IEC SRD 62913-1

Edition 1.0 2019-05

SYSTEMS REFERENCE DELIVERABLE

colour inside

Generic smart grid requirements –
Part 1: Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach

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Generic smart grid requirements – Part 1: Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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GENERIC SMART GRID REQUIREMENTS –

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FOREWORD

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IEC SRD 62913-1, which is a Systems Reference Deliverable, has been prepared by IEC systems committee Smart Energy.

The text of this Systems Reference Deliverable is based on the following documents:

Draft SRD	Report on voting
SyCSmartEnergy/80/DTS	SyCSmartEnergy/100/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- withdrawn,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.

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INTRODUCTION

IEC SRD 62913 generic smart grid requirements are needed to fulfil the SG3 decision 2 made by the SMB at its February 2010 meeting (SMB/4204/DL, Decision 137/10) requesting the need to describe all the functional and system requirements for all smart grid applications.

The IEC Smart Grid Standardization Roadmap states that "the standardization process should offer a formal path between the application as "requested" by smart grid (stakeholders) and the standards themselves, i.e. a "top-down" process", whilst at the same time recognizing that for various reasons in many cases this path has not been the one implemented. This has in turn led to inconsistencies in standards.

The purpose of the IEC's systems approach is to ensure and improve the interoperability between smart energy systems and components. This approach is based on the business needs expressed by the market. The main purpose of capturing and sharing generic smart grid requirements is the constitution of a basis for coming standardization work, with standards ensuring and facilitating the deployment of smart grid applications.

A working group has been set up within IEC SyC Smart Energy in order to capture the smart grid requirements derived from the market needs, using a standardized approach based on Use Cases as described in the IEC 62559 series. This work is building on existing Use Cases, namely within the IEC when they exist, and is carried out collaboratively with the experts of the relevant technical committees.

IEC SRD 62913 will deliver an applicable methodology to draft Use Cases (IEC SRD 62913-1), clarifying 'who does what' with regards to smart energy Use Cases, and it will also initiate the process of listing, organizing and making available the Use Cases which carry the smart energy requirements which should be addressed by the IEC core technical standards (IEC SRD 62913-2). The IEC's systems approach will require adapted tools and processes to facilitate its implementation, and until they are available to the IEC National Committees and experts, IEC SRD 62913-2 should be understood as the first stepping stone towards this systems approach implementation. IEC SRD 62913-3 will be a roles database, based on a harmonized naming methodology, to ensure consistency when drafting smart energy Use Cases. This will provide a consistent and ready-to-use framework for all standardization stakeholders.

Use Cases in the top-down approach of IEC SyC Smart Energy (C/1845/RV) are tools to identify smart grid requirements used to assess situations in standards (gaps or overlaps) and in that way contribute to interoperability. These requirements may also be used further as input for interoperability profiles for the testing phase.

These requirements should then feed into the work carried out by IEC SyC Smart Energy with other technical committees in order to ensure the technical standards are developed taking into account the needs and priorities of the smart grid market.

This document corresponds to the specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach

GENERIC SMART GRID REQUIREMENTS –

Part 1: Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach

1 Scope

This part of IEC SRD 62913 describes a common approach for IEC technical committees to define generic smart grid requirements for further standardization work. It uses as input the Use Case methodology defined as part of the IEC 62559 series, and provides a more detailed methodology for describing Use Cases and extracting requirements from these Use Cases. This is necessary to achieve a consistent and homogeneous description of generic requirements for the different areas which make up the smart grid environment.

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
activity
part of a scenario that can be executed by one or more roles

Note 1 to entry: The details of an activity are described through actions. However, if it is necessary, intermediate levels can be created where activities describe an activity.

3.1.2
actor
entity that communicates and interacts

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

Note 2 to entry: In IEC SRD 62913 this term includes the concepts of business role and system role involved in Use Cases.

[SOURCE: IEC 62559-2:2015, 3.2]

3.1.3
business case
explanation or set of reasons describing how a business decision will improve a business, product, etc. and how it will affect costs and profits and attract investments

Note 1 to entry: Equivalent to strategic goals and principles which drive business processes.

3.1.4
business process
chain of logical connected, repetitive activities that utilizes the enterprise's resources to refine an object (physical or mental) for the purpose of achieving specified and measurable results/products for internal or external customers

Note 1 to entry: In the context of IEC SRD 62913, the business processes describe the sequenced interactions between several roles of a system.

Note 2 to entry: Business processes can be described or modelled as business Use Cases.

[SOURCE: Ericsson Quality Institute (1993): Business Process Management, Gothenburg, Sweden]

3.1.5
business role
role describing a finite set of responsibilities that is assumed by a party

Note 1 to entry: Organizations, organizational entities and physical persons are examples of business roles.

3.1.6
cluster
group of items organized by criteria

3.1.7
consumer
end user of electricity

Note 1 to entry: Consumers never generate or store the use of electricity.

Note 2 to entry: Traditionally, three consumer types are discussed: residential, industrial and commercial.

3.1.8
demand response
DR
action resulting from management of the electricity demand in response to supply conditions

[SOURCE: IEC 60050-617:2011, 617-04-16]

3.1.9
domain
group of related subjects of standardization

[SOURCE: IEC 60050-901:2013, 901-01-03, modified – The term "field of standardization" has been replaced by "domain".]

3.1.10
functional requirement
requirement that describes what the system must do

Note 1 to entry: They are actions in response to events, or actions performed autonomously. They represent operations and features provided.

[SOURCE: IEC PAS 62559:2008, 7.2.6.2]

3.1.11
level of maturity
one of a set of structured levels that describe how well a process, or Use Case, is implemented through an organization and relates to its degree of formality, optimization and reliability

Note 1 to entry: Proposed levels of maturity:

– Level "Already implemented": the process is implemented in and between several organizations, it is well defined, reliable, sustainable and few uncertainties remain in its framework (regulatory, business or technological).

– Level "Adjustments in progress": the process is implemented in a few organizations, it is well defined but subject to remaining major uncertainties in its framework (regulatory, business or technological).

– Level "Explorative": the process is tested in very few organizations, it is not completely defined and subject to numerous major uncertainties in its framework (regulatory, business or technological).

3.1.12
non-functional requirement
NFR
requirement that describes what qualities the system must contain from an execution and performance perspective

Note 1 to entry: These are also known as “constraints”, “behaviour”, “criteria”, “performance targets”, etc. They set limits or controls on how well the system performs the functional requirements.

Note 2 to entry: Non-functional requirements include: reliability, security, usability, upgradeability, expandability, scalability, compatibility, safety, performance, and conformance.

[SOURCE: IEC PAS 62559:2008, 7.2.6.2]

3.1.13
prosumer
end user of electricity who may also generate, store and manage the use of electricity

3.1.14
requirement
provision that conveys criteria to be fulfilled

[SOURCE: IEC 60050-901:2013, 901-05-05]

3.1.15
role
type of actor which has responsibilities and represents the external intended behaviour of a party

EXAMPLE A legally defined market participant (e.g. grid operator, customer), a generic role which represents a bundle of possible roles (e.g. flexibility operator) or an artificially defined body needed for generic process and Use Case descriptions.

Note 1 to entry: IEC SRD 62913 series uses two kinds of role: business roles and system roles.

Note 2 to entry: Legally or generically defined external actors can be named and identified by their roles.

[SOURCE: SG-CG/M490/C:2012-12]

3.1.16
scenario
possible sequence of interactions

[SOURCE: SG-CG/M490/E:2012-12; definition 3.10]

3.1.17
service
specific transaction satisfied by a business process involving two or more roles

3.1.18
smart grid
electric power system that utilizes information exchange and control technologies, distributed computing and associated sensors and actuators

Note 1 to entry: Purposes of smart grids are, for example,

– to integrate the behaviour and actions of the network users and other stakeholders,

– to efficiently deliver sustainable, economic and secure electricity supplies.

[SOURCE: IEC 60050-617:2011, 617-04-13, modified – The second part of the definition has been moved to a Note to entry.]

3.1.19
smart grid function
transformation of a number of input data, collected with the use of information and communication technologies, into a number of technical results to enable one or several business processes of the electric power system

Note 1 to entry: The implementation of smart grid functions requires the coordinated use of a series of equipment and software (generally called smart grid systems, such as AMI or DER management system).

Note 2 to entry: Smart grid functions and the associated interactions between systems, devices and operators can be described or modelled as system Use Cases.

3.1.20
system
set of interrelated elements considered in a defined context as a whole and separated from their environment

Note 1 to entry: System is defined in the systems activities Administrative Circular AC/33/2013 as: "a group of interacting, interrelated, or independent elements forming a purposeful whole of a complexity that requires specific structures and work methods in order to support applications and services relevant to IEC stakeholders".

[SOURCE: IEC 62559-2:2015, 3.7]

3.1.21
system role
role describing a finite set of functionalities that is assumed by an entity

Note 1 to entry: Device, information system and equipment are examples of system roles.

3.1.22
transmission of electricity
transfer in bulk of electricity, from generating stations to areas of consumption

[SOURCE: IEC 60050-601:1985, 601-01-09]

3.1.23
use case

specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system

[SOURCE: SG-CG/M490/E:2012-12]

Note 1 to entry: There are two types of Use Case:

– Business Use Cases describe how business roles interact to execute a business process. These processes are derived from services, i.e. business transactions, which have previously been identified.

– System Use Cases describe how system and/or business roles of a given system interact to perform a smart grid function required to enable or facilitate the business processes described in business Use Cases. Their purpose is to detail the execution of those processes from an information system perspective.

Note 2 to entry: Since a smart grid function can be used to enable or facilitate more than one business process, a system Use Case can be linked to more than one business Use Case.

Table 2 highlights the differences between these two types of Use Case.

Table 1 – Differences between business and system Use Cases

Type of Use Case	Description	Roles involved
Business Use Cases (BUC)	Depicts a business process – Expected to be system agnostic	Business roles (organizations, organizational entities or physical persons)
System Use Cases (SUC)	Depicts a function or sub-function supporting one or several business processes	Business roles and system roles (devices, information system)

3.2 Abbreviated terms

AMI	advanced metering infrastructures
BPMN	business process model and notation
BUC-SUC	business use case-system use case
CCTS	core component technical specification
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CIM	common information model
DER	distributed energy resources
DSO	distribution system operator
ebIX	European forum for energy business information exchange
EES	electrical energy storage
EFET	European federation of energy traders
ENTSO-E	European network of transmission system operators for electricity
ETSI	European Telecommunications Standards Institute
EURELECTRIC	Union of the Electricity Industry
EV	electric vehicle
EVSE	electric vehicle supply equipment
GWAC	GridWise®[1] Architecture Council
HV	high voltage
LV-MV	low voltage-medium voltage
MDA	model driven architecture
NFR	non-functional requirement
NIST	US National Institute of Standards and Technology
SDO	standards development organization

1 This information is given for the convenience of users of this document and does not constitute an endorsement by IEC.

SGAM	smart grid architecture model
SMB	IEC Standardization Management Board
TSO	transmission system operator
UML	unified modelling language
UN/Cefact	United Nations/centre for trade facilitation and electronic business
WAN-IAN	wide area network – internet area network
XML	extensible markup language

4 Systems approach

4.1 A systems perspective

As stated in the Administrative Circular AC/33/2013: As part of the system approach implemented by the IEC, systems committees have been defined to work "at the systems instead of the product level to define reference architectures, Use Cases and appropriate standards and guidance on the interfaces, functionality and interaction of a system ...".

The multiplicity of technologies and their convergence in many new and emerging markets, however – particularly those involving large-scale infrastructure – now demand a top-down approach to standardization, starting at the system or system-architecture rather than at the product level. System standards are also increasingly required in sectors such as environment, safety and health.

Although the introduction of such processes in the IEC began some years ago, a major effort is now required to improve understanding of them and to widen their application. It will be necessary to take account of the implied need for increased co-operation with many other standards-developing organizations, as well as with relevant non-standards bodies in the international arena. There will also be implications for the IEC's conformity assessment systems and processes.

Use Cases are used to facilitate co-operation at a system level with other standards development organizations (SDOs), non-traditional players of electrotechnology, regional organizations and users of smart energy systems closing the many open loops. Inside IEC they provide a convergence platform with overall system level value for support and guidance of the technical committees and other standards development groups, both inside and outside the IEC.

In order to achieve interoperability, Use Cases are used, in a top-down approach of IEC SyC Smart Energy, to derive generic smart grid requirements further used to assess situations in standards (gaps and overlaps) and so contribute to interoperability through better standardization. Note that Use Cases also provide a solid platform to define the testing cases to specify interfaces.

As defined in IEC 60050-617:2011, 617-04-13, a smart grid is an "electric power system that utilizes information exchange and control technologies, distributed computing and associated sensors and actuators, for purposes such as:

- to integrate the behaviour and actions of the network users and other stakeholders,
- to efficiently deliver sustainable, economic and secure electricity supplies."

Smart energy in addition to smart grid includes heat and gas in its scope as interactions. IEC SyC Smart Energy explores needs to optimize the energy use between electricity, heat and gas and seek value through a larger range of flexibility possibilities (technologies, cost).

The use of the term 'generic' in this document needs to be clarified. IEC standards need to address the maximum number of requirements needed by its stakeholders, namely those that bring value to several actors and that are not project specific. Use Cases are a tool to capture requirements, and the importance or the relevance of a requirement is not just determined by the number of Use Cases that capture it (although it may be a valid indication). A regulatory requirement, for example, will be considered a priority in one geography and perhaps not in another. The fact that there is only one Use Case that captures that regulatory requirement does not diminish the importance of the requirement, nor the fact that it needs to be addressed.

4.2 Applying the IEC systems approach to smart energy

"Systems committees (SyC) aim to extend the use of strategic or other horizontal groups to bridge areas covered by more than one or two TCs or SCs."

