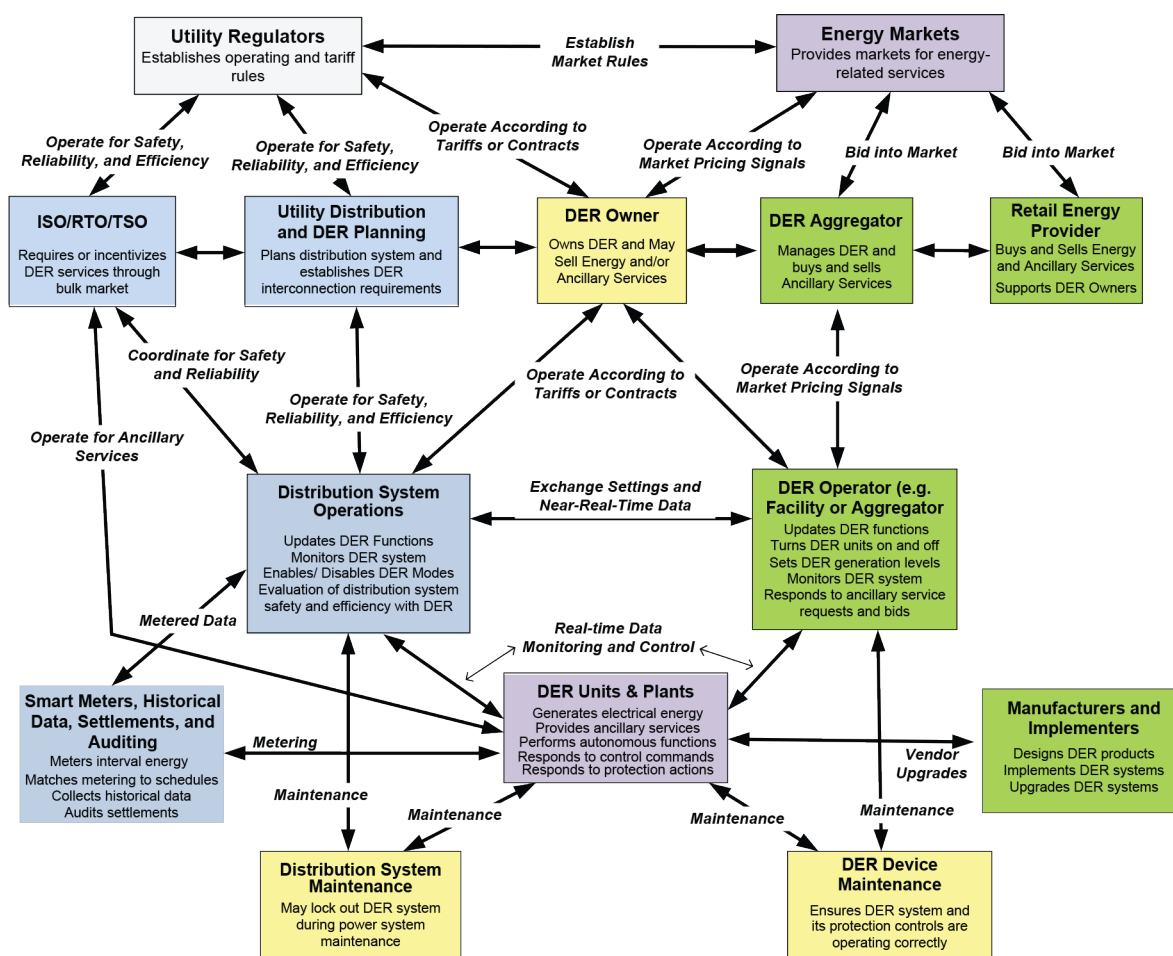
In some situations, depending on regional options and regulations, utilities may request or require DER systems to be located at critical electrically important points, while utility assessments of new DER implementations may determine which DER functions could be preferred or even mandatory for providing grid support. For any DER systems to be active participants in grid operations, their operations must be coordinated with other DER systems and with distribution grid equipment such as load tap changers, capacitor banks, and voltage regulators.

Many commercial and industrial customer sites would likely include facility DER energy management systems (FDEMSs) that could modify DER autonomous settings and issue direct commands. The area EPS operators could interact with these FDEMSs occasionally to update settings or broadcast pricing signals and/or emergency commands. In addition, the distribution-level area EPS operators could provide some of the DER benefits to regional transmission organizations (RTOs) and/or independent system operators (ISOs) for reliability

and market purposes. In some regions, retail energy providers (REPs) or other energy service providers (ESPs) would be responsible for managing groups of DER systems.

4.2.2 Stakeholders involved in the DER domain

DER systems involve many different stakeholders, each of which has different business cases. Some of the DER Use Cases benefit just one stakeholder, but in most situations, many of the DER Use Cases can benefit multiple stakeholders often through tariff agreements or market pricing that balance the compensations across these stakeholders. Some of the primary stakeholders are shown in Figure 2.



IEC

Figure 2 – DER primary stakeholders

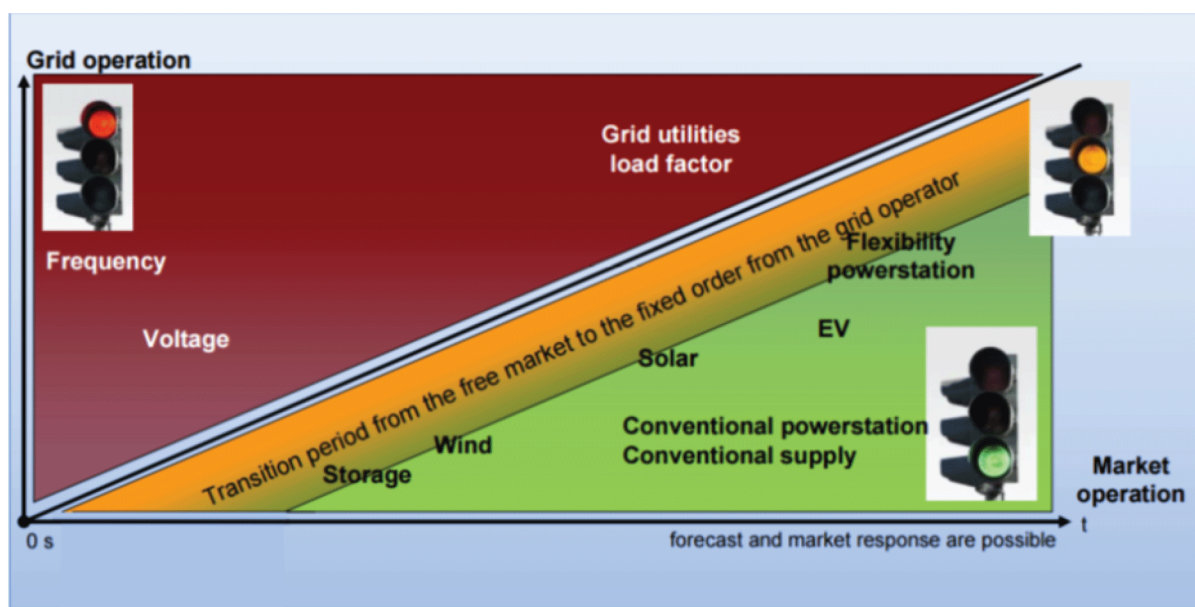
The list of primary stakeholders should also include the following:

- consumers;
- market-based third parties, such as flexibility aggregators;
- system maintenance personnel;
- society.

4.2.3 Traffic light concept for DERs

The traffic light concept for DERs identifies when markets should operate as the primary grid management force and when system operators must take over grid management in order to maintain grid safety and reliability (see Figure 3).

- The green state defines the region where the 'smart market' competitively operates freely; the system operator may or may not interact with the market at this point. This should be seen as the 'normal operating state'.
- The yellow state indicates the state where the system operator 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 decides when they can use what is in their home or business premises. Instead intelligent solutions and economic incentives should be provided to allow the customer to decide and accept some limits.
- In the red state, the system operator can override contracts existing in the market, execute dedicated emergency actions through flexibility operators, or execute direct controls over generation or demand in order to re-stabilize the system as far as a contract or regulation/legislation allows. However, actions in this state must be specific and well defined and be temporary in nature.



IEC

SOURCE: SG-CG/M490/Methodology & New Applications, Annex B.

Figure 3 – Traffic light concept

In the green and yellow states, DER owner/operators may respond to market signals, such as price incentives or demand response requests, according to established contracts between the DER owner and market actors. They would in this case have the possibility to opt out.

In the red state, DER operators may receive emergency signals from the system operator and would in this case have to prioritize electrical usages in order to temporarily reduce their consumption/generation – they would not have the possibility to opt out in this case.

4.2.4 Business drivers and objectives of DER stakeholders

4.2.4.1 General

As illustrated in Figure 4, DER stakeholders are driven by economic requirements, and are constrained by regulatory and environmental policies. In some cases, mission statements are used to outline the key interests of the stakeholders.