Although definitions like the one above (from the IEC website) help understand the IEC systems approach, certain clarifications are useful to help understand the scope of IEC SRD 62913.

a) SyC Smart Energy is tasked with consolidating and ensuring the consistency of the generic smart grid requirements, as well as the actors and terminology, for the smart energy domain.
   - This work is carried out according to the Use Case methodology in standardization as described in the IEC 62559 series, which includes the management processes of the IEC Use Case Repository (UCR) as well as a Use Case template (IEC 62559-2).
   - Use Cases are the basis to identify the smart grid standardization requirements as well as components of the working architectures.
   - Ensuring consistency means also ensuring the consistency of the naming of the actors. A proposed naming methodology is included in IEC SRD 62913.
   - The specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach is the purpose of this document.

b) SyC Smart Energy will achieve its task by supporting TCs to draft Use Cases.
   - This document provides methodology and drafting guidelines to draft Use Cases, differentiating between business and system Use Cases.
   - Use Cases are a common language to identify and describes requirements inside a TC and between TCs.
   - TCs continue to provide in-depth technical knowledge of a considered domain.
   - SyC Smart Energy needs to ensure that market drivers are captured in the business Use Cases ("WHY") and can contribute on drafting system Use Cases when relevant. This is important because it is via the aggregation of system Use Cases and system actors that a global architecture will emerge, and that is needed to determine whether there are any gaps in the existing standards (thus completing the IEC's Smart Grid Standards Map).
   - The purpose of IEC SRD 62913-2 (all parts) is to initiate the process of listing, organizing, making available the Use Cases which carry the smart energy requirements which will be addressed by the IEC core technical standards. The IEC's systems approach will require adapted tools and processes to facilitate its implementation, and until they are available to IEC National Committees and experts, IEC SRD 62913-2 can be seen as the first stepping stone towards this systems approach implementation.
   - The current content of IEC SRD 62913-2 is not exhaustive, but the current content represents the priorities for the smart energy domain at the time of publication. It is important that the content in terms of Use Cases and requirements continues to grow to encompass the requirements of the broad smart energy stakeholders (both within the IEC community as well as more generally the other market stakeholders).
   - The purpose of the work carried out in SyC Smart Energy is to ensure consistency in the way requirements are gathered, shared and addressed by the IEC, and to improve the efficiency of the production of technical standards by reducing the time it takes to

identify gaps or overlaps in the existing technical standards and address these situations. The fact that SyCs are organized to interact regularly with the market stakeholders (inside as well as outside the IEC) will ensure that standardization work is aligned on the market priorities at any given time, and so ultimately help improve the delivery acceptance of the IEC core standards.

– Note that system Use Cases can describe different and conflicting approaches to address the same requirement.

– For the avoidance of doubt, SyC Smart Energy and all its working groups are not and never had the intention of being a 'control mechanism' on the publications of technical standards.

c) SyC Smart Energy works on what is needed for "further" standardization work in the smart energy domain.

   – The standardization process taking into account the systems approach focuses on the priorities today which need further standardization as it will be an impossible task to include all existing Use Cases and requirements according to the IEC SRD 62913 methodology.

   – The scope covers "what changes or what is new" – although potentially this can cover more. Ultimately, any Use Case which brings value to several actors of the electric power system is of interest to the IEC.

   – The basis of work is the on-going standardization work in the TCs and potentially also new market needs – that determines the priorities for the SyC Smart Energy working groups.

In addition to a shared and applicable methodology as described in this document, consistency will be achieved if there is a collaborative work environment between TCs and SyC Smart Energy.

4.3 Main areas of work

The IEC Smart Grid Standardization Roadmap states:

"Care must be taken to concentrate standardization efforts on providing additional value to the smart grid implementation. This will be especially true for all interoperability standards, which will help to reach the goal of increased observability and controllability of the power system. In this respect the IEC offers the absolute precondition for a further promotion of smart grid. On the other hand, the IEC refrains from standardization of solutions or specific implementations itself. This would actually block innovation and the further development of smart grid."

These key points will be taken into account when describing generic smart grid requirements. They translate as simple yet fundamental guidelines for describing generic smart grid requirements.

a) Describe what changes, what is improved, needs to be improved, what is new

   The focus is on defining what is new, what is improved, or what changes in the electric power system with the emergence of smart grid functions. The purpose of IEC SRD 62913 is not to define all electric power system requirements, nor does it seek to standardize solutions-specific or architecture-specific requirements.

b) Keep an electric power system perspective

   Emerging smart grid functions, on the back of new and more reliable information and communication technologies, offer new opportunities which are gradually changing the way in which the electric power system operates. One major changing trend is the need to integrate and manage the increasing number of distributed and/or intermittent energy resources onto the transmission and distribution networks. Another example of these changes is the growing role of the market within the electric power system, and the possibilities being offered to these markets to operate increasingly closer to real-time.

At the heart of these changing trends, the electric power system still needs to meet the objectives listed above (ensuring security and quality of supply, ensuring security of people and assets and optimizing costs for all stakeholders). The development of smart grid functions does not alter these objectives, only the more efficient way they can be met.

c) Describe the relevant functional and non-functional requirements for all smart grid applications

Defining generic requirements addressing mainly interfaces supporting smart grid applications must ultimately facilitate the development and deployment of smart grid applications, and to do this means providing the sufficient level of detail which enables this. Striking the right balance between 'generic' and 'functional and non-functional requirements' is one of the key challenges in defining generic smart grid requirements.

d) Take into account the fundamental rules that govern the electric power system

Another important parameter to bear in mind is that the actors of the electric power system all need to respect certain fundamental rules and take them into account in the way they operate, i.e. in their business processes. These rules include grid rules, essentially derived from grid/network codes, and market rules, derived from national and/or regional regulations and grid/network codes.

Regulatory bodies at regional and state levels define and contribute to enforce both grid and market rules – they can delegate to state agencies or to some actors of the electric power system the elaboration of those rules, which they will ultimately validate. In turn, both the grid codes and the market models impose requirements to the different users or resources which connect to the grid.

It is the mission of standards to support/enable the implementations of these requirements.

4.4 Breaking down the scope

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*.

The IEC SRD 62913 series 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 grids.

4.5 Link with some existing conceptual models

This necessary split has been inspired by existing conceptual models which have been drafted previously, such as the NIST smart grid conceptual model, the SGAM or the conceptual model developed as part of the European mandate M/490 Smart Grid Coordination Group. These existing conceptual models are listed in Annex D.

A conceptual model can be defined as the grouping of roles and actors (systems, components, operators, …) within coherent domains related to a general system (the electric power system here). It provides a high-level reference architecture model and proposes a decomposition of a system in domains. This facilitates the description of smart grid systems and interoperability analysis. The roles and systems of each domain interact with each other, as well as with the roles and systems of other domains.

Based on the commonly accepted breakdown and other existing conceptual models (NIST SGIP conceptual model, EU M/490 smart grid conceptual model SGAM), in order to apprehend its complexity and to help maintain a global vision of the smart grid market needs, IEC SRD 62913 has been organized around the smart grid domains identified in Table 1.

Table 2 – Links between SGAM and IEC SRD 62913 domains

SGAM domains	IEC SRD 62913 series domains	
Bulk generation	Bulk generation	
Transmission	Transmission grid management	Smart substation automation
Distribution	Distribution grid management	
	Microgrids [a]	
DER	Distributed energy resources	
	Energy storage	
Customer premises	Smart home / commercial / industrial / DR-customer energy management	
	Electric transportation	
	Metering management	
	Asset management	
	Market	

[a] Actually microgrids are small versions of smart grids and may encompass a large variety of domains including distribution, DER and customer premises.

The distribution domain, as described in the SGAM, has been broken into three domains – distribution grid management, microgrids and smart substation automation – to facilitate capturing and sharing generic smart grid requirements on what is new or what changes in the electric power system with the emergence of smart grid functions. Following the same approach, DER has been split in two domains: distributed energy resources for ‘generation’ DER and energy storage for ‘storage’ DER (note that DER could be further refined to also include controllable load). customer premises has been split in smart home / commercial / industrial / DR-customer energy management and electric transportation.

In addition, we define a market domain as the one defined in NIST/SGIP Smart Grid Conceptual Model and two cross-domains metering management and asset management.

The business analyses which underlie the definition of generic smart grid requirements are carried out per domain initially, and then consolidated to take into account dependencies and interactions between the domains.

5 Specific application of Use Case methodology for defining generic smart grid requirements

5.1 General

The purpose of Clause 4 is to describe the methodology which can be shared and easily applied to carry out a comprehensive and consistent description of generic smart grid requirements based on a business analysis of the identified smart grid domains and to detail the context in which smart grid functions are or may be used.

5.2 Why the Use Case methodology is particularly adapted to smart grid

5.2.1 General

It provides a robust, tried and tested common methodology to describe complex systems. The methodology strikes the correct balance between a necessary structure and form and enough flexibility to leave room to take into account emerging requirements or regulatory uncertainty. The Use Case methodology is widely used within IEC as well as other SDOs and the Industry, which will facilitate re-use and making sure existing work is taken into account from the outset.

It is based on a collective approach which requires putting all the stakeholders around the table to ensure all requirements have been taken into account. It helps highlight the inevitable 'grey' areas which will need to be clarified. It should be noted that smart grid requirements may evolve rapidly.

It uses a comprehensible and flexible format with a wide range of representations at different levels based on user needs, which makes it understandable by users, business analysts, IT experts all the way through to senior executives.

The Use Case methodology can be used at all levels of a company: to translate a company's strategy per domain, to highlight how existing business processes will be impacted, or to design new information systems or modify existing ones.

5.2.2 Linking the Use Case methodology with existing frameworks

Different frameworks have been elaborated by SDOs to grasp the complexity of smart grid, present and validate Use Cases in relation to existing standards, and ultimately ensure interoperability of systems and components. A common denominator of the various works is the identification of different interoperability layers, inherent to the complexity of smart grid.

The model proposed by the US Department of Energy's GridWise Architecture Council (GWAC) and adapted by the NIST, referred to as "GWAC stack", has identified eight layers of interoperability based on different drivers (organizational, technical, or informational); see Figure 1. It provides a "context for determining Smart Grid interoperability requirements and defining exchanges of information" (NIST, 2012).

Figure 1 – The GridWise Architecture Council's Model (NIST, 2012)

The Smart Grid-Coordination Group, established by CEN/CENELEC/ETSI to fulfil the tasks laid down by the M/490 European Commission Mandate, has simplified this model by grouping different layers with the Smart Grid Architecture Model (SGAM), see Figure 2. This framework aims at decomposing the electric power system by interoperability layers, domains, and zones.

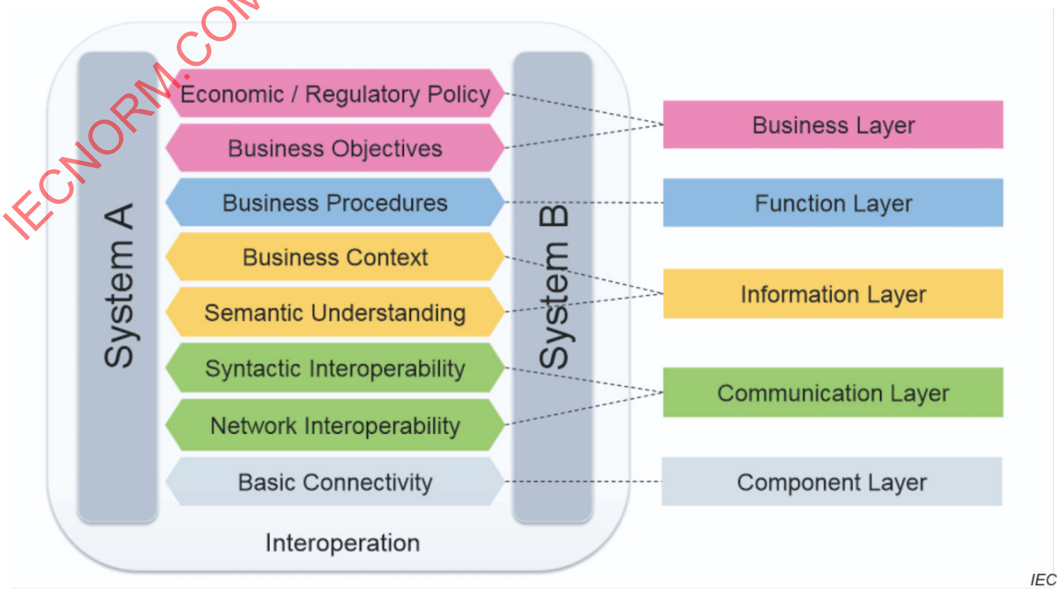


Figure 2 – Simplification of the GWAC model (CEN/CENELEC/ETSI, 2014)

The SGAM framework enables to organize the design of new smart grid architecture components on a 3 axes basis (see Figure 3 and Figure 4):

- Domains: the physical partitions of the energy chain from the generation down to the customer premises as described in 4.4; see Figure 3.
- Zones: the partitions for the management of the electrical processes (See Figure 3).
- Interoperability layers: a set of abstract points of view enabling a simple handling of architecture model. It allows representing smart grid systems in five layers – business objectives and processes, functions, information exchange and models, communication protocols, and components – as well as the interactions between them.

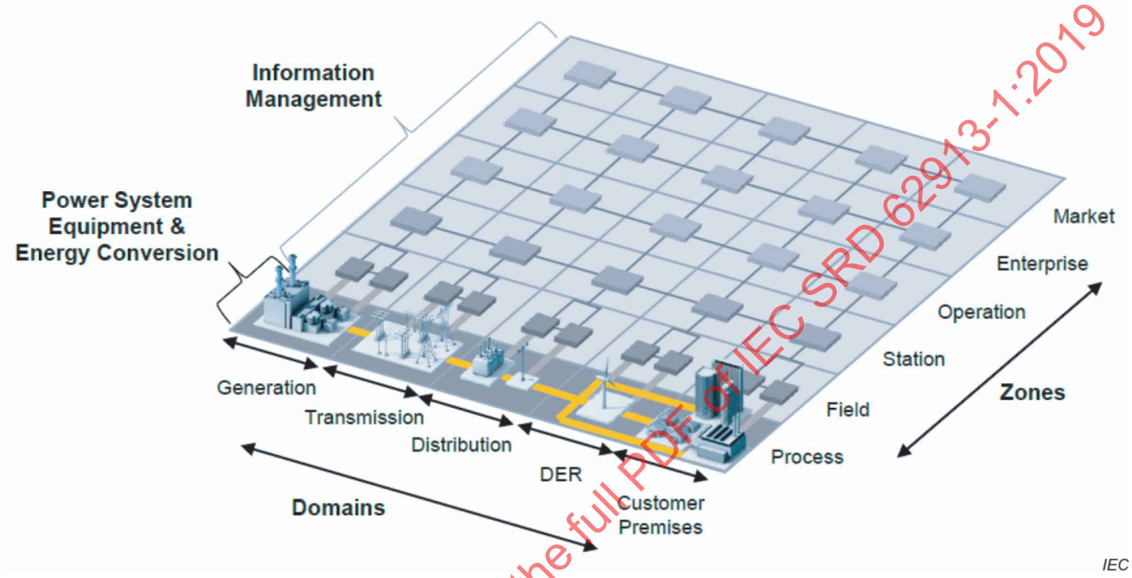


Figure 3 – Smart grid plane domains and hierarchical zones

Every smart grid component to be deployed on the field has to be first specified through different layers of abstraction, from the business down to the component implementation. In order to facilitate the high level specifications, IEC decided to leverage an approach based on the design of Use Cases capturing the smart grid requirements.

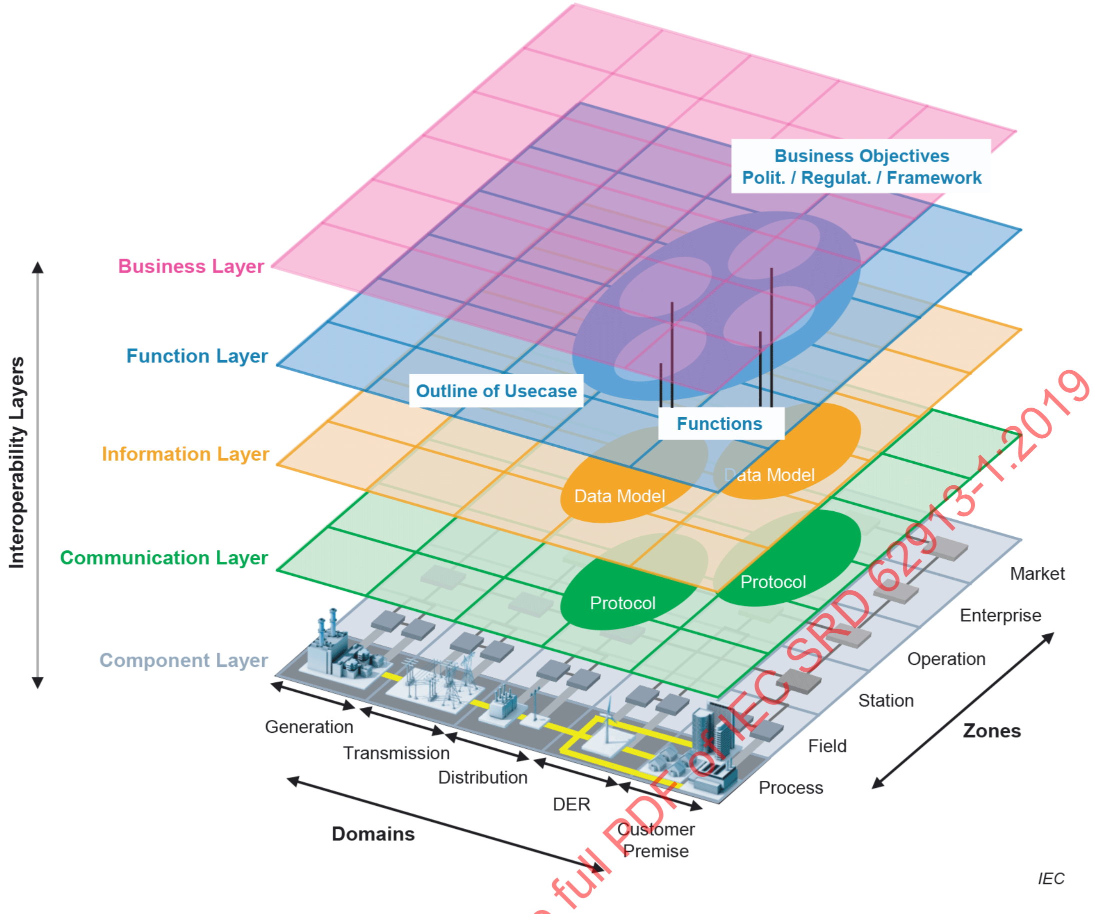


Figure 4 – The Smart Grid Architecture Model (CEN-CENELEC-ETSI, 2014)

These different frameworks have helped structure the work for IEC SRD 62913. They have contributed to ensure the methodological approach to capture generic smart grid requirements is business-driven, not solutions-driven.

IEC established a link between the SGAM framework and the Use Case methodology through key concepts: roles, business processes, activities, systems and functions.

Figure 5 highlights the link between the five layers of the SGAM model described above, and the interactions with the key concepts of the Use Case methodology. More precisely, it shows how a given role within the electric power system provides a service to another role, through the execution of a business process composed of different activities. Moreover, a business process needs to be implemented in various systems. These systems also have different processes (named functions) that can be described through activities.

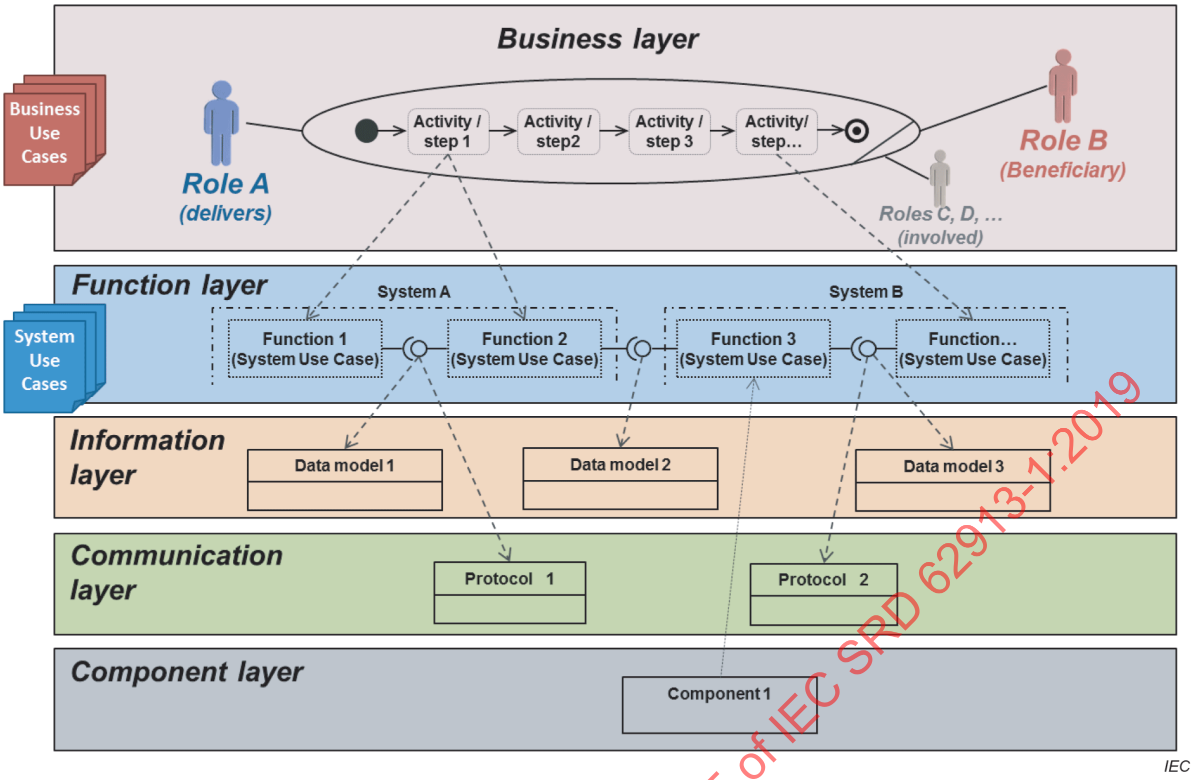


Figure 5 – Interactions between the Use Case methodology and the Smart Grid Architecture Model (based on CEN-CENELEC-ETSI, 2014)

5.2.3 Notion of role

The notion of 'role' is fundamental in the Use Case methodology. A role may be defined as "an intended behaviour of a business party"[2]. It is associated with responsibilities. A business party, when carrying out a business transaction, takes on a certain role. According to ENTSO-E Role Model (ENTSO-E, EFET, and ebIX, 2011), "the objective of decomposing the electricity system into a set of autonomous roles and domains is to enable the construction of business processes where the relevant role participates to satisfy a specific transaction (service). Business processes should be designed to satisfy the requirements of the roles and not of the parties."

Although the notions of roles and actors are often interchanged, it is important not to confuse the two. Actors are entities that communicate or interact with a given system. A role on the other hand is a type of actor which has responsibilities, for a business role, or functionalities, for a system role (information systems, or devices) within a given system. A role can be played by different parties (legal or physical entity) – depending on geographies for example.

"A role must be able to stand alone within the model. In other words it must represent a relatively autonomous function. A good guide to determining the validity for the insertion of a role is to determine whether it provides:

- All the information relevant to interoperability. It must be able to participate in the development of a business process by being a key factor in the construction of the allowable sequences of information exchanges and satisfy the conditions in which it is allowed to send information. In this respect it has to be autonomous.

2 SG-CG/M490/C:2012-12.

- The process constraints to be satisfied in which the role participates. Such constraints impose restrictions on how roles may or must react. These constraints will be defined within the business process specification.” [3]

In the Use Case methodology, roles interact with each other within a role model, which represents all of the interactions between the different roles and domains of a given system. The purpose of a role model is to share a common understanding and ultimately to facilitate communication and the development of information exchanges. See Annex A for examples of existing actor lists.

5.3 Applying the Use Case methodology to define generic smart grid requirements

5.3.1 A business processes driven approach

5.3.1.1 General

The methodology to capture the generic requirements for all smart grid applications illustrated in Figure 6 is structured on an approach based on business processes. This business-driven approach is particularly relevant to define generic smart grid requirements so ensuring that fundamental requirements of the electric power system (including network rules or market rules) as well as strategic goals are taken into account at all times.

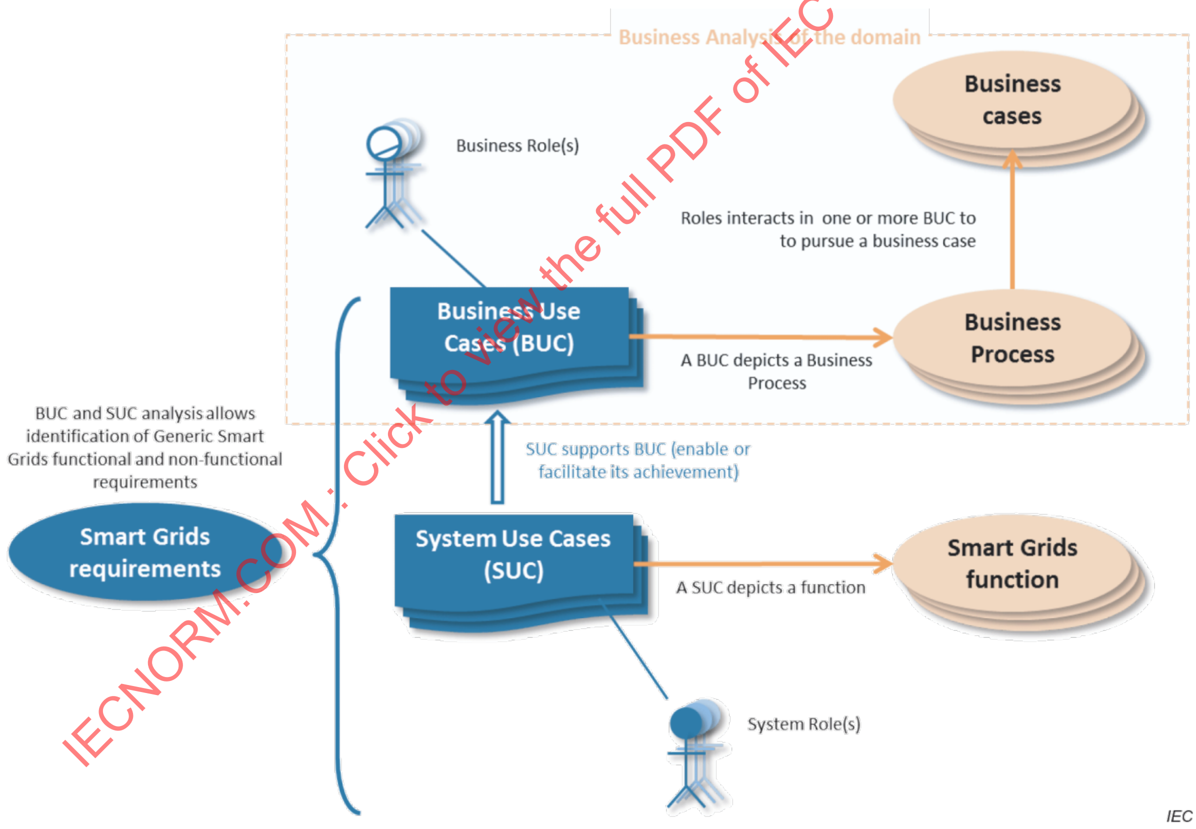


Figure 6 – Defining smart grid requirements methodology

The business analysis which needs to be carried out covers the activities and operations within the electric power system.

The business analysis will focus on the adapted existing business processes or new business processes impacted by new trends and market needs. This is formalized through business

3 ENTSO-E, EFET & EBIX, The Harmonised Electricity Market Role Model, 2014-01.

Use Cases which are just a pragmatic and structured method to describe business processes, functions, and ultimately their associated requirements.

In order to capture generic smart grid requirements with a business driven and top-down approach, it is necessary to first identify business cases (domain strategic goals and principles). To do so, the roles interacting with the domain need to be considered, as described in 5.2.3.

Figure 7 provides a simplified overview of the point of view of the 'business role' of a domain.

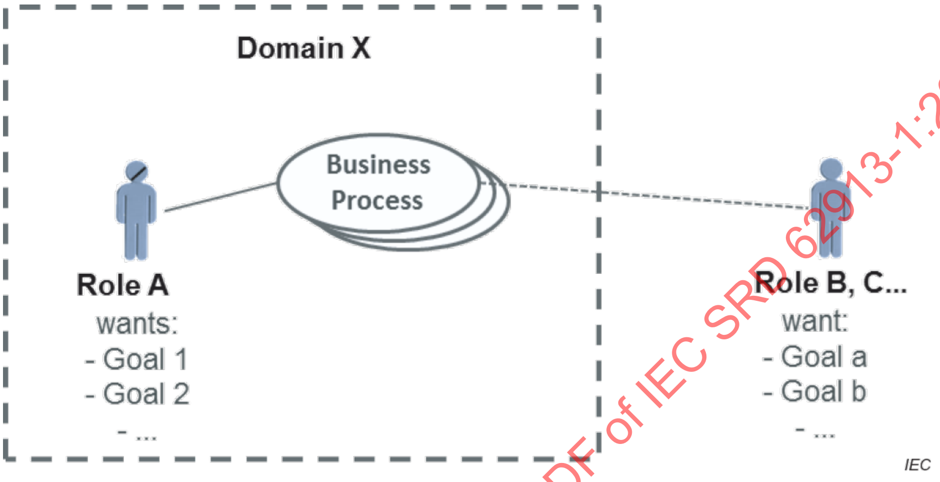


Figure 7 – Point of view of a domain role

Figure 7 also highlights the fact that the business analysis carried per domain will need to take into account interactions with other roles or stakeholders. Indeed, the latter (Role B, C…) may contribute to achieve the goals of role A, or they may have different goals – which are not necessarily convergent with those of role A. These situations need to be identified as part of the business analysis per domain and are to be addressed as part of the consolidation phase.