Business objectives, reflected in business cases, identify the key purposes that must be met in order to follow the policies and resulting constraints. From these business cases, more

detailed business use cases can be developed that reflect the business processes. Finally, system use cases can be developed to identify specific requirements and functionalities.

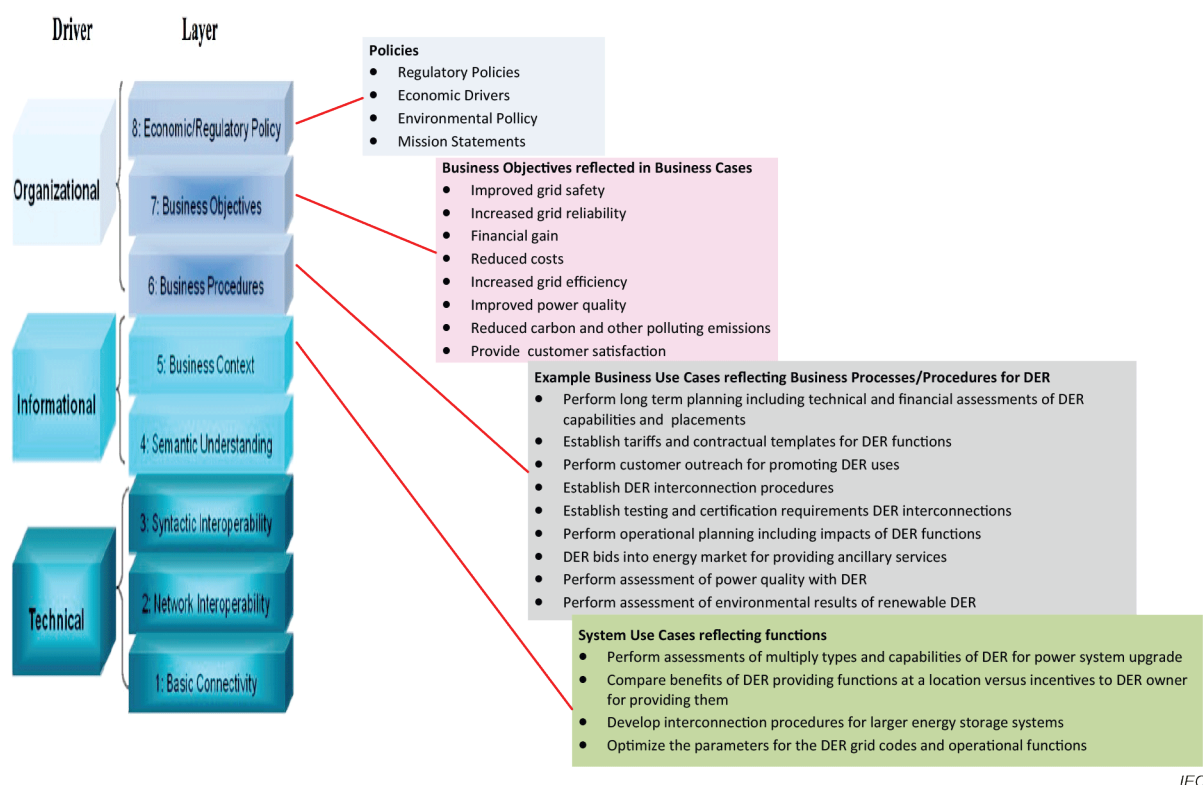


Figure 4 – Business policies, business objectives, business processes, and system use cases

4.2.4.2 Business objectives

For DERs, the primary business objectives of the stakeholders include:

- financial gain;
- reduced energy costs;
- improved grid safety;
- increased grid reliability;
- increased grid efficiency;
- improved power quality;
- reduced carbon or other pollutant emissions.

The matrix of stakeholders versus their primary business purposes is shown in Table 2.

Table 2 – Matrix of stakeholders versus their primary business purposes

Stakeholders	Improved grid safety	Increased grid reliability	Financial gain	Reduced energy costs	Increased grid efficiency	Improved power quality	Reduced emissions
DER owner		X (microgrid)	X	X		X	

Stakeholders	Improved grid safety	Increased grid reliability	Financial gain	Reduced energy costs	Increased grid efficiency	Improved power quality	Reduced emissions
DER operator including facility operators or third party operators				X		X	
Transmission system operator	X	X		X	X	X	X
Distribution system operator	X	X		X	X	X	X (if incentivized)
Market-based third parties, such as flexibility aggregators			X				X (if incentivized)
DER manufacturers			X				
DER implementers			X				
Metering, settlements, and auditing parties							
Distribution system maintenance personnel	X						
DER maintenance personnel	X						
Consumers		X		X		X	
Society	X			X			X

Although Table 2 indicates the types of business objectives that different stakeholders may have, the methods for achieving these business objectives can involve many of the different DER capabilities at different levels in the hierarchy of DER system management. There is no one-to-one correspondence, but rather a mixture and a balancing of purposes. For instance, the DER owner may be looking for reduced energy costs while the DSO is looking for improved reliability – these may need to be balanced against each other with appropriate incentives if, say, the increased use of DER by an owner may cause voltage power quality problems.

4.2.5 DER grid services

4.2.5.1 Overview of DER grid services

DERs are able to provide many services to the grid. Some of these services are (or are becoming) mandatory in some jurisdictions, and are termed "grid codes". These grid codes are focused on improving grid safety, grid reliability, and grid power quality, although some may have additional purposes. Other DER services are focused more on providing financial, reliability, and/or power quality benefits to their owners. Table 3 outlines the types of grid services that DERs may provide.

Table 3 – Types of DER services

DER services	Business objective
DER grid codes mandated by regulations	
Disconnect / connect function	Improved grid safety
Cease to energize / return to service function	Improved grid safety and reliability
High/low voltage ride-through (fault ride-through) mode	Improved grid reliability
High/low frequency ride-through mode	Improved grid reliability
Dynamic reactive current support mode	Improved grid reliability
Frequency watt mode (frequency sensitivity mode)	Improved grid reliability
Volt-watt mode	Improved grid reliability Improved power quality
Fixed (constant) power factor mode	Improved grid reliability
Fixed (constant) reactive power mode	Improved grid reliability
Volt-var mode	Improved grid reliability Improved power quality
Watt-var mode	Improved grid reliability Improved power quality
Watt-PF mode	Improved grid reliability Improved power quality
Active power limiting mode	Improved grid reliability
Active power setting mode	Improved grid reliability Improved power quality
Low frequency-watt emergency mode for demand side management (fast load shedding)	Improved grid reliability
Low voltage-watt emergency mode for demand side management	Improved grid reliability
Monitoring key status, alarm, and measurement values: in real-time (seconds), in near-real-time (minutes), as revenue metering, and as forecasts for next minutes, hours, and/or days Provide forecast information on weather, planned maintenance, changes in capacities, etc.	Improved grid reliability Improved power quality Reduced energy costs Increased energy efficiency Reduced pollution emissions Metering and billing
Scheduling of power settings and modes	Improved grid reliability Improved power quality Reduced energy costs Increased energy efficiency Reduced pollution emissions
DER grid services for DER owner benefit	
Peak power limiting mode	Reduced energy costs
Load following mode	Reduced energy costs
Coordinated charge/discharge management mode	Reduced energy costs
Generation following mode	Financial gain
Active power smoothing mode	Financial gain
Frequency-watt primary frequency mode	Financial gain
Automatic generation control (AGC) mode	Financial gain
Frequency-watt smoothing mode	Financial gain

DER services	Business objective
Power factor limiting (correcting) mode	Financial gain
Tertiary frequency (operating or spinning reserve)	Financial gain
Microgrid separation control (intentional islanding)	Improved reliability
Provide black start capability	Financial gain
Provide backup power	Improved reliability
Historical Information	Improved reliability, efficiency, power quality Reduced emissions Metering and billing
DER grid services provided by system operators	
Maintain DER nameplate database in DER database and management systems (DERMS)	Improved reliability and safety
Update DER capabilities database	Improved reliability and safety
Perform short term load and generation forecasting	Improved reliability and safety
Perform state estimation of transmission and distribution grids	Improved reliability and safety
Perform power flow analysis of grids	Improved reliability and safety
Perform contingency analysis of grids	Improved reliability and safety
Evaluate possible ameliorations to contingencies	Improved reliability and safety
Determine settings for groups and individual DERs to reflect near-term requirements	Improved reliability and safety
Issue schedules and/or commands to DERs to comply with near-term requirements	Improved reliability and safety
Determine day ahead and next hour electricity prices	Improved reliability and safety
Provide to DERs the electricity prices, including energy, ancillary services, locational, etc.	Improved reliability and safety
Monitor the grid in real-time	Improved reliability and safety
Issue any emergency updates to DER settings	Improved reliability and safety

4.2.5.2 DER functions providing grid services

DER systems are capable of providing many functions that support power system operations and contribute to grid benefits. Many of these inverter-based functions are described in IEC TR 61850-90-7 and are being updated in the second edition of IEC 61850-7-420¹.