One of the main challenges in drafting Use Cases is to converge on the level of detail. It is suggested to proceed in three levels:

1) Defining the main business cases of the domains, which are strategic goals and principles, constitute the first level of detail. They involve multiple business processes (see below).

   Key questions: Why are we doing this? Is it consistent with our mission statement? What is in it for the stakeholders?

2) Defining business processes of the domains, which are the set of activities that the business roles of the domains have to achieve, constitute the second level of detail. Note that a business process can be related to several business cases.

   Key questions: What activities do we need to carry out to achieve this operational goal? (from the trigger to a visible/valued end result).

As an example, optimizing the planning of the network represents a business case for both transmission grid management and distribution grid management domains.

Business processes and the associated interaction between business roles (inside and outside a given domain) can be described as business Use Cases and will be referred to as business Use Cases (BUC) in the IEC SRD 62913 series.

Figure 8, consistent with SGAM business layer, shows the first two levels of detail (business Cases and business Use Cases).

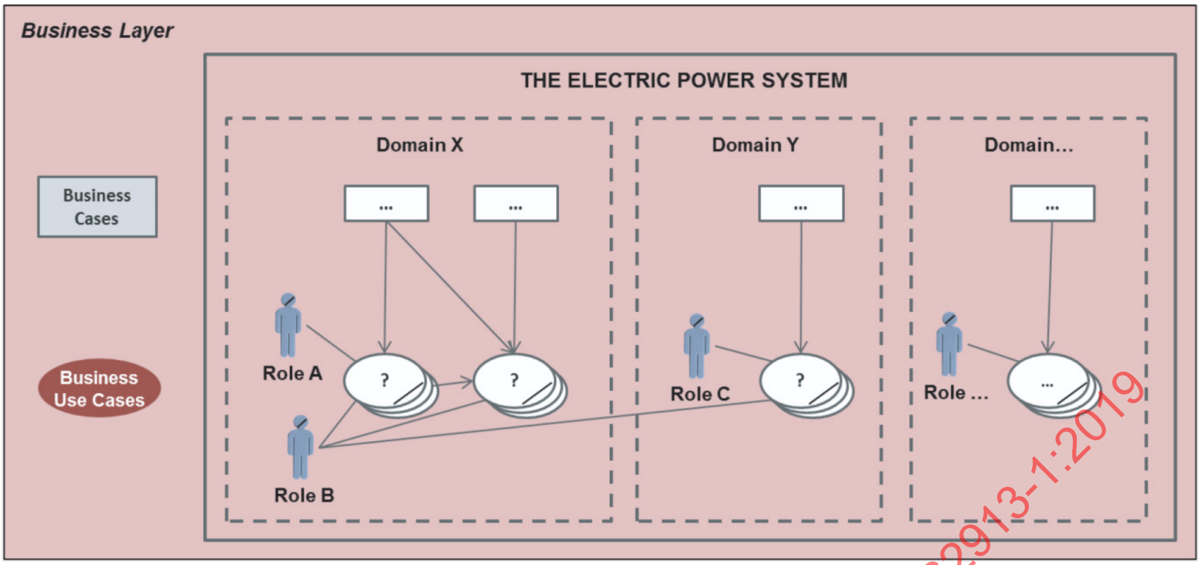


Figure 8 – The first two levels of detail used to capture generic smart grid requirements

It should be noted that:

- A business Use Case may require the execution of another business Use Case within the same domain.
- A business Use Case can be related to several business cases.
- Business Use Cases should be system agnostic: It is highly recommended to ensure that business Use Cases are depicted in such a way that they do not presume the solutions and means which will be used to run the targeted business process, i.e. do not imply system roles.
- Roles of a given domain may interact with business Use Cases of another domain.

These interactions increase the complexity of the electric power system, but need to be described as they will ultimately materialize as additional requirements.

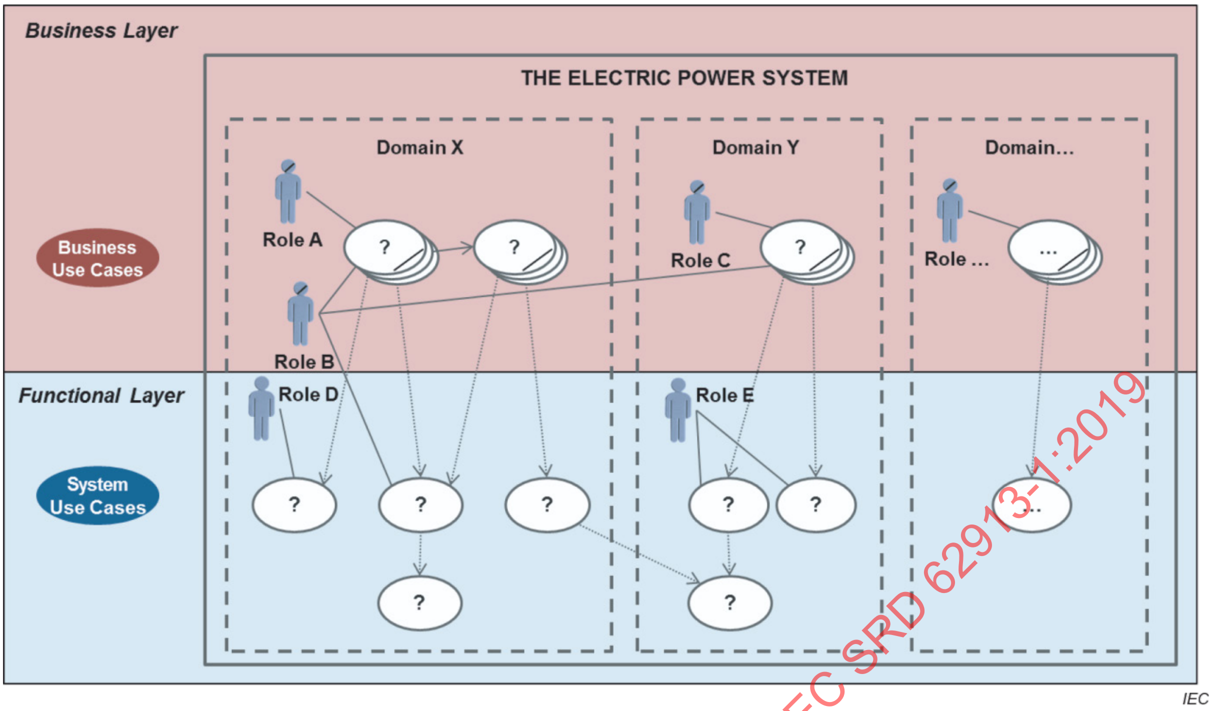
When describing the business Use Cases of the domain, some smart grid functions required to enable or facilitate those business Use Cases have to be identified and defined.

3) Defining the smart grid functions constitutes a third level of detail. Smart grid functions are means or tools to support business Use Cases; they may be solution-specific. One smart grid function can be used in several business Use Cases. There will be several system Use Cases – and potentially associated functions – as there are different solutions or ways to support the business cases.

For instance, a load-flow calculation is a function that may be used to prevent faults, optimize the grid and operate it – one of their main business processes.

Smart grid functions and the associated interactions between roles (business and/or system roles) can be described in system Use Cases and will be referred to as system Use Cases (SUC) in the IEC SRD 62913 series.

It should be noted that as smart grid functions may be made up of sub-smart grid functions, system Use Cases can be made up of other system Uses Cases, smart grids are often systems of systems, see Figure 9.



NOTE The number of business Use Cases and system Use Cases which are represented, as well as the number and the nature of the links between these different elements, are indicative.

Figure 9 – The levels of detail used to capture generic smart grid requirements

5.3.1.2 Proposed step-by-step approach

On the basis of what has been described above, the different steps to carry out a business analysis and from there define the generic smart grid requirements could be summarized as follows.

- Share new smart grid ideas under consideration through the IEC systems approach, identify and gather existing Use Cases.
- Identify and describe Use Cases compliant with IEC 62559-2 and this document:
  – identify and describe the business roles of the domain;
  – identify and describe the strategic goals of the domain (the business cases);
  – describe the business Use Cases, including the set of activities enabling them to achieve their business cases;
  – identify and describe the system roles of the domain;
  – describe the system Use Cases required to execute/enable the business Use Cases, and the working architectures associated in order to map data flows.
- Derive generic smart grid requirements from Use Cases.

5.3.2 Generic smart grid requirements

5.3.2.1 Functional and non-functional requirements

The key point behind using the proposed application of the Use Case methodology is to ensure the business viewpoint is borne in mind at all times during the analysis work, thereby ensuring each domain addresses the business-related, or functional requirements associated to the different Use Cases. Those functional requirements mainly concern interfaces supporting all smart grid applications.

Requirements mainly focus on capabilities of the interfaces of the different roles/functions which appear to be needed through the Use Case descriptions, and then on capabilities that existing standards are supporting or coming standards should support.

Because requirements mostly focus on interaction, their expression can be simplified and should comply with ISO/IEC directives:

- Use the present tense, use forms such as: shall, is to, is required to, it is required that, has to, only … is permitted, it is necessary, needs to … and their negative form.
- Indicate which are the roles interacting (one to one, one to many).
- Indicate the element to be exchanged (may not be exclusively of information type) in a non-ambiguous manner.
- Indicate the constraint identified to this interaction – the non-functional requirements (NFRs). These NFRs cover topics as broad as response time performance, scalability, cyber-security, criticality, availability, resilience or interoperability.

Functional requirements are derived from information exchange with a methodology inspired by:

- ISO/IEC directives;
- IEC 61850-5:2013: see PICOM (Piece of Information for Communication);
- IEC 61968-1, IEC 61968-100: see message types.

It is essential to split complex requirements until it can be considered as a discrete test case.

In order to facilitate extraction of generic smart grid requirements, Use Cases should be written following those rules, referring to IEC 62559-2 Use Case template sections:

- Scope and objectives of use case (1.3);
- Narrative of use case (1.4);
- Use case conditions (1.6);
- Step by step analysis of use case (4);
- Information exchanged (5);
- Requirements (6).

Requirements format adopted for IEC SRD 62913 series:

Requirement ID (unique)	Requirement description	Link to Use Cases
Part number followed by a unique requirement number Example: 62913-2-3-087	Functional or non-functional nature can be specified	Annex subclause number followed by the part of the Use Case concerned Example: Annex B.3.2.1 Scenario 1 – step 1.5

Other testable and usable (one can demonstrate that a standard supports or not the achievement of it) requirements can be extracted, even if they cannot be directly linked to an interface supporting a smart grid application.

It should also be noted that not all of the NFRs will have to be captured in the Use Cases. Complex algorithms and formulae and graphical user interface requirements will not need to be detailed in the Use Cases for example – they are clearly linked to a specific solution or implementation approach and thus out of scope of the IEC SRD 62913 series, as explained in Figure 10.

There are a few cases when a sequence of interactions is absolutely needed to perform a specific function, and guarantee interoperability (for example “select-before-execute”), and such a sequence may appear as a requirement to be supported by the standard as a standard “state machine”.

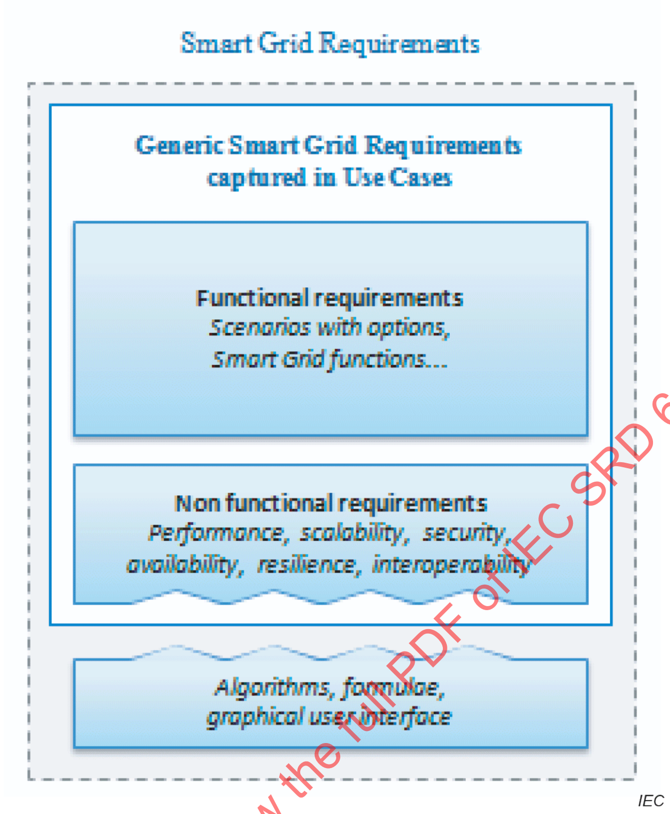


Figure 10 – Generic smart grid functional and non-functional requirements captured in Use Cases

The Use Case template as defined in IEC 62559-2 includes placeholders designed to detail NFRs.

As an example of NFRs, Annex D provides an example of telecom related NFRs which may be used when describing a Use Case.

5.3.2.2 Extracting generic smart grid requirements from Use Cases

A Use Case-driven approach is necessary for a top-down development of standards. From a Use Case perspective actors and deliverables are identified and requirements are derived. This is the base for future standardization.

The generic smart grid requirements will be extracted from business Use Cases and their associated system Use Cases and included in IEC SRD 62913-2 documents as proposed. The Use Cases themselves will be published as an informative annex in parts of the IEC SRD 62913-2 series.

In order to provide some insight into the complexity of the smart grid systems and help the reader make a link between the listed generic smart grid requirements and the context provided as part of the Use Cases, a note will be added with reference to the relevant Use Cases where this requirement occurred.

5.4 Proposed working principles for drafting and managing smart energy Use Cases and requirements

5.4.1 General

The IEC systems approach has moved on from a strategic vision to an operational reality today. It is therefore necessary to go into more detail as to how this approach could be implemented and how the systems committee and TCs interact around smart energy Use Cases and requirements.