Certain of these DER functions are crucial for grids that have high penetrations of DER systems. The implementation of these critical DER functions can avoid power systems outages and the possible need to retrofit DER systems during the course of their useful life or their contractual period, as unfortunately occurred in Europe. Some of those critical DER functions have already been implemented in Europe, are included in many DER products, are mandatory in California, and are expected to become mandatory for grid operations in North America.

Most DER systems can or must operate autonomously in order to respond rapidly to changing power system conditions and meet power system safety, reliability, and efficiency criteria. At the local level, DER systems must manage their own generation activities autonomously, based on local conditions, pre-established settings, and DER owner preferences. However, communications with utilities, facility energy management systems, and/or market-based retail energy providers can support additional functions and provide updated functional parameters,

¹ Under preparation. Stage at the time of publication: IEC CD 61850-7-420:2018.

so that the DRs can participate more effectively in the management of the area EPS. On the other hand, direct control by utilities is not feasible for the thousands if not millions of DER systems connected to the distribution system, so a hierarchical approach is necessary for utilities to interact with most of these widely dispersed DER systems through facility energy management systems and through retail energy providers/aggregators.

In some situations, utilities may request or require DER systems to be located at critical electrically important points, while utility assessments of new DER implementations may determine which DER functions could be preferred or even mandatory for providing grid support. For any DER systems to be active participants in grid operations, their operations must be coordinated with other DER systems and with distribution grid equipment such as load tap changers, capacitor banks, and voltage regulators.

Many commercial and industrial customer sites would likely include facility DER energy management systems (FDEMSs) that could modify DER autonomous settings and issue direct commands. The area EPS operators could interact with these FDEMSs occasionally to update settings or broadcast pricing signals and/or emergency commands. In addition, the distribution-level area EPS operators could provide some of the DER benefits to regional transmission organizations (RTOs) and/or independent system operators (ISOs) for reliability and market purposes. In some regions, aggregators or other energy service providers (ESPs) would be responsible for managing groups of DER systems.

4.2.5.3 Balancing and frequency services

4.2.5.3.1 Balancing purpose

Balancing authorities are responsible for ensuring that generation and load balance each other at all times. The primary measure of whether they are balanced is the frequency of the power system. This frequency must stay within a "normal" range of its nominal value (50 Hz or 60 Hz) and must avoid any lengthy (a few minutes) excursions outside of this normal range as well as any very high or low (exceeding nominal by more than 2 Hz to 3 Hz) excursions.

4.2.5.3.2 Frequency ride-through

As more DERs connect to the grid, it is increasingly important that they are capable of autonomously "riding-through" short frequency anomalies, and do not trip off unless the frequency exceeds its normal range for long times and/or spikes or sags steeply for shorter periods of time. DER systems can ride-through such situations, including ceasing to energize without tripping off, and recovering within a short time after the frequency returns within its normal range.

During a ride-through event, DERs may also attempt to counteract the frequency anomaly by increasing power output if the frequency has decreased, or by decreasing power output if the frequency has increased. This DER function is called frequency-watt, frequency-sensitivity, or frequency droop.

In addition, loads could be shed, either locally or on a larger area if commanded by the system operator.

4.2.5.3.3 Frequency regulation

One of the primary responsibilities of balancing authority is to maintain the power quality of electricity supply. By constantly matching power generation to demand in a power system, the grid frequency can be maintained within ranges as regulated by authorities. Grid-integrated DERs can be used for frequency regulation. This can be handled through enabling DERs to change their power output to counter frequency changes even while the frequency is within its normal range. Alternatively, the balancing authority can directly issue commands for more or less energy from DERs. In this latter case, DERs are typically aggregated into multi-megawatt groups, either in the form of DER power plants or through an aggregator who is managing dispersed DERs as a group.

4.2.5.3.4 Operating reserves

Operation of electricity grids always needs a certain amount of power capacity which can be available in a short time after power generation plants become unavailable due to unplanned maintenance or troubles. Reserve power can be in the form of either generation or demand reduction to be able to deal with power demand being greater than forecast demand and/or plant unavailability. DER can be one of the sources for the operating reserves.

There are generally three types of operating reserves as follows:

- Spinning (operational) reserve (synchronized) – Spinning reserves are the fastest acting contingency reserve. Generators providing spinning reserves are synchronized to the grid (the turbine is "spinning" but not generating power), allowing the reserve to be provided very quickly. Energy storage systems are particularly suited to provide such operational reserve since their main purpose is not necessarily generation, but rather ancillary services. Since they can be continuously connected to the grid even if charging, they can respond very quickly to a request from the balancing authority.
- Non-spinning reserve (non-synchronized) – Non-spinning reserves are extra generating capacity that is not currently connected to the power system but can be brought online after a short delay.
- Supplemental reserves – Supplemental reserves, on the other hand, are not required to be synchronized to the grid and are a backup capacity for spinning and non-spinning reserves.

4.2.5.3.5 Black start capabilities

Many facilities with critical loads use DERs to provide power in case of power grid outages. These DERs are typically uninterruptible power supply systems which combine batteries for instantaneous power with diesel generators for longer duration power outages.

Black start capabilities are necessary to restore power to grids after a wide-area outage where the bulk power supply from the grid is not available. Diesel generators or hydroelectric power plants that are capable of supplying load beyond their own facilities may become designated as black start resources.

DER systems, particularly if they are part of microgrids, can be another source of black start capabilities, and help system operators during a catastrophic failure of grids by restoring their power.

4.2.5.4 Power grid voltage infrastructure services

4.2.5.4.1 Voltage ride-through

Both transmission systems and distribution systems may experience voltage anomalies. Just as for frequency anomalies, it is critical that DERs do not trip off for short duration voltage sags and spikes, but are able to "ride-through" these events. Whenever DERs sense the voltage is beyond the voltage limits, they can cease to energize without tripping off, and recover within a short time after the voltage returns within its normal range.

During a ride-through event, DERs may also attempt to counteract the voltage anomaly by increasing power output if the voltage has decreased, or by decreasing power output if the voltage has increased. This DER function is called the volt-watt function.

In addition, loads could be shed either locally or on a larger area if commanded by the system operator.

4.2.5.4.2 Voltage support

System operators are required to maintain the voltage of both the transmission and distribution systems within specified ranges. To do this, the operators manage active and

reactive power to maintain normal voltage levels, typically with utility-owned equipment. However, DERs can also be used as voltage support resources within the grid through being set at a fixed power factor, by providing autonomous volt-var support or through responding to direct requests from the system operators for specific levels of active or reactive power.

Variations of these autonomous functions include the watt-power-factor function and the watt-reactive power function. In addition, DERs can provide autonomous volt-watt support if the volt-var function is producing excessive reactive power. DERs may also respond to power limiting commands in order to reduce local voltage levels.

4.2.5.5 Energy management services

4.2.5.5.1 Energy shifting

The true and market cost of energy can vary significantly during the hour, the day, the week, and the season. For some DER owners, the cost to purchase electricity from the wholesale electricity markets can be reduced by increasing their DER generation (or decreasing load) during high cost times. In particular, energy storage systems can increase their power output to compensate for loads. Utilities also use energy storage systems, including pumped hydro and battery storage units within substations. The primary purpose of these energy storage systems is to shift energy from peak times to lower cost times. These energy storage systems are then recharged during off-peak times.

As with all of the energy management services, energy shifting may provide a large benefit to utilities by allowing them to defer construction, such as avoiding the need to build additional substations, upgrade transformers, and increase the carrying capacity of wires.

4.2.5.5.2 Peak shaving

Peak shaving is similar in concept to energy shifting, except that it is focused on the time of a customer's demand peak, which may or may not coincide with the cost of energy at that time. For instance, the utility tariffs may not include time-of-use (a very common practice for residential customers). Therefore, there is no incentive for these customers to shift energy. However, some tariffs for larger customers include demand charges, which provide an incentive to minimize demand at specific times of day, thus "shave the demand peak", particularly if their energy bills vary according to their highest power demand. This service may be profitable if the peak demand is predictable and of relatively short duration.

As with energy shifting, peak shaving not only allows time shift of energy but also works to reduce the necessity of installing additional facilities. DER can be used to reduce the need to construct power generation plants, mainly oil-fired thermal power, which produce a large amount of carbon dioxide, to meet weekday peak demands.

4.2.5.5.3 Load and/or generation following

Load following involves an entity matching (or following a percentage of) the generation and loads by ramping up or down of generation to follow load changes throughout a day. For local loads, DER can be used effectively to carry out this load following function.

DERs can also provide generation following services. For instance, if a solar power plant produces fluctuating power due to clouds, energy storage systems can follow the dips in generation and provide compensating energy during those dips.

Combinations of solar and storage systems are becoming increasingly popular even for residential and commercial customers. In these systems, the storage systems can compensate for any solar dips due to clouds and thus provide maximum export of any excess power during the day, or conversely, provide more power during the early morning and later afternoon as the sun is rising and setting.