5.4.2 Governance policies

Figure 11 provides an indicative overview of 'who does what' when drafting smart energy Use Cases:

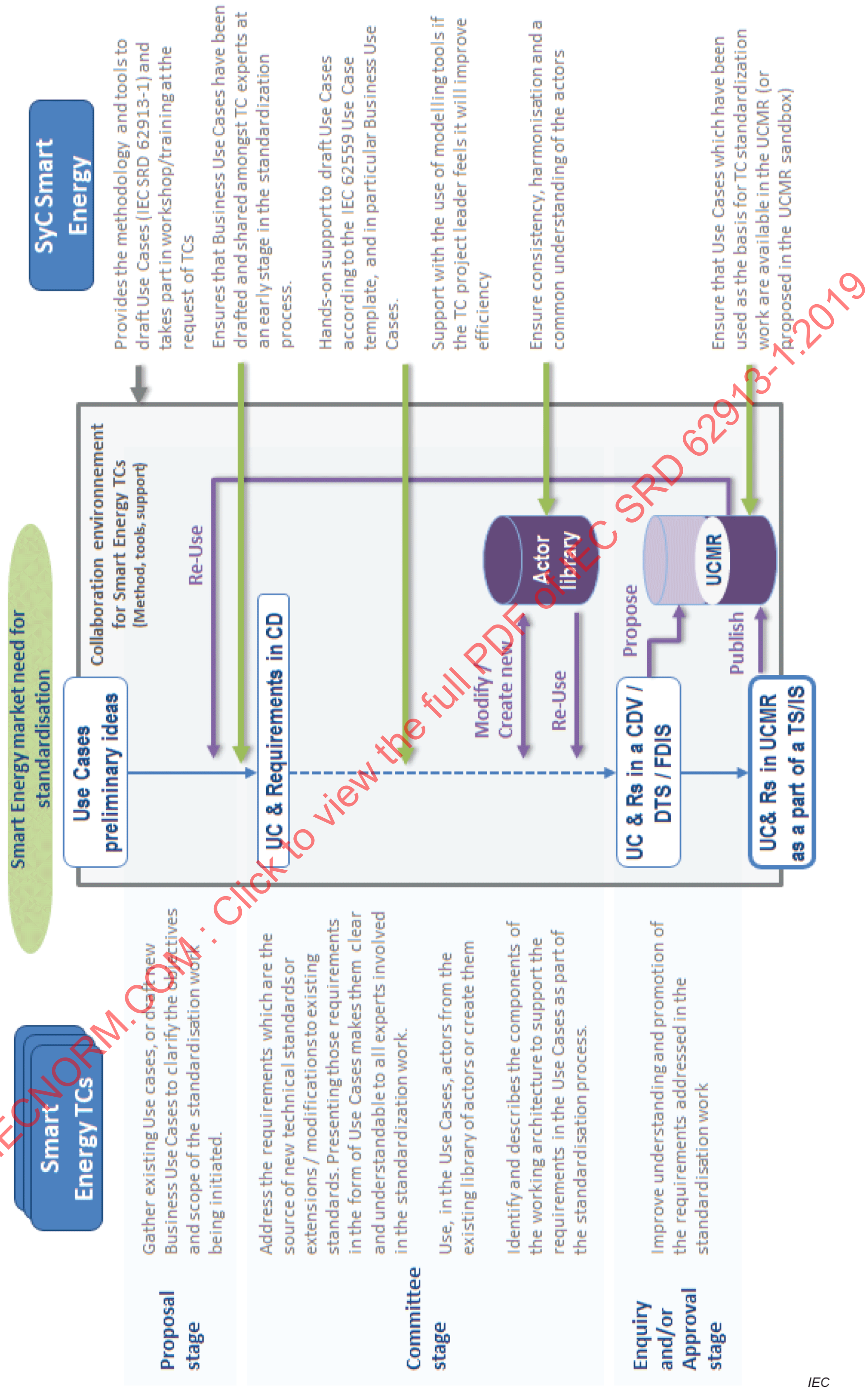


Figure 11 – Indicative interactions between SyC Smart Energy and smart energy TCs for drafting Use Cases

5.4.3 The Use Case Manager function

5.4.3.1 General

A Use Case manager function may be useful within a technical committee (TC) to help manage Use Cases. The following roles and responsibilities are based on best practices currently in use within IEC TCs (specifically TC 57) and may serve as guidelines for TC officers.

In the working process of describing requirements for future standardization work with systems committees, it is important for a technical committee to be able to consolidate, share and explain the Use Cases used as a basis for its standardization work.

In order to reinforce the way Use Cases are managed by TCs, offer a view/map of the TC area or domain, and allow self-measure by TC of their level of maturity on Use Cases, 4.4.2 proposes simple and easy-to-use guidelines on roles and responsibilities of Use Case managers and Use Case roadmap reporting (template of Technical Report, Use Case roadmap and priorities, KPIs, …).

Subclause 4.4.2 is mainly inspired by the Use Case manager's roles and responsibilities and the links with the ongoing work on the management of Use Cases in IEC TC 57.

5.4.3.2 Roles and responsibilities

Today, some TCs and SyC Smart Energy have identified the role of Use Case manager amongst their Working Groups and are working on their organization. This function is justified by the numerous Use Cases used for a long time in standardization work, those Use Cases are to be managed, shared and re-used. The first mission of a TC/SC or WG/JWG/PT Use Case manager is to consolidate a vision of the Use Case used for standardization work by his/her group. The main role of the Use Case manager is to make available, promote, explain and support its Use Cases for use in on-going and future standardization work in his/her group (TC or WG) or on-going work by other groups in IEC, independently or through JWG or TF as well as roadmaps and strategic vision through ad-hoc groups, strategic groups, systems evaluation groups or systems committees.

A Use Case manager is responsible for:

- identifying in existing International Standards, Technical Specifications, Technical Reports and in on-going work (CD, DTS, DTR, …) of his/her group perimeter the Use Case used as well as their links to standards, their status as Use Cases (level of description, standardization of the description referring to IEC 62559) and as IEC deliverables (Are they in a TR/TS/IS? What is the status of the document, CD, CDV,…?);
- helping the Systems Committee consolidate Use Cases through terminology work (link with existing relevant standards on the TC terminology) and building links between roles and modelling frameworks (role models). For example, building links between the Use case methodology and the roles used in IEC SRD 62913-2 with CIM Interface Reference Model (IRM – IEC 61968) is in progress;
- sharing and promoting those Use Cases within his/her TC and outside it, using the appropriate tools (update the future IEC Use Case Repository, use the collaboration tools of his/her TC, publish a TR on his/her Use Cases) and the appropriate structures (SyC, AC, JWG, …);
- explaining the content of his/her Use Cases to potential users and providing support on using those Use Cases for standardization (context, maturity of the Use Case, use in standardization work, roles implied, requirements extracted from it, …).

A Use Case manager should be responsible for the Use Case as well as the standardization requirements, the components of the working architectures extracted from Use Cases and the roles (business and systems) and terminology used in the Use Cases.

5.4.3.3 Managing a Technical Report reporting on TC Use Case roadmap

Some TCs are structuring the Use Case manager work in a TR, for example TC 57 has a preliminary work item consolidating TC 57 Use Cases (status, WG and documents linked, roles used, …).

This TR allows a TC to self-assess its work on Use Cases through KPIs such as:

- percentage of Use Cases compliant with IEC 62559-2;
- percentage of normative documents under preparation including or referencing business Use Cases;
- percentage of underwork normative documents including or referencing system Use Cases.

This is intended to be an annual TR to report on Use Cases to facilitate the use and re-use of Use Case for standardization work inside a TC and in its collaboration with other TCs. It will list the following elements:

- existing Use Cases used to develop standards and their links with source documents, the IEC status of this source document, a short Use Case description, its compliance to IEC 62559-2 (see Table 3);
- a roadmap: planned or drafted Use Cases (in on-going standardization work and PWI);
- roles used in those Use Cases, see Table 4;
- terminology used in standardization work and not present in existing standards.

Table 3 is an example of reporting of a TC Use Cases roadmap.

Table 3 – Reporting of a Technical Committee Use Cases roadmap

Organization	Document	Use Case Title	Status	Description	Compliance IEC 62559-2	Actors
IEC TC 57	IEC 62325-451-2:2014	Transmit planned schedules	IS	Business Use Case The transmission system operator has to be informed of the commodity trades made by the market participant, either through a third party, such as market operator (power exchange) or a nomination validator (coordinated international OTC trade), or with another market	No	TSO Market operator Nomination validator
IEC TC 57	IEC TR 61850-90-6	Volt-Var Control	TR	System Use Case	Yes	

Table 4 is an example of reporting on roles used in a Technical Committee Use Case.

Table 4 – Reporting on roles used in a Technical Committee Use Case

Document	Actor name	Actor description
IEC 61968-9	AM-EINV (substation and network inventory)	Substation and network inventory The electrical substation and network assets that a utility owns, or for which it has legal responsibility, and will maintain an accurate asset register developed around an asset hierarchy that supports advanced asset management functions. Abstract components: • Equipment characteristics • Connectivity model • Substation display • Telecontrol database

5.4.4 Naming and harmonization of roles and actors

Roles and actors are a fundamental component of Use Cases (see 5.2.3), and ensuring the consistency of smart energy requirements will be more easily achieved if we can ensure the consistency of the naming of the roles and actors and their definitions, and make them available to IEC experts when drafting smart energy Use Cases.

A future part of IEC SRD 62913 will be a database-type deliverable (see ISO/IEC Directives Part 1: IEC Supplement, Annex SL), namely a collection of roles and actors with their definitions, managed in a web-accessible database requiring maintenance on a continual basis (additions, amendments).

The methodology proposed for the naming of roles and actors will be detailed in this future part of IEC SRD 62913 (IEC SRD 62913-3), and is based on the following principles.

- Roles and actors need to be described both in a short format, so they can be easily manipulated, and a long format, which needs to be unique and unambiguously understandable.
- Long name format should be based on existing names and definitions to facilitate understanding. We propose to use the Interface Reference Model (IEC 61968) to initiate the naming, as it is a solid foundation for the electric grid functions and components, which could be extended for example to include communication networks (not just power networks). The Smart Grid Architecture Model (SGAM) zones could then be added to the name in order to clarify the area of application of a role.
- System actors may require a further level of detail when named to include its functions, possibly sub-function and if needed, then specialization.
- The proposed long name methodology highlighted above can also be used to determine whether existing roles or actors with their short names are actually one and the same.

5.5 Approach used to elaborate a consolidated smart grid role model

The business analysis carried out per domain will identify the business roles and the Use Cases they are contributing to achieve. These business roles and Use Cases will be consolidated to elaborate a smart grid role model. Navigation into the complexity of this role model will be facilitated by UML models.

The purpose of this role model is to give an overall view of the interactions between domains, roles, and the business Use Cases which are being created or modified with smart grid. More precisely, the role model outlines the nature and the importance of these interactions. This role model will figure in all subparts of IEC SRD 62913-2 (see Figure 12).

Several types of relations may be highlighted, such as:

- relations between domains, which can be deduced from relations between business Use Cases from different domains or between business Use Cases and roles from different domains;
- relations between roles, deduced from 'inherited' relationships;
- relations between a role and several Use Cases;

Note that the importance of the relations between domains or roles is represented on the diagrams by the thickness of the line between them (illustrated in Figure 13).

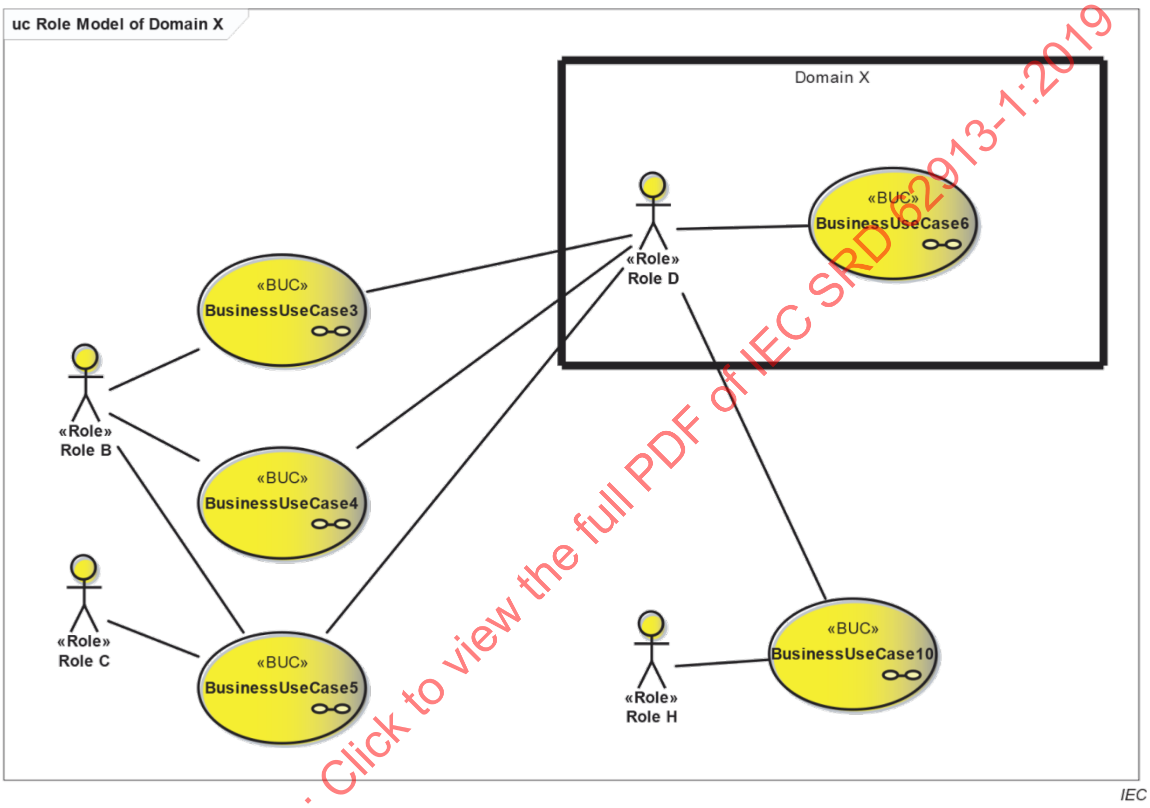


Figure 12 – Example of representation of a domain's role model

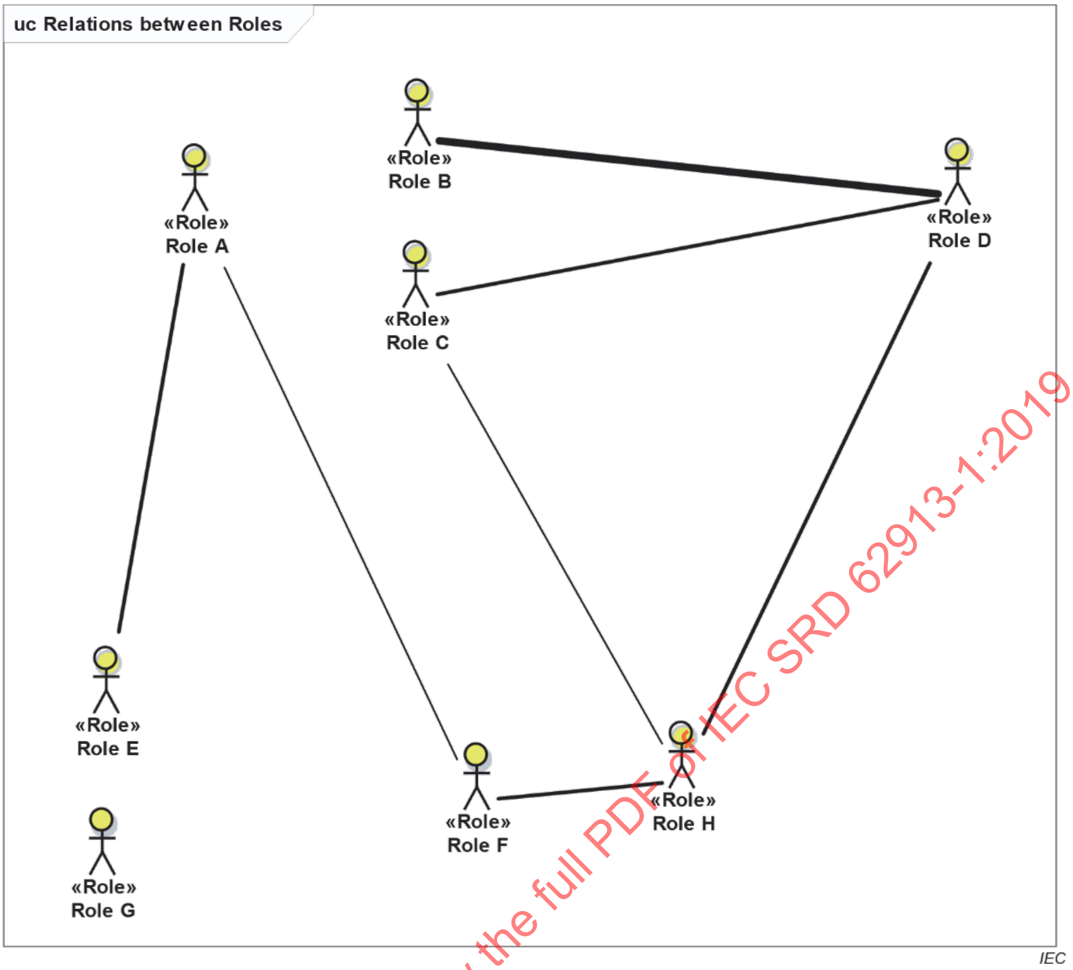


Figure 13 – Example of representation of relations between roles

6 UML profile for modelling smart grid Use Cases

6.1 A formal approach of Use Cases modelling

6.1.1 General

Subclause 5.1 presents the benefits of a formal Use Case model within a model driven engineering context and proposes a UML profile to model a Use Case. This UML profile for describing IEC SRD 62913 Use Cases is aligned with the IEC 62559 series which enables direct mapping with serialized IEC 62559-3 exchange format and automation such as import/export capability between IT environments, coherency analysis, validation, and other engineering automations (documentation generation, code generation).

Based on this profile, other work extensions can be provided, for example, it will be now possible to align this work with enterprise architecture metamodels.

6.1.2 Key principles

To ensure consistency in the UML Use Case approach and to tailor the IEC 62559 Use Case methodology to the need of deriving generic smart grid requirements, this document sets up key principles for Use Cases modelling.

a) Organize information

During the modelling phase of the system with this approach, information will quickly grow. However, having more data is only helpful when it is possible to manage it in order to retrieve the desired bits of information. Therefore, to preserve its usefulness an organization system must be set up. In particular, this system must be able to facilitate the exploration of the data and minimize the redundancy.

b) Remove ambiguity

Project teams using this UML Use Case approach will generally comprise people with various backgrounds. Therefore, people can be novices in the modelling domain. To soften the learning curve and to foster communication, a first step is to remove ambiguity: assign one clear purpose to each artefact.

c) Prefer practicality

Use Cases are written in the context of the general specification of a system. All information in Use Cases helps to write this specification. Therefore, Use Case delivers value only if its data are relevant and understandable to members of the system domain. For example, an action on comprehension can be: other things being equal, Use Case must respect standards of the domain (e.g. vocabulary).

6.2 UML driven top-down approach methodology

6.2.1 Formalism and objectives

Use Case methodologies possess a low level of formalism using semi-structured data. The constraint to comply with an IEC standard favours a higher level of formalism to enable automated processes (transformation, analyses). A formal model also facilitates the creation, selection and management of information described by Use Cases.

To model a Use Case, different elements need to be considered.

- A first level of description outlines information specific to the Use Case under study, such as its roles or its activities. This information can be modelled using UML diagrams.
- A second level of description covers information specific to the system under design, which is shared between all Use Cases. This includes any information required to position a Use Case within the system, such as its relations with other domains or with other Use Cases.

Moreover, information can be structural or behavioural. Structural information describes static properties of an entity, such as the roles of a Use Case. Behavioural information represents dynamic properties. For example, the execution of an activity in a flowchart depends on previous executed activities.

To benefit from a high level of formalism with limited disadvantages, this methodology creates two kinds of artefact: diagram and view. A diagram describes visually a system in a Use Case context. It must strictly conform to a meta-model and therefore possesses a high level of formalism. Diagrams contain reference data and must minimize information redundancy. Therefore, diagrams are used to input information during the creation phase. Views do not comply with a meta-model and therefore allow for more freedom and creativity. Views are used to communicate on Use Cases but do not contain reference data.

6.2.2 Modelling language

Criteria to select a modelling language were a widespread dissemination to reduce the learning curve, a strong ecosystem to provide mature tools and technologies, a visual representation to facilitate manipulation and comprehension and a customization capability. UML (Unified Modelling Language) maintained by the OMG (Object Management Group) is widely used and possesses high expressivity power to describe workflows.

The methodology retains UML for three reasons. Firstly, it can be used not only to model processes but also data for example. Secondly, it has strong customization capability (profile). Thirdly, the initial community using the methodology was more familiar with UML and UML is mentioned as the preferred choice in IEC 62559-2 for diagramming Use Cases. In a technical context, this methodology respects the standard model driven architecture (MDA) approach and its formalism is defined through a UML profile. Figure 14 describes the position of this methodology within the four-layer architecture from the OMG.

Specific notions like business Use Cases or system Use Cases are defined through a dedicated UML profile in the M1 layer. Then a model using these elements applies the UML profile to represent structured information in coherence with IEC SRD 62913 and IEC 62559. Therefore, a specification written with this methodology is an instantiation of the model presented in the M1 layer.

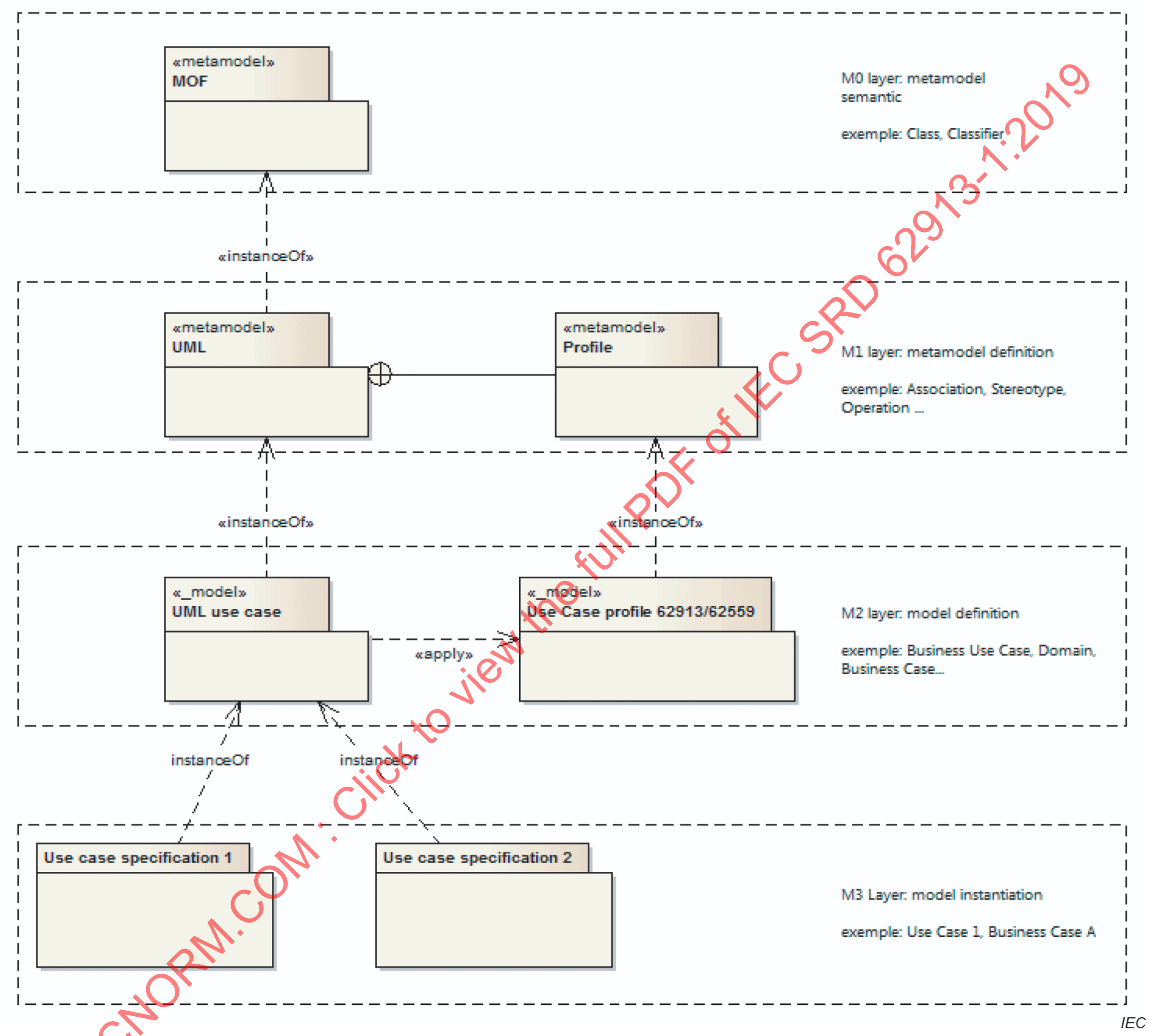


Figure 14 – Four-layer model architecture

6.2.3 Scope and information type classification: diagrams and main elements

To organize information, an organization plan is built around two axes: scope and information type.

The first axis, scope, allows refining the description of the system through a list of successive scopes. Each successive scope increases the level of detail at the cost of a reduced perimeter. Therefore, each scope is built around a different set of main elements. The following scopes exist.

- The domain scope has the specificity to position the system through its Use Case in its environment. The main elements are the domains and business cases. A business case explains why a course of action is aligned with enterprise goals. The obligation to associate business Use Cases to business cases ensures that Use Cases deliver value and support the enterprise strategy.

- The second scope is built around the Use Case element. A Use Case is a specification of a set of actions performed by a system which yields an observable result that is of value for one or more actors or other stakeholders of the system (definition from IEC 62559-2). Moreover, a Use Case in IEC SRD 62913 is specialized into a business Use Case (BUC) or a system Use Case (SUC) to describe respectively the business and system points of view. A Use Case represents an information unit of the system that can be disputed and understood on its own.
- The third scope details a part of a Use Case through a scenario. A scenario describes a workflow that achieves some goals of the Use Case. To facilitate the combination of scenarios to model the Use Case workflow, a scenario is not considered like a simple alternative to a normal/best path.
- The fourth scope uses the main element activity to add finer grained details. An activity represents a step of a process that can be accomplished by one or more roles. In the case of complex system, an activity can be subdivided into a set of internal activities. This scope is also used to describe information exchanges.

The second axis, information type, is used to classify information in two categories: structural, and behavioural.

- Structural information belongs to the overview diagrams. These diagrams present static data about a main element. For example, a Use Case overview diagram shows objectives of a Use Case. This information is independent of the current execution state of the Use Case.
- Behavioural information belongs to the flowchart diagrams. These diagrams describe a process through a graphical representation of a workflow. For example, the execution of a scenario can be described with a succession of activities.

6.2.4 Key benefits

6.2.4.1 From a formal meta-model

A meta-model is a model of a model (i.e. an abstraction of an abstraction). A meta-model can be seen as the grammar of the model. To remove ambiguity and to allow a program to reason on the model, we choose a formal meta-model. In our proposed UML approach, we can gain two major benefits from our meta-model: model verification and transformation.

The verification can check if the model respects formally the semantic and the syntax defined in the meta-model. However, the same mechanism can be used to improve the quality of model by detecting suspicious choices and proposing to refactor these parts.

Model transformation is at the heart of the MDA. A meta-model allows defining transformation between semantic concepts. These transformations are then instantiated and applied on models. Model transformation can generate views, exchange files, listing reports, etc. from information found in diagrams in the model.

Moreover, the content coherence can be analysed by business experts thanks to the use of generated views simplifying and aggregating details of a set of Use Cases for the specific different purposes depending on the responsibility of each expert.

6.2.4.2 From free views

The Use Case methodology, described in IEC 62559, considers strongly its environment. Use Cases are useful to establish a general specification of a system. However, this specification needs input data (business case, strategic vision, enterprise goal, ...) and will be refined through detailed specifications. During these phases, various points of view will be taken on the system. To maximize the usefulness of Use Case, it is required to analyse its data and present it in various views.

In our approach, we fulfil this requirement by introducing the notion of view, a non-formalized diagram. Views are used to communicate, show a subset of inputted or deducted data from the Use Cases.

6.2.4.3 From compliance with standard

This UML Use Case approach has been developed first and foremost to support IEC 62559 and IEC SRD 62913. Compliance with standards ensures an alignment of the approach with internationally approved practices that have been refined through various field experiments. For example, the core concept of categorization of Use Case in business and system Use Case derives straight from the standard. Sharing concepts in an international level allows creating a common Use Case set that will be the foundation of a common comprehension of a domain (like smart grid). IEC 62559 also defines interoperable exchange file formats to facilitate the creation of this Use Case set (see Figure 15).

The choice of a modelling language, a UML profile, which respects a well-established specification by the Object Management Group, allows being compatible with a large set of modelling tools. It also reduces significantly the learning curve by leveraging an adopted core semantic.