4.2.5.6 Customer energy management services

4.2.5.6.1 Improve grid power quality

Power quality at customer sites can be improved by compensating for electrical anomalies and disturbances such as voltage sag, unstable voltage, frequency variations, and sub-synchronous resonance. DER may be used for such power quality support. In particular, for islanded grids (either natural islands or artificial microgrids), DER responses to power quality issues become even more important since the power system inertia is relatively low. Some types of DER systems, such as biomass DER and hydro DER or even diesel generators, could become important resources to mitigate the instability caused by the variability of renewable DER systems.

4.2.5.6.2 Islanding or microgrids

Electricity supply can be maintained within a local island or microgrid even if there is a total loss of power from a power grid due to wide area outage. This service can be delivered with DERs which can continuously supply electricity to customer loads within an islanded grid.

System operators could minimize the influences of wide-area power outages by warning customers with pre-established islanding capability of the likelihood of an outage. In addition, microgrid energy management systems could detect anomalous situations and initiate the creation of an island.

4.2.6 Regional differences

Different regulatory jurisdictions are expected to require different grid services, while DER owners will also have very different purposes for their DERs. For this reason, flexibility is crucial. In some cases this flexibility will just reflect different values in a function (e.g. 10 % vs. 5 %) while in other cases the same function may be used for different purposes (e.g. emergency frequency-watt vs. frequency-watt smoothing).

Tariffs, individual contracts, and market structures in different regions will also differentiate how different grid services may be performed and validated. For instance, if smart meters are not available or capable of capturing and/or measuring DER actions, then separate systems must be used to verify if the DERs are performing the indicated grid services. These systems may be managed by utilities, by flexibility market entities, or by multiple third parties such as aggregators.

4.2.7 List of business roles and business Use Cases of the domain

The primary policies that drive the business objectives are:

- regulatory for power grid safety and reliability, and for utility tariffs;
- economic for tariffs, contracts, and market structures for providing energy and ancillary services.

The business Use Cases shown in Table 4 are associated with one or several of the business objectives of the domain, which include:

- sell energy to an aggregator/to the market/to a customer;
- provide ancillary services to system or grid operators;
- provide flexibility in managing energy production through contractual arrangements;
- operate and maintain the DER in a cost-efficient way.

These business Use Cases include the business roles that have been identified so far. This list is not exhaustive.

Table 4 – Business roles

Business roles	Definition
Energy generation roles	
DER owner	Responsible party for overall market and financial decisions and contracts related to DER including microgrid design and operations
DER operator	Responsible party for operational aspects of the facilities and their DER systems including real-time microgrid operations
Flexibility aggregator	A party which aggregates flexibilities for its customers. May activate flexibility sites. Equivalent to retail energy provider (REP) in this document.
DER equipment manufacturer	Entity that produces, tests, sells, and implements DER systems
Producer	Party generating electric energy. Additional information: This is a type of grid user. [SOURCE: IEC 60050-617:2009, 617-02-01]
Prosumer	Party both generating and consuming electric energy
Decentralized electricity producer	Electricity producer with generator(s) connected to the distribution grid. Production can be dispatchable and/or non-dispatchable. This is a type of producer.
Power plant operator	Responsible party for operational aspects of a power plant
Power plant owner	Responsible party for market and financial decisions and contracts related to a power plant
Utility roles	
Microgrid operator	Responsible party for operational aspects of a microgrid
Microgrid owner	Responsible party for market and financial decisions and contracts related to a microgrid
Retail energy provider (REP)	Third party managing DER systems based on market information
System operator	A party that operates one or more grids. This term is used when it is not necessary to specify whether distribution or transmission system operator is meant.
Distribution system operator (DSO)	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity distribution network (LV, MV, and potentially HV), the quality of electricity supply (power delivery, voltage, etc.) and for customer access to energy supply retail market through his or her system under regulated conditions. Equivalent to MV/LV system operators.
Transmission system operator (TSO)	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity transmission network (HV), the quality of electricity supply (frequency and voltage), and access to the bulk market system for DER systems capable of participating Equivalent to HV system operators. According to Article 2.4 of the Electricity Directive 2009/72/EC (Directive): "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity". Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area. [SOURCE: EU Commission Task Force for smart grids, EG3]
Balancing authority	Entity responsible for balancing generation and load, using frequency management to achieve this responsibility
Customer roles	
Client/customer (of electricity supplier)	A party connected to the grid that contracts for the ability to consume electricity at a metering point.

Business roles	Definition
Consumer	A party connected to the grid that contracts for the ability to consume electricity at a metering point.
Grid user	A party connected to the grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers. Equivalent to Party Connected to the Grid.
Market services roles	
Service provider or energy service provider	Entity providing electricity-related services (such as energy efficiency or communication services).
Bulk power market or transmission market	Entity providing a market for buying and selling energy and ancillary services to the bulk power system
Distribution market	Entity providing a market for buying and selling energy and ancillary services to the distribution power system In general, this entity does not exist as a "market", but many energy service providers may provide related capabilities.
Demand response market	Entity providing energy prices to consumers and prosumers so that they may change their energy demand based on those prices.
Third party roles	
Meter operator	A party responsible for installing, maintaining, testing, certifying and decommissioning physical meters in compliance with the regulated conditions for contract between ESP and their customers. [SOURCE: ENTSO-E, EFET, and eBIX, 2010]
Metering point administrator	A party responsible for registering the parties linked to the metering points in a metering grid area. The metering point administrator is also responsible for maintaining the Metering Point technical specifications and is responsible for creating and terminating metering points. [SOURCE: ENTSO-E, EFET, and eBIX, 2014]
Telecommunications operator	Entity that offers telecommunications services.
Electricity installer	Entity that installs and maintains smart electric systems for industrial, commercial and residential purposes.
Equipment manufacturer	Entity that produces and sells electrical devices and electricity management devices.

Table 5 outlines the high level business objectives which lead to business cases of the DER domain and examples of their associated business Use Cases to achieve those objectives. The first business objective is primarily regulatory, while the remaining business objectives include a mixture of regulatory and economic purposes.

Table 5 – Business Use Cases

Business cases	Index of the business Use cases	Identified business Use Cases
Improved grid safety and reliability through regulations		
Regulators and system operators establish DER interconnection requirements including mandatory grid code functions	UC62913-2-3-B001	• Develop overall regulatory interconnection requirements for different types, sizes, and capabilities of DER systems, including functional requirements, communication requirements, and performance requirements.
	UC62913-2-3-B002	• Define regional or utility-specific DER interconnection requirements within the overall regulatory requirements.
	UC62913-2-3-B003	• Establish timeframes for DER compliance with new regulations
System operators establish DER	UC62913-2-3-B004	• Define operational settings for different DER sizes, locations, and capabilities

Business cases	Index of the business Use cases	Identified business Use Cases
operational requirements for grid safety and reliability	UC62913-2-3-B005	– Develop communication systems for interacting with DER systems as necessary for grid safety and reliability
DER owners/operators operate the DER per the grid codes for grid safety and reliability	UC62913-2-3-B006	• Implement all mandatory DER grid codes and the necessary communications for interacting between the utility and the DER, its owner, and/or its operator.
	UC62913-2-3-B007	• Deliver the grid services as and when mandated.
Financial gain, reduced energy costs, increased grid efficiency through tariffs and contracts		
Regulators and system operators provide tariffs and/or contracts for energy and ancillary services	UC62913-2-3-B008	• Develop tariffs for all types of energy and ancillary services from different types, locations, and capabilities of DER systems
	UC62913-2-3-B009	• Outline contract requirements for specific types of energy and ancillary services from different types, locations, and capabilities of DER systems
DER owner sells energy to the grid based on energy tariffs	UC62913-2-3-B010	– Invest in DERs to use and to sell excess energy based on the appropriate tariff
	UC62913-2-3-B011	• Optimize the operation of DERs from a technical and economic perspective
Aggregator manages DER systems in order to sell energy to the grid based on contracts	UC62913-2-3-B012	• Develop DER systems for sale or for installation by "renting a roof".
	UC62913-2-3-B013	• Install DERs at customer sites for the purpose of selling excess energy based on a tariff or contract with the system operator
	UC62913-2-3-B014	– Optimize the operation of DERs from a technical and economic perspective
Financial gain, increased grid reliability, increased grid efficiency through market operations		
Regulators establish market structures	UC62913-2-3-B015	• Develop market structures based on input from stakeholders and taking into account power system regulatory requirements
	UC62913-2-3-B016	– Oversee market interactions and revise rules when necessary for fairness
Balancing authority manages frequency support services	UC62913-2-3-B017	• Receive energy offers from DER owner/operators
	UC62913-2-3-B018	• Analyse energy offers to determine ranking and amount for different time periods
	UC62913-2-3-B019	– Notify DER owner/operators of energy offer results when appropriate
	UC62913-2-3-B020	– Receive offers for frequency support services from DER owner/operators
	UC62913-2-3-B021	• Analyse frequency support offers to determine ranking and type for different time periods
	UC62913-2-3-B022	– Notify DER owner/operators of frequency support results when appropriate
	UC62913-2-3-B023	• Issue frequency support commands to DERs based on the market results
System operator receives offers from DER owners and aggregators for providing voltage support services	UC62913-2-3-B024	• Receive voltage support offers from DER owner/operators
	UC62913-2-3-B025	• Analyse voltage support offers to determine ranking and amount for different time periods
	UC62913-2-3-B026	– Notify DER owner/operators of voltage support offer results when appropriate
	UC62913-2-3-B027	– Issue voltage support commands to DERs based on the market results
Distribution system operator receives offers from DER owners and aggregators for	UC62913-2-3-B028	• Receive power quality support offers from DER owner/operators
	UC62913-2-3-B029	• Analyse power quality support offers to determine ranking and amount for different time periods

Business cases	Index of the business Use cases	Identified business Use Cases
providing additional power quality support services	UC62913-2-3-B030	• Notify DER owner/operators of power quality support offer results when appropriate
	UC62913-2-3-B031	– Issue power quality support commands to DERs based on the market results
Financial gain, reduced energy costs through demand response		
DER owners/operators receive pricing information for energy and respond by changing DERs and loads	UC62913-2-3-B032	• Receive demand response pricing information
	UC62913-2-3-B033	• Respond to demand response pricing information
DER owners/operators receive pricing information for ancillary services and respond appropriately	UC62913-2-3-B034	– Receive demand response pricing information
	UC62913-2-3-B035	– Respond to demand response pricing information
Improved grid safety, increased grid efficiency through maintenance		
DER owners/operators maintain the DERs to provide optimal availability and capabilities	UC62913-2-3-B036	• Optimize the operation of a distributed energy resource from a technical and economic perspective
	UC62913-2-3-B037	• Monitor the DER unit, provide data to third parties, and carry out urgent maintenance operations (including incidents management)
	UC62913-2-3-B038	• Carry out renewal programmes of a DER
Increased grid reliability, increased grid efficiency through long term planning		
System operator establishes long term planning procedures which include incentivizing different types of DER to be located in optimal places on the grid	UC62913-2-3-B039	• Develop long term energy and ancillary service requirements
	UC62913-2-3-B040	• Request estimates and commitments from third parties for locating DER
	UC62913-2-3-B041	• Determine which requirements may be met by DER and which require expansion or other changes to the grid

4.2.8 List of system Use Cases and system roles

Table 6 lists the system Use Cases which have been identified so far to enable the business Use Cases described above to operate. The list is non exhaustive and will be updated as new editions of IEC SRD 62913-2-3 are published.

Table 6 – Identified system Use Cases of the domain

Index of the system Use Cases	Identified system Use Cases	
Grid code modes		
UC62913-2-3-S001	Disconnect/connect function	The disconnect command initiates the galvanic separation (usually via switches or breakers) of the DER at its ECP or at the PCC. There may be a time delay between receiving the command and the actual disconnect.
	Disconnect or connect the DER from the grid at its ECP	The connect command initiates or allows the reconnection of the DER at its ECP or at the PCC. A permission to reconnect may also be issued.

Index of the system Use Cases	Identified system Use Cases	
UC62913-2-3-S002	Cease to energize and return to service The DER ceases all active power output Allow active power output at the PCC	"Cease to energize" is a different function from disconnect/connect. The (draft) definition is: "The DER shall not export active power during steady-state or transient conditions. Reactive power exchange (absorb or supply) shall be less than a percentage set of nameplate DER rating and shall exclusively result from passive devices.". There may be a time delay between receiving the command and the actual cease to energize. "Return to service" allows current flow at the PCC. A permission to return to service may also be issued.
UC62913-2-3-S003	High/low voltage ride-through mode The DER rides through temporary fluctuations in voltage	The DER follows the utility-specified voltage ride-through parameters to avoid tripping off unnecessarily. The function would block tripping within the fault ride-through zones. Although normally enabled by default, this ride-through mode may be updated, enabled, and disabled.
UC62913-2-3-S004	High/low frequency ride-through mode The DER rides through temporary fluctuations in frequency	The DER follows the utility-specified frequency ride-through parameters to avoid tripping off unnecessarily. The function would block tripping within the fault ride-through zones. Although normally enabled by default, this ride-through mode may be updated, enabled, and disabled.
UC62913-2-3-S005	Dynamic reactive current support mode The DER reacts against rapid voltage changes (spikes and sags) to provide dynamic system stabilization	The DER provides dynamic reactive current support in response to voltage spikes and sags, similar to acting as inertia against rapid changes. This mode may be focused on emergency situations or may be used during normal operations. When the dynamic reactive current support mode is enabled, the DER monitors the voltage at the Referenced ECP and responds based on the parameters.
UC62913-2-3-S006	Frequency-watt mode The DER responds to large frequency excursions during abnormal events at a Referenced ECP by changing its production or consumption rate	The DER is provided with frequency-watt curves that define the changes in its watt output based on frequencies around the nominal frequency during abnormal events. When the emergency frequency-watt mode is enabled, the DER monitors the frequency and adjusts its production or consumption rate to follow the specified emergency frequency-watt curve parameters.
UC62913-2-3-S007	Volt-watt mode The DER responds to changes in the voltage at the Referenced ECP by changing its production or consumption rate	The DER is provided with voltage-watt curves that define the changes in its watt output based on voltage deviations from nominal, as a means for countering those voltage deviations. When the volt-watt mode is enabled, the DER receives the voltage measurement from a meter (or other source) at the Referenced ECP. The DER adjusts its production or consumption rate to follow the specified volt-watt curve parameters.
UC62913-2-3-S008	Fixed (constant) power factor mode The DER power factor is set to a fixed value.	The DER power factor is set to the specified power factor. A leading power factor is positive and a lagging power factor is negative, as defined by the IEEE or IEC sign conventions.
UC62913-2-3-S009	Fixed (constant) reactive power mode The DER is requested to provide a fixed amount of reactive power	The DER is requested to provide a fixed amount of reactive power
UC62913-2-3-S010	Volt-var control mode The DER responds to changes in voltage at the Referenced ECP by supplying or absorbing vars in order to maintain the desired voltage level	The DER is provided with voltage-var curves that define the vars for voltage levels. When the volt-var mode is enabled, the DER receives the voltage measurements from a meter (or other source) at the Referenced ECP. The DER responds by supplying or absorbing vars according to the specified volt-var curve in order to maintain the desired voltage level.

Index of the system Use Cases	Identified system Use Cases	
UC62913-2-3-S011	Watt-var mode The DER responds to changes in power at the Referenced ECP by changing its vars	The DER is provided with watt-var curves that define the changes in its vars based changes of power. When the watt-var mode is enabled, the DER modifies its vars setting in response to the power level at the Referenced ECP.
UC62913-2-3-S012	Watt-PF mode The DER responds to changes in power at the Referenced ECP by changing its power factor	The DER is provided with watt-PF curves that define the changes in its power factor based changes of power. When the watt-PF mode is enabled, the DER modifies its PF setting in response to the power level at the Referenced ECP.
UC62913-2-3-S013	Set active power mode Set the DER to generate or consume energy as a percentage of maximum capability	The DER is set to a percentage of maximum generation or consumption rate. A positive value indicates generation, negative means consumption.
UC62913-2-3-S014	Limit active power production or consumption mode Limits the production and/or consumption level of the DER based on the Referenced ECP	The production and/or consumption of the DER is limited at the Referenced ECP, indicated as absolute watts values. Separate parameters are provided for production or consumption limits to permit these to be different.
UC62913-2-3-S015	Low frequency-watt emergency mode for demand side management (fast load shedding)	Enable automatic "low frequency" disconnection of a specified proportion of their demand (in stages) in a given time frame.
UC62913-2-3-S016	Low voltage-watt emergency mode for demand side management	Provide capabilities to enable automatic or manual load tap changer blocking and automatic "low voltage" disconnection.
UC62913-2-3-S017	Monitoring function The DER provides nameplate, configuration, status, measurements, and other requested data	The DER provides status, measurements, alarms, logs, and other data as authorized and requested by users. Examples include connect status, updated capacities, real and reactive power output/consumption, state of charge, voltage, and other measurements. Also of interest are forecast status and expected measurements.
UC62913-2-3-S018	Scheduling of power settings and modes The DER follows the highest priority schedules	The DER follows the schedule which consists of a time offset (specified as a number of seconds) from the start of the schedule and is associated with: • a power system setting • the enabling/disabling of a function • a price signal
Non-grid code modes		
UC62913-2-3-S019	Peak power limiting mode The DER limits the load at the Referenced ECP after it exceeds a threshold target power level	The active power output of the DER limits the load at the Referenced ECP if it starts to exceed a target power level, thus limiting import power. The production output is a percentage of the excess load over the target power level. The target power level is specified in absolute watts.