Use Cases are useful as input to other models or processes and therefore need to be analysed, transformed, converted. To do so Use Cases need to be formal, a possible approach to fulfil this prerequisite. The UML profile introduced in this document for describing IEC SRD 62913 Use Cases is aligned with the IEC 62559 series. This enables direct mapping with serialized IEC 62559 exchange format and automation such as import/export capability between IT environments, coherence analysis, validation, and other engineering automations (documentation generation, code generation, ...).

- IEC 62559-1: defines the Use Case methodology and core concepts.
- IEC 62559-2: defines the structure of a use case template, template lists for actors and requirements, as well as their relation to each other.
- IEC 62559-3 defines an XML based format for exchanging Use Case descriptions between IT environments (IEC Repository, UML Modelling Tools, other modelling tools, private enterprise repository, ...).
- This document describes a common approach to define generic smart grid requirements using the IEC Use Case methodology.

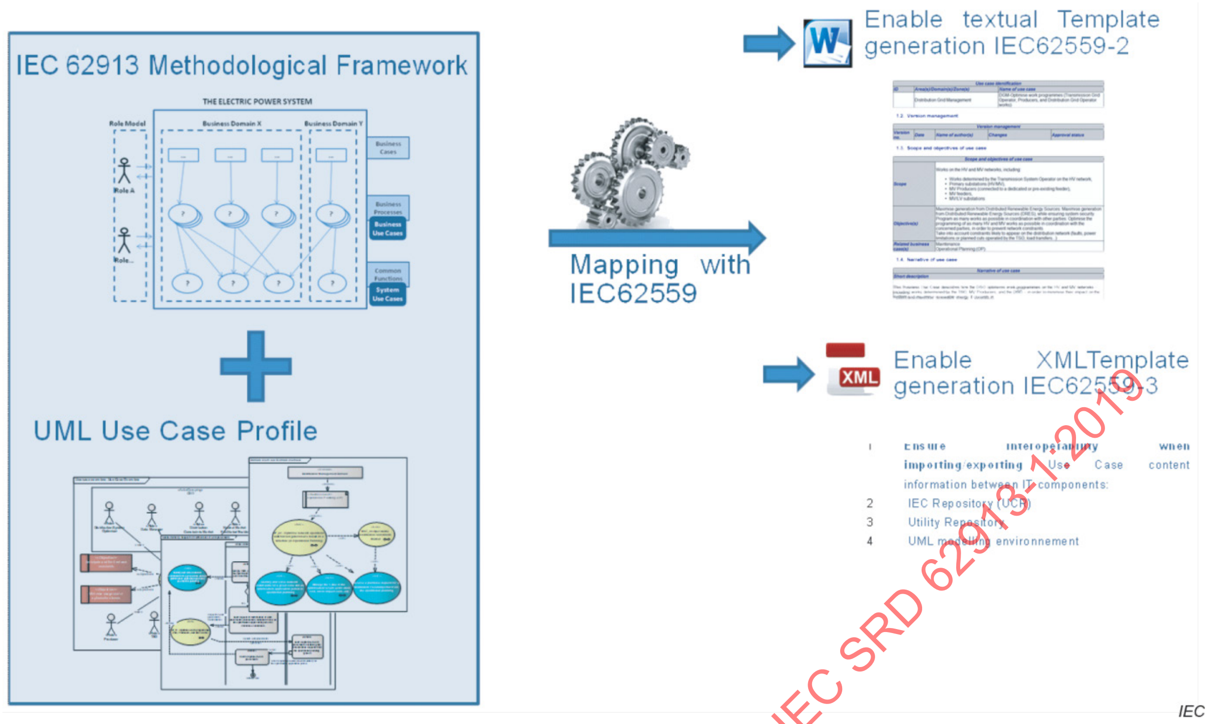


Figure 15 – UML Use Case profile for the IEC SRD 62913 series aligned with the IEC 62559 series

6.2.5 Types of diagrams and views

Four types of diagrams (with several views) are recommended to be used:

- Use Case overview diagram;
- domain overview diagram;
- BUC-SUC relations diagram;
- Use Case “flowchart” (activity and/or sequence).

The Use Case overview diagram (see Figure 16) contains structural information. It presents the main properties of a Use Case such as objectives or scenarios, and the major associated entities. It can be considered as an alteration of the standard UML Use Case diagram with additional information.

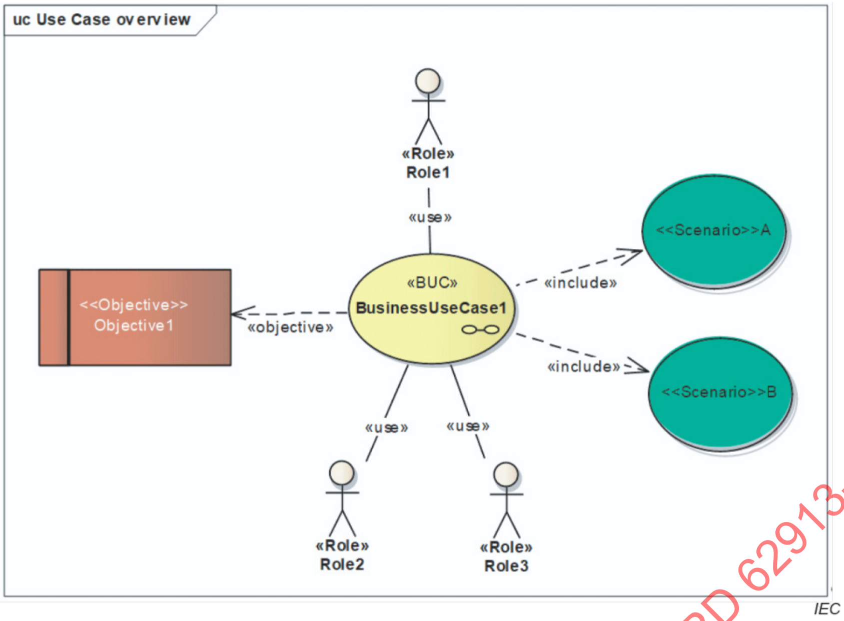


Figure 16 – Use Case overview diagram

The domain overview diagram (Figure 17) describes the system under design and contains structural information. It details the business context of the business Use Case under study by highlighting relations with other business Use Cases, strategic goals (business cases), and domains. It should be noted that a business Use Case may be linked to business Use Cases from other domains.

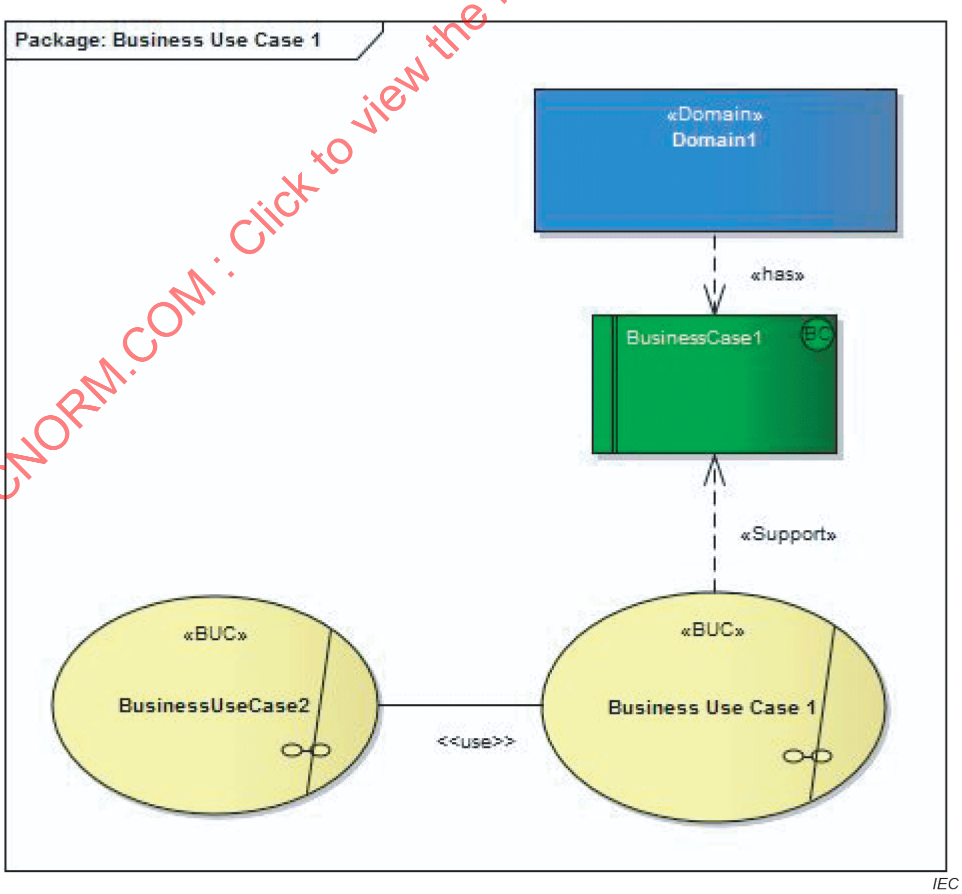


Figure 17 – Domain overview diagram

The BUC-SUC relations diagram (see Figure 18) highlights the relations between a business Use Case and its supporting system Use Cases. The latter describe the functions required to execute the business Use Case under study. These functions can be grouped within functional system groupings, i.e. information systems.

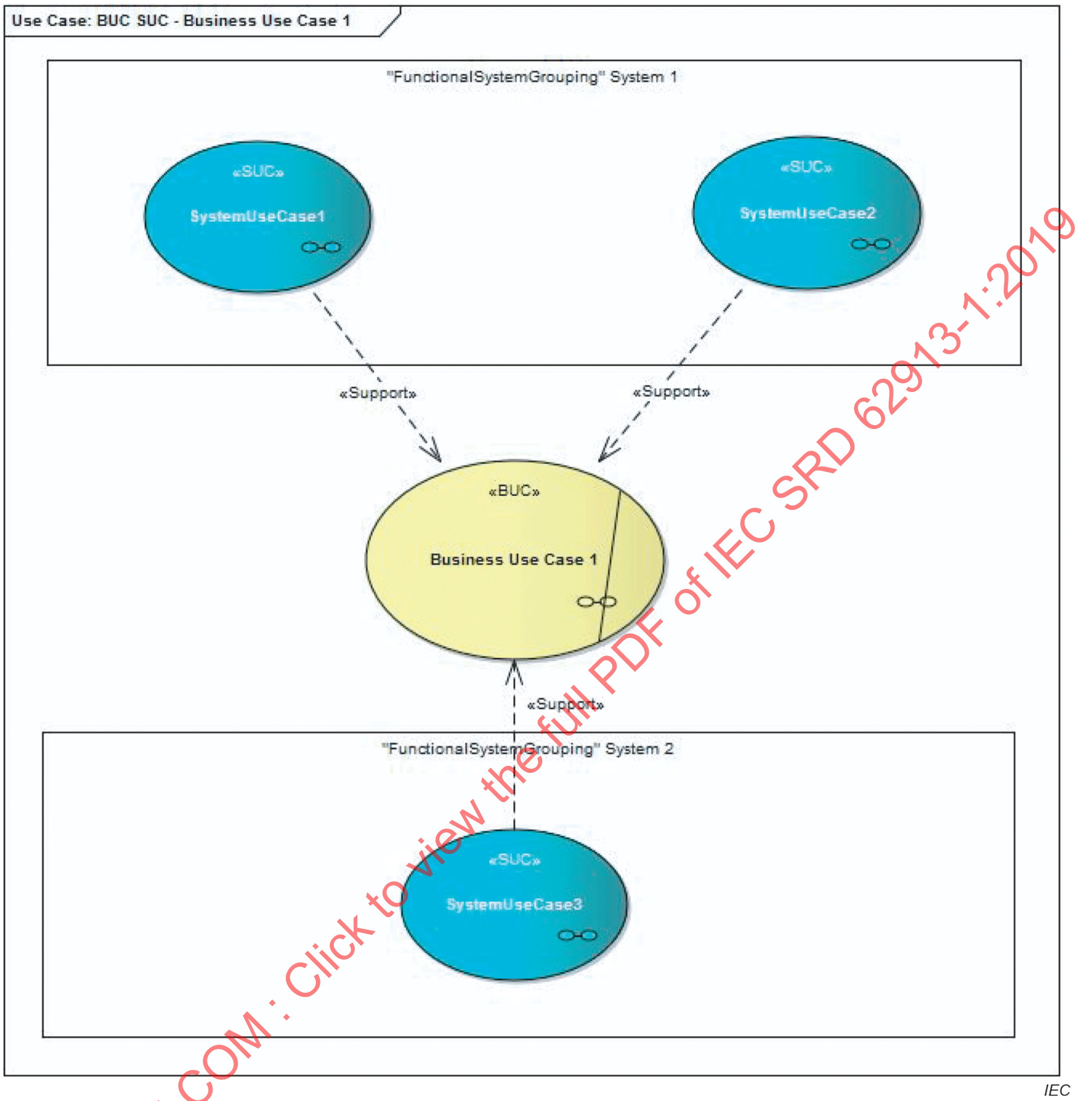


Figure 18 – BUC-SUC relations diagram

The Use Case flowchart contains behavioural information. It describes the internal process of the Use Case during its execution, through scenarios and activities. It is possible to represent the system Use Cases called by the steps of the business Use Case under study. Modelling approaches used are UML activity diagram.

6.3 IEC Use Cases UML profile concepts

Use Case concepts are listed in Table 5 and illustrated in Figure 19. The first column gives the name of the stereotype possibly followed by its attributes, the second column indicates which metaclass is extended and the third column provides short texts of description.

In this list, some stereotypes seem to be already present in basic UML like "activity". There are three reasons for this overlap. The first one is to allow greater flexibility when adapting the visual representation. The second one is to facilitate model manipulation by identifying clearly elements relevant to Use Cases. The third and last one is to anticipate future needs. Base metaclass defines what kind of association can be used between stereotyped elements.