Index of the system Use Cases	Identified system Use Cases	
UC62913-2-3-S020	Load following mode The DER counteracts the load by a percentage at the Referenced ECP, after it starts to exceed a threshold target power level	The active power output of the DER follows and counteracts the load at the Referenced ECP if it starts to exceed a target power level, thus resulting in a flat power profile. The production output is a percentage of the excess load over the target power level. The target power level is specified in absolute watts.
UC62913-2-3-S021	Generation following mode The consumption and/or production of the DER counteracts generation power at the Referenced ECP.	The consumption and/or production of the DER follows and counteracts the generation measured at the Referenced ECP if it starts to exceed a target power level. The consumption and/or production output is a percentage of the excess generation watts over the target power level. The target power level is specified in absolute watts.
UC62913-2-3-S022	Active power smoothing mode The DER produces or absorbs active power in order to smooth the changes in the power level at the Referenced ECP. Rate of change of power	The DER follows the specified smoothing gradient which is a signed quantity that establishes the ratio of smoothing active power to the real-time delta-watts of the load or generation at the Referenced ECP. When the power smoothing mode is enabled, the DER receives the watt measurements from a meter (or other source) at the Referenced ECP. New data points are provided multiple times per second.
UC62913-2-3-S023	Frequency-watt primary control mode	The DER provides primary frequency control
UC62913-2-3-S024	Automatic generation control (AGC) mode The DER responds to raise and lower power level requests to provide frequency regulation support	When AGC mode is enabled, the DER responds to signals to increase or decrease the rate of consumption or production every 4 to 10 seconds, with the purpose of managing frequency.
UC62913-2-3-S025	Coordinated charge/discharge management mode The DER determines when and how fast to charge or discharge so long as it meets its target state of charge level obligation by the specified time	The DER is provided with a target state of charge and a time by which that SOC is to be reached. This allows the DER to determine when to charge or discharge based on price. The DER takes into account not only the duration at maximum consumption/production rate, but also other factors, such as that at high SOC the maximum consumption rate may not be able to be sustained, and vice versa, at low SOC, the maximum discharge rate may not be able to be sustained
UC62913-2-3-S026	Frequency-watt smoothing mode The DER responds to changes in frequency at the Referenced ECP by changing its consumption or production rate based on frequency deviations from nominal, as a means for countering those frequency deviations	The DER is provided with frequency-watt curves that define the changes in its watt output based on frequency deviations from nominal, as a means for countering those frequency deviations and smoothing the frequency. When the frequency-watt mode is enabled, the DER monitors the frequency and adjusts its production or consumption rate to follow the specified frequency-watt curve parameters. New data points are provided multiple times per second.

Index of the system Use Cases	Identified system Use Cases	
UC62913-2-3-S027	Power factor limiting (correcting) mode The DER supplies or absorbs vars to hold the power factor at the Referenced ECP within the PF limit	When the PF limiting (correcting) mode is enabled, the DER is provided with the target PF. The DER supplies or absorbs vars in order to maintain the PF at the Referenced ECP within the limits of the target PF.
UC62913-2-3-S028	Historical information	Detailed measurement and performance data which may be valuable to record in an operational historian
Non-functional capabilities		
UC62913-2-3-S029	Establish ramp rates	In addition to the default ramp rate, the DER may support multiple ramp rates that reflect different conditions.
UC62913-2-3-S030	Soft-start return to service	Use ramp rate and/or random time within window when reconnecting
UC62913-2-3-S031	Delta power control function Decrease active power output to ensure there remains spinning reserve amount that was bid into the market	Decrease active power output to ensure there remains spinning reserve amount that was bid into the market
UC62913-2-3-S032	Power rate control The power is limited by the maximum ramp rate.	Another is ramp time, when the active power should be at the required power level by the end of the ramp time. It may reach the required power level earlier, but not later.
UC62913-2-3-S033	Operating reserve (spinning reserve) The DER provides operating reserve	The DER can provide reserve power available within about 10 minutes
Capabilities not yet defined		
UC62913-2-3-S034	Microgrid separation control (intentional islanding)	Process for normal separation, emergency separation, and reconnection of microgrids. These microgrids could be individual facilities or could be multiple facilities using area EPS grid equipment between these facilities.
UC62913-2-3-S035	Provide black start capability	Ability to start without grid power, and the ability to add significant load in segmented groups
UC62913-2-3-S036	Provide backup power	Ability to provide power to local loads when not connected to the grid

According to the IEC smart grid standardization roadmap, "a successful operation of a virtual power plant requires the following technical equipment:

- an energy management system that monitors, plans and optimizes the operation of the decentralized power units;
- a forecasting system for loads that is able to calculate very short-term forecasts (1 hour) and short-term forecasts (up to 7 days);
- a forecasting system for the generation of renewable energy units. This forecast must be able to use weather forecasts in order to predict the generation of wind power plants and photovoltaics;
- an energy data management system which collects and keeps the data that is required for optimization and forecasts, e.g. profiles of generation and loads as well as contractual data for customer supply;
- a powerful front end for the communication of the energy management system with the decentralized power units."

Table 7 lists the system roles that have been identified so far. This list is not exhaustive and will be updated as the system Use Cases are drafted.

Table 7 – System roles of the domain

System roles		Definition
Level 0 Electric power system		
Electric power system (EPS) (high level)		Facilities that deliver electric power to a load
	Local EPS	An EPS contained entirely within a single premises or group of premises
	Area EPS	An EPS that serves local EPSs
	Microgrid EPS	A local EPS that can operate as an island and is operated as a virtual resource to the area EPS
	DC EPS	A local EPS that operates direct current
Electrical point of connection (ECP)		Point of electrical connection between the DER source or sink of energy and any EPS Each DER unit has an ECP connecting it to its local power system; groups of DER units have an ECP where they interconnect to the power system at a specific site or plant; a group of DER units plus local loads have an ECP where they are interconnected to the utility power system. NOTE For those ECPs between a utility EPS and a plant or site EPS, this point is identical to the point of common coupling (PCC) in IEEE Std 1547.
	Point of common coupling (PCC)	The point where a local EPS is connected to an area EPS.
	PCC switch	Switch plus its controller at the point of common coupling (PCC) between the local EPS and the area EPS
	EPS switch	Switch plus its controller within an EPS
Synchronizing equipment		Equipment that synchronizes the frequency between two EPSs
Weather system		Meteorological service providing weather system that can affect DER capabilities
Level 1 DER		
Virtual resource (high level)		A set of one or more energy service resources, including generators, energy storage, controllable load, and ancillary services
Distributed energy resource (DER) (high level)		A distributed set of one or more energy service resources, including generators, energy storage, controllable load, and ancillary services
	Renewable DER	DER system whose prime mover energy comes from renewable sources, including water, solar, wind, and biofuels
	Combined heat and power (CHP)	DER system whose primary purpose is creation of heat but can also provide electrical energy from the heat creation capability. In some circumstances, electrical energy is the primary purpose with heat as a secondary purpose
	Photovoltaic system (PV)	
	Fuel cell	
	Wind turbine	
	Hydro plant	
	Gas turbine	
	Biomass plant	
	Wood chip boiler	

System roles		Definition
	Battery energy storage	
	Pumped water storage	
DER unit (high level)		Prime mover and converter to and/or from electrical energy, including generators, energy storage, and controllable load
DER controller (high level)		Controller of DER unit
DER system (high level)		Combined DER controller and DER unit, including generators, energy storage, and controllable load
	Regulating DER system	DER system responsible for frequency and/or voltage regulation. The regulating DER system could be a generator, an energy storage system, or controllable load.
	Non-regulating DER system	DER system not participating in frequency or voltage regulation.
DER storage unit (high level)		DER unit that includes energy storage that can be converted to electrical energy
DER generating unit (high level)		DER unit that includes generation of electrical energy
DER controllable load (high level)		DER that consists primarily of a load that is allowed to be modified based on operating conditions, tariffs, contracts, or other criteria
	Non-controllable load	Load that is not allowed to be modified
	Critical load	Loads within a local EPS having the highest priority of service. These loads are served at the expense of all other loads.
	Non-critical load	Loads within a local EPS having the lowest priority of service. These loads may be left unserved in favour of critical loads.
Time synchronization source		Source of an accurate time signal
DER protection function		Safety-related function to prevent harm to personnel, the DER system, and/or other electrical equipment
DER log		Log of significant events and alarms for use in market settlements, operational analysis, and other audit purposes
DER meter		Meter that records the energy produced within specified time periods, energy used within specified time periods for DER charging of storage, and demand curves of DER generation and storage over time
Level 2 FDEMS		
DER management system (DER-MS) (high level)		System that manages the settings and dispatch of DER systems
Facility DER EMS (FDEMS)		System that manages the settings and dispatch of DER systems within a facility. This facility could be a residence, a building, a commercial site, an industrial site, or any other high level location.
	Microgrid DER EMS (MDEMS)	System that manages the settings and dispatch of DER systems within a microgrid, and that can cause the microgrid to become an island and to reconnect with the area EPS.
	Power plant DER EMS (PDEMS)	System that manages the settings and dispatch of DER systems within a power plant
	Building DER EMS (BDEMS)	System that manages the settings and dispatch of DER systems within a building
	Virtual power plant (VPP) DER EMS (VDEMS)	System that manages the settings and dispatch of DER systems that are enrolled in a virtual power plant

System roles		Definition
	Meter data management system (MDMS)	
Energy services interface (ESI)		
Facility local area network (Facility LAN)		
Level 3 Aggregators		
Aggregator		See definition in Table 5
	Aggregator DER management system (ADEMS)	
	Retail DER energy management system (RDEMS)	System that manages the settings and dispatch of DER systems that have been contracted to be operated by REPs and/or aggregators
Level 4 DSO and TSO		
Transmission system operator (TSO)		See definition in Table 5
	TDEMS or TSO EMS	TDEMS is part of the TSO EMS that manages large DER systems or large aggregations of smaller DER systems
Distribution system operator (DSO)		See definition in Table 5
	DSO planner	Planner
	DSO DER EMS (DDEMS)	
Distribution management system (DMS)		High level term for all applications used for distribution management.
	Distribution operations model and analysis (DOMA)	Topological model of distribution system, including the location and profile characteristics of all distribution equipment and DER systems (individually and/or in aggregate). This model is derived from the geographic model in the GIS, the facilities information (often included in the GIS and/or an asset management database), and the DER profiles (derived from the CIS and DER characteristics database)
	Distribution system power flow (DSPF)	Application that determines the power flows of the distribution system, using the DOMA model
	Transmission bus load model (TBLM)	
Geographic information system (GIS)		Geographic model of the distribution system, including the location and characteristics of all distribution equipment and DER systems (individually and/or in aggregate)
Customer information system (CIS)		System with customer information, including personal information, billing information, customer profile information, etc.
Outage management system (OMS)		
Distribution SCADA system (DSCADA)		
Level 5 Market		
Transmission energy market (high level)		
	Wholesale energy market	
	Balancing authority (market)	

System roles		Definition
	Transmission market operator	
Retail market (high level)		
	Demand response (DR) system	System providing demand response pricing information for different energy products during different time frames
Demand response (DR) pricing schedule		Schedule provided by REPs, DSOs, TSO, and others to indicate contractual and/or forecast prices for energy and ancillary services during specific time periods
Level 6 Communications		
Wide area network (WAN)		
	Public network	
	Advanced metering infrastructure (AMI)	
	Cellular system	
	Public Internet	
	Communication nodes	
Cyber security		
	Password and certificate management	
	Firewalls	
	Key management systems	
	Role-based access control systems	

5 Smart home/commercial/industrial/DR-customer energy management

5.1 Purpose and scope

5.1.1 Clause objective

The intention of Clause 5 is to present a business analysis of the smart home / commercial / industrial and DR-customer energy management domain, and more specifically to describe the smart grid requirements of the domain using the Use Case approach as defined in IEC SRD 62913-1.

In this document, the technical possibilities of smart homes, smart building, multi-building complexes and other customer energy management devices and their behaviour are considered. The Use Cases further detail the communication between actors by describing the signals and data models. It also helps determine if existing or proposed architectures are compatible with the smart grid requirements which have been defined.

5.1.2 General context

According to the evolution of the smart grid, the following main points are identified.

- The role of the consumer
 - The consumer is slowly turning into a "prosumer," a term which denotes a person who both produces and consumes energy. More and more consumers are installing their own renewable energy products to lower energy costs, increase use of renewable sources, and/or increase energy efficiency. Depending upon regulations and business opportunities within different regions, these prosumers are cogenerating heat and

power with their own solar panels or micro CHPs, selling energy back to the grid, or simply reducing their use of grid-supplied energy. 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.

- The consumer is empowered and wants to take advantage of the new possibilities in terms of internal optimization according to his or her priorities and choices (comfort, industrial processes, sustainable consumption, ...) and make use of his or her flexibility on the market taking into account external signals (prices, demand response).
- Considering the possible complexity of the home management, some consumers are delegating this task to authorized third parties.
- The evolution of the technology of smart homes
 - Smart homes are becoming "active" and able to participate in the grid and market business processes to satisfy the consumer's needs.
 - Commercial and industrial smart buildings are becoming more easily monitored and controlled than residential ones. For the smart home, simple architectures are critical to meet the many diverse situations in the world.

5.2 Business analysis

5.2.1 General overview

Information and communication technologies (ICT) offer new opportunities to customers to manage their electricity consumption. They are able to take a more active part in the electric power system (EPS), with the development of demand response (DR), communication devices connected to their electrical equipment, and communicating electrical equipment. According to IEC TR 62746-2:2015, demand response is: "a concept describing an incentivizing of customers by costs, ecological information or others in order to initiate a change in their consumption or feed-in pattern".

This trend is impacting all types of consumers, including residential, industrial, and tertiary ones. With the development of smart homes, residential customers have the opportunity to optimize their energy consumption/generation according to their needs, and potentially to support the activities of different stakeholders of the electric power system by responding to various signals.

A smart home is a house or an apartment equipped with a communicating and structured home area network (HAN). Residents who live in smart homes are able to remotely control or programme home electrical devices by activating/enabling and/or disabling internal controls and/or external events (excluding emergency signals).

Residents can thus better manage their energy consumption/generation and set the behaviour of the smart home to respond to external events, according to their preferences (economic optimization, comfort, environmental concerns). This customization could be done in a manual or automatic mode, depending on the configuration of the smart home. In automatic mode, when receiving a signal from the smart grid, smart home devices can adapt their operations without any further resident intervention. Residents/clients can always "keep control", except in emergency situations. Residents/clients may also decide to partially or totally delegate the customization to external roles, such as energy service providers, whom they have contracted with. These parties could for instance elaborate and propose to the residents/clients load schedules based on the analysis of the smart home data. Smart grid technologies including smart metering systems empower residents/clients to be aware of their consumption habits, energy costs and behaviour.

Furthermore, smart homes offer residents/clients the opportunity to become more active in the functioning of the grid and electricity markets. They can respond to signals designed to manage the electrical flexibility of the smart home depending on the state of the network (for instance, responding to emergency conditions when the power system "traffic light" shows "red" conditions).

5.2.2 List of business roles and business Use Cases of the domain

The business Use Cases listed are a result of the business analysis carried out previously – the list is not exhaustive, and it is likely to grow as new Use Cases come to light.

The Use Cases are associated with one or several of the business objectives of the domain, which include:

- configure the smart site (smart home or smart building) to enable interoperability with the smart grid;
- optimize the smart site (smart home or smart building) behaviour;
- manage the flexibility of the smart site (smart home or smart building);
- customer preferences to minimize customer costs and/or maximize customer convenience;
- regulatory requirements to ensure safety and reliability of the power system;
- societal to minimize the ecological impact of customer use of energy.

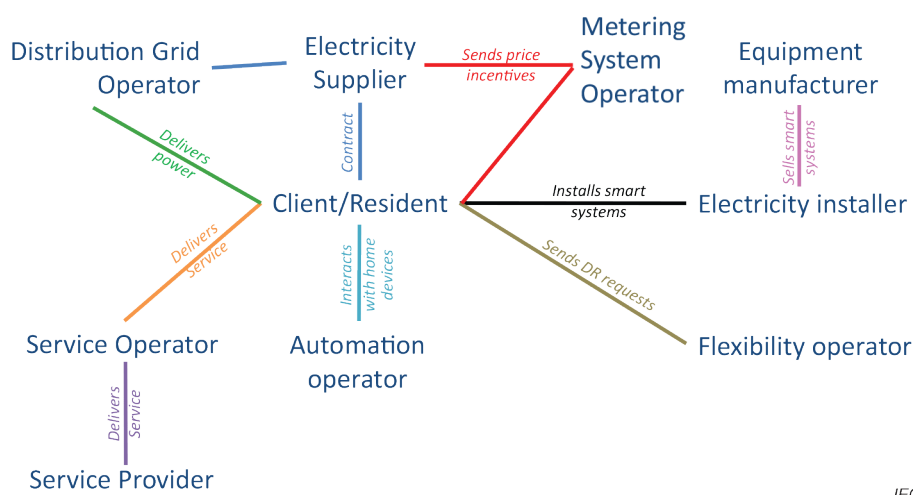
Table 8 lists the business roles that have been identified so far. This list is not exhaustive.

Table 8 – Business roles of the domain

Business roles	Definition
After-sales service operator	Entity that offers after-sales services at home.
Automation operator	Entity managing home devices (electrical devices, electricity management devices, WAN-IAN interface).
Building resident	A party that is a resident of the building and that may customize some of the uses or equipment according to the rights that the energy manager has given to him or her.
Client/customer (of electricity supplier)	A party connected to the grid that contracts for the ability to consume electricity at a metering point.
Consumer resident	Electricity end user residing in a smart home with capability of electricity flexibility and possible capability of energy storage.
Electricity feed-in administrator	A party which remunerates its clients for the electricity fed in the smart grid by the smart home or smart building.
Electricity installer	Entity that installs and maintains smart electric systems for industrial, commercial and domestic purposes.
Electricity supplier/retailer	Entity whose activity is the wholesale purchase of electricity and the subsequent direct resale to client through a contract. The supplier may also deliver energy-related services such as providing flexibility through electricity price modulation e.g. time-of-use, critical peak prices).
Energy manager	A party in charge of the energy management of the smart building.
Equipment manufacturer	Entity that produces and sells electrical devices and electricity management devices.
Facility manager	A party in charge of supervising the equipment of the smart building.
Flexibility operator (FO)	A party which technically operates flexibilities for its customers.
Grid operator	A party that operates one or more electrical grids. [SOURCE: ENTSO-E, EFET, and eBIX, 2014]

Business roles	Definition
Metering system operator	A party responsible for: - operations of the metering system, including communication with the Metering Points; - meter reading and quality control of the reading – taking the role of Metered Data Collector defined by ENTSO-E, EFET, and eBIX in their role model. May also be referred to as AMI system operator.
Producer client	A party connected to the grid at a metering point that generates and sells electricity through a contract.
Producer resident	Smart home resident producing electricity.
Resident	Electricity end user residing in a smart home who can be a consumer resident, a producer resident or both, with capability of electricity flexibility and possible capability of energy storage.
Service provider	Entity providing electricity-related services (such as energy efficiency or communication services).
Service operator	Entity connected to a service provider information system and to the home automation operator one. This entity operates services on behalf of a service provider. This entity can also collect and aggregate the smart home data before sending them to a service provider.
Telecommunications operator	Entity that offers telecommunications services.

Figure 5 is an extract from the role overview regarding the smart home. This diagram is not exhaustive but only highlights some of the relations between the roles involved in the domain.



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Figure 5 – Role highlights of the smart home domain

Table 9 lists and provides a brief description of the smart home business Use Cases that have been identified so far (they do not cover the entire domain business Use Cases).

Table 9 – Identified smart home business Use Cases of the domain

Index of the business Use Cases	Identified business Use Cases	Brief description	System Use Case required to enable/execute the business Use Case	Level of maturity
UC62913-2-3-B042	Adapt the smart home behaviour to the resident/client's preferences	The business Use Case describes how the resident/client customizes the management of his or her appliance(s) namely during dynamic peak periods and the monitoring of events, according to his or her preferences (decision between comfort and economic optimization). The resident/client may choose to respond to events in manual mode or automatic mode, and may in this second case delegate the customization to an authorized third party.	Customize automatic responses (price signals, DR requests, emergency signals)	Already implemented
UC62913-2-3-B043	Enable the interoperability between the smart home and the smart grid	The business Use Case describes how the client configures his or her smart home to receive smart grid signals (market or emergency signals). The configuration may include the installation of smart home devices	Configure the smart home in order to enable the interoperability with the smart grid	Adjustments in progress
UC62913-2-3-B044	Manage flexibility on electricity demand and generation within the smart home from market signals	The business Use Case describes how the resident/client responds to market signals (price incentives or DR requests) and adapts the behaviour of the smart home.	• Manage the flexibility of the smart home on electricity demand and generation from price incentives • Manage the flexibility of the smart home on electricity demand and generation from DR requests • Manage opt-outs to automatic responses (only price signals and DR requests, emergency excluded) including manual actions	• Already implemented • Adjustments in progress • Already implemented
UC62913-2-3-B045	Manage flexibility on electricity demand and generation within the smart home from emergency signals		• Manage the flexibility of the smart home on electricity demand and generation from emergency signals	• Adjustments in progress
UC62913-2-3-B046	Provide enriched smart home data to relevant parties in order to make the resident/client more active	The business Use Case describes how the resident/client or an authorized third party receives electricity data regarding the electricity behaviour of the smart home. The occurrence of events is monitored and the resident/client is warned if an event occurs.	• Provide alarms related to the smart home electricity behaviour to the client or resident • Provide a third party with enriched smart home electricity data	Already implemented

Index of the business Use Cases	Identified business Use Cases	Brief description	System Use Case required to enable/execute the business Use Case	Level of maturity
UC62913-2-3-B047	Assess the value of the flexibility of the smart home		- Process metering data to invoice electricity supply of the smart home - Process data related to the smart home behaviour to aggregate (forecasting, real-time), assess the value of and certify flexibilities - Process metering data to remunerate electricity feed in by the smart home	- Already implemented - Adjustments in progress

Regarding the smart building, similar business Use Cases have been identified (see Table 10). This first list may be amended with the detailed description of the smart building BUC.

Table 10 – Identified smart building business Use Cases of the domain

Index of the business Use Case	Identified business Use Case	Brief description	System Use Cases required to enable/execute the business Use Cases	Level of maturity
UC62913-2-3-B048	Adapt the smart building behaviour to the energy manager /client preferences	The business Use Case describes how the client/smart building energy manager customizes the energy management of the smart building namely during dynamic peak periods and the monitoring of events, according to his or her preferences (decision based on economic optimization). He or she may delegate the customization to an authorized third party.	- Customize automatic responses of the smart building (price signals, DR requests, emergency signals) - Optimize the smart building behaviour regarding internal and external information received	Adjustments in progress
UC62913-2-3-B049	Enable the interoperability between the smart building and the smart grid		Configure the smart building in order to enable the interoperability with the smart grid	Adjustments in progress

Index of the business Use Case	Identified business Use Case	Brief description	System Use Cases required to enable/execute the business Use Cases	Level of maturity
UC6291 3-2-3- B050	Manage flexibility on electricity demand and generation within the smart building from market signals	The business Use Case describes how the client/smart building energy manager responds to market signals (price incentives or DR requests) and adapts the behaviour of the smart building.	- Manage the flexibility of the smart building on electricity demand and generation from price incentives - Manage the flexibility of the smart building on electricity demand and generation from DR requests (Level of maturity: Incomplete due to uncertainty) - Manage opt-outs to automatic responses (only price signals and DR requests, emergency excluded) of the smart building including manual actions (Level of maturity: Already implemented)	Adjustments in progress
UC6291 3-2-3- B051	Manage flexibility on electricity demand and generation within the smart building from emergency signals		Manage the flexibility of the smart building on electricity demand and generation from emergency signals	Adjustments in progress
UC6291 3-2-3- B052	Provide enriched smart building data to relevant parties in order to make the energy manager/client more active	The business Use Case describes how the client/smart building energy manager or an authorized third party receives electricity data regarding the electricity behaviour of the smart building. The occurrence of events is monitored and the client/smart building energy manager is warned if an event occurs.	- Provide alarms related to the smart building electricity behaviour to the client or resident - Provide a third party with enriched smart building electricity data	Adjustments in progress
UC6291 3-2-3- B053	Assess the value of the flexibility of the smart building		- Process metering data to invoice electricity supply (Level of maturity: Already implemented) - Process data related to the smart building behaviour to aggregate (forecasting, real-time), assess the value of and certify flexibilities - Process metering data to remunerate electricity feed in by the smart building	Adjustments in progress

5.2.3 List of system Use Cases and system roles

5.2.3.1 System Use Cases and system roles of the domain

Table 11 describes the system Use Cases which have been identified so far to enable the business Use Cases described above to operate. The list is non exhaustive and will be updated as new editions of IEC SRD 62913-2-2 are published.

Table 11 – Identified system Use Cases of the domain

Index of the system Use Cases	Identified system Use Cases	Brief description
UC62913-2-3-S037	Configure the smart building in order to enable the interoperability with the smart grid	The smart building is configured in order to enable the communications: – externally with the smart grid through the smart grid connection point; – internally between the system roles. The smart building is configured as required in order to operate the flexibility management and the ancillary services. This business process takes into account the first configuration of the smart building and the following upgrades.
UC62913-2-3-S038	Configure the smart home in order to enable the interoperability with the smart grid	The smart home is configured in order to enable the communications: – externally with the smart grid through the smart grid connection point; – internally between the system roles. The smart home is configured as required in order to operate the flexibility management and the ancillary services. This business process takes into account the first configuration of the smart home and the following upgrades.
UC62913-2-3-S039	Customize automatic responses of the smart home (price incentives, DR requests, or emergency signals)	A resident/client customizes the management of his or her appliance(s) namely during dynamic peak periods. A resident/client also customizes the monitoring of events. <u>Described function</u> • First function: Customize the automatic responses of the smart home – Depending on the smart home capabilities and the resident/client needs, the customization may be defined and applied to different scopes: the whole smart home, one or several areas (rooms), one or several uses, one or several appliances. – Depending on the smart home capabilities, the customization may be defined and applied to different timescales: i. price period, ii. standard day, iii. standard week, iv. standard season, v. use/appliance consumption time slot. • Second function: Customize warnings (events to be tracked) and specify the related emission channel – The event to be tracked is exceeding an electricity data threshold in the smart home (such as a threshold of consumption in kWh). • Third function: Notify that the new customization has been taken into account • Fourth function: Read the customization