Table 5 – Use Cases concepts

Stereotype	Metaclass	Description of the Use Cases concept
Activity	Activity	An activity describes a part of a scenario that can be executed by one or more roles. The details of an activity are described through actions. However, if it is necessary, intermediate levels can be created where activities describe an activity.
Activity set	Activity region	An activity set groups activities executed by the same business roles and/or system roles.
Actor	Class	Entity that communicates and interacts.
Area	Class	Major usage area for Use Cases which supports grouping, filtering and administration of Use Cases within a common Use Cases database.
Assumption	Class	Is a constraint that must be verified in order to have a valid Use Case.
Business case	Class	An explanation or set of reasons describing how a business decision will improve a business, product, etc. and how it will affect costs, profits and attract investments, equivalent to strategic goals and principles of a domain.
Business object	Class	Describes information exchanged. It defines the nature of the information.
Business role	Class	A business role describes a finite set of responsibilities that is assumed by a party (organizations, organizational entities or physical persons).
Business Use Case	UseCase	Describe how business roles of a given system interact to execute a business process. These processes are derived from services, i.e. business transactions, which have previously been identified.
Contain	Dependency	Indicates an inclusion relationship between two elements.
Domain	Class	Area of knowledge or activity characterized by a set of concepts and terminology understood by the practitioners in that area [OMG UML]. A domain offers several business cases.
Has	Dependency	Denotes that an entity can only carry a comprehensible, useful meaning in relation with another entity. It is a directional relation. Moreover, if the source entity becomes irrelevant, the target entity also becomes irrelevant.
Key performance indicator	Class	Assesses the level of success of an objective.
Is mapped over	Dependency	Allows to establish a mapping between entities belonging to different semantic area.
Objective	Class	Refers to the goal of a Use Case. The success of an objective can be gradual and is assessed with key performance indicators.
Postcondition	Class	A condition that must hold true when the associated execution (scenario, macro-activity, action) is finished.
Precondition	Class	A condition that must hold true when the associated execution (Use Case, scenario, macro-activity, action) is beginning.
Requirement	Class	A requirement associated to any object must always be verified if the model is valid. A requirement can be seen as an invariant. A requirement can be functional or not (indicated by the kind attribute).
Scenario	Activity	Is a possible sequence of interactions [SG-CG/M490/E:2012-12 def 3.10].
Support	Dependency	An entity supports another one if it contributes to its process/goal.
System role	Class	A system role describes a finite set of functionalities that is assumed by an entity (devices, information system, equipment).
System Use Case	UseCase	Describes how system and/or business roles of a given system interact to perform a smart grid function required to enable / facilitate the business processes described in business Use Cases. Their purpose is to detail the execution of those processes from an information system perspective.

Stereotype	Metaclass	Description of the Use Cases concept
Use	Dependency	Describes a bidirectional association. Each of the linked entities can be understood without the other. Moreover, each entity can be employed in a very large panel of situations.
Use Case Classification Complete description Remark Scope Keyword LevelOfDepth Nature Prioritization	UseCase	Is a specification of a set of actions performed by a system which yields an observable result that is of value for one or more actors or other stakeholders of the system (IEC 62559-2). Information is structured through classification, complete description, remark and scope properties. Meta-information is written in keywords (tags), level of depth (granularity), nature (black-white box) and prioritization (international, national, regional,…) properties.
Zone	Class	Automation levels, classified in combination with a reference architecture

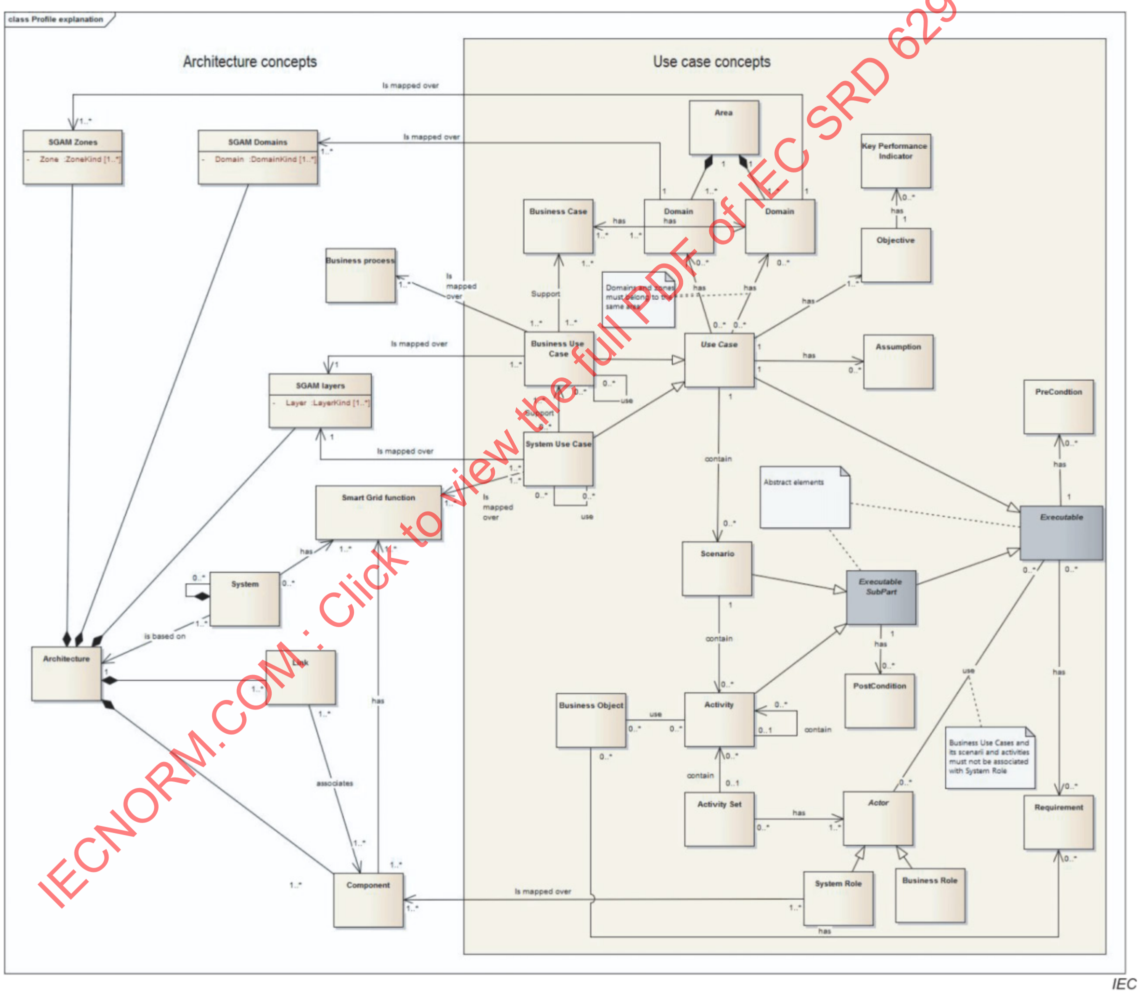


Figure 19 – Mapping between Use Case concepts and architecture concepts

7 UML modelling diagrams

Figures 20 to 23 show the diagram subsets. To complete these subsets, purely graphical elements like note or boundary are allowed.

Flowchart diagrams are based on UML activity diagram and describe steps of a process that can be a Use Case, a scenario or an activity. To organize information, in a flowchart diagram, all steps are described by a same type of element: scenario or activity. Moreover, exchanges of information occur only at the activity scope and these exchanges instantiate business object. To specify roles interacting during an exchange, activities are located inside activity sets. The activity sets are then associated to roles.

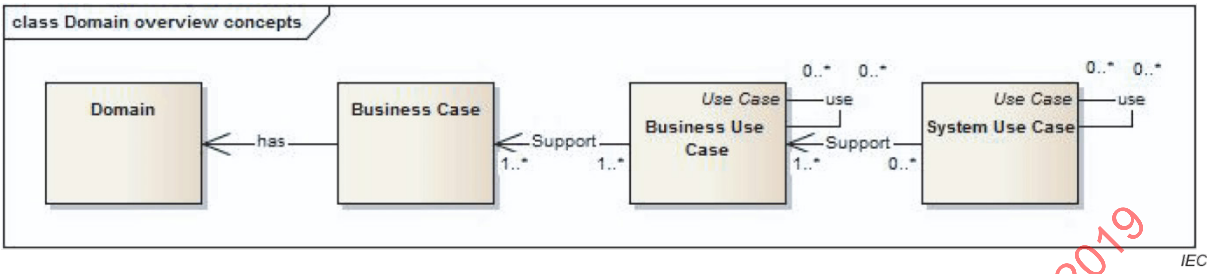


Figure 20 – Domain overview concepts UML model

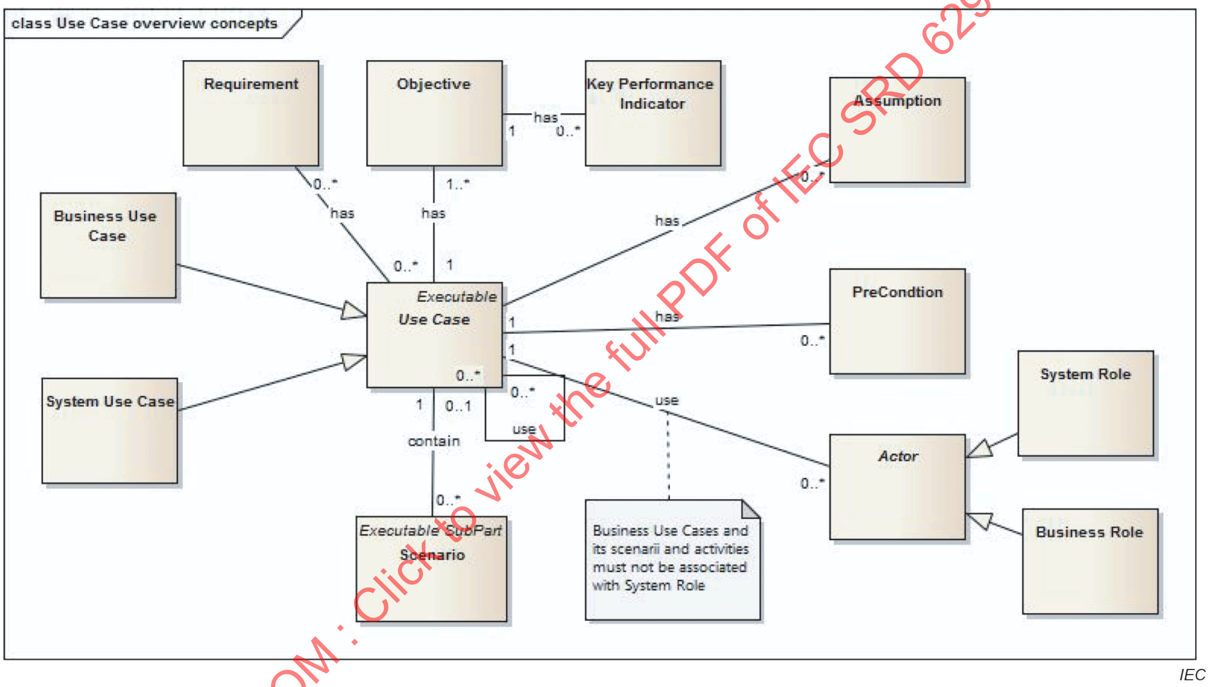


Figure 21 – Use Case overview concepts UML model

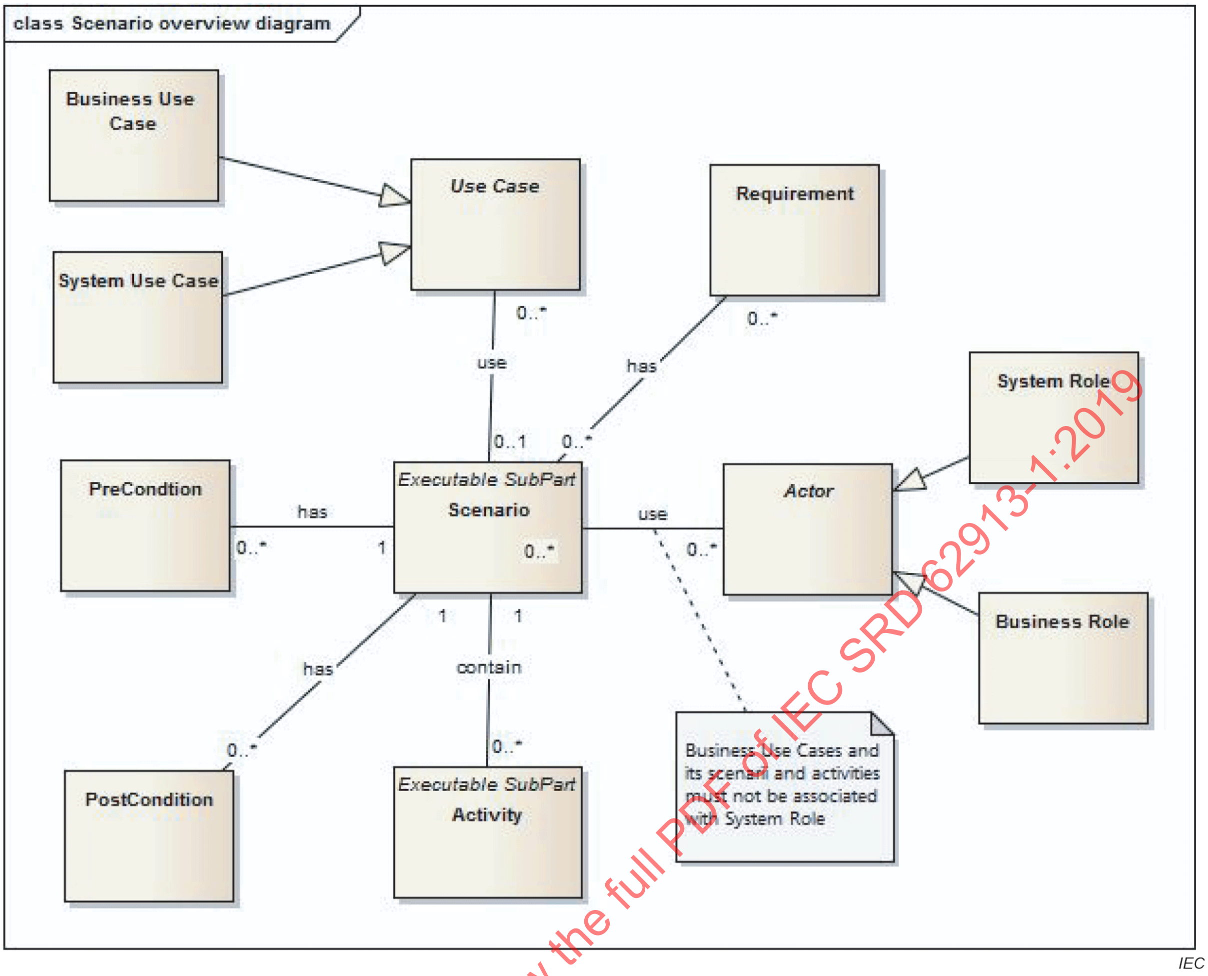


Figure 22 – Scenario overview concepts UML model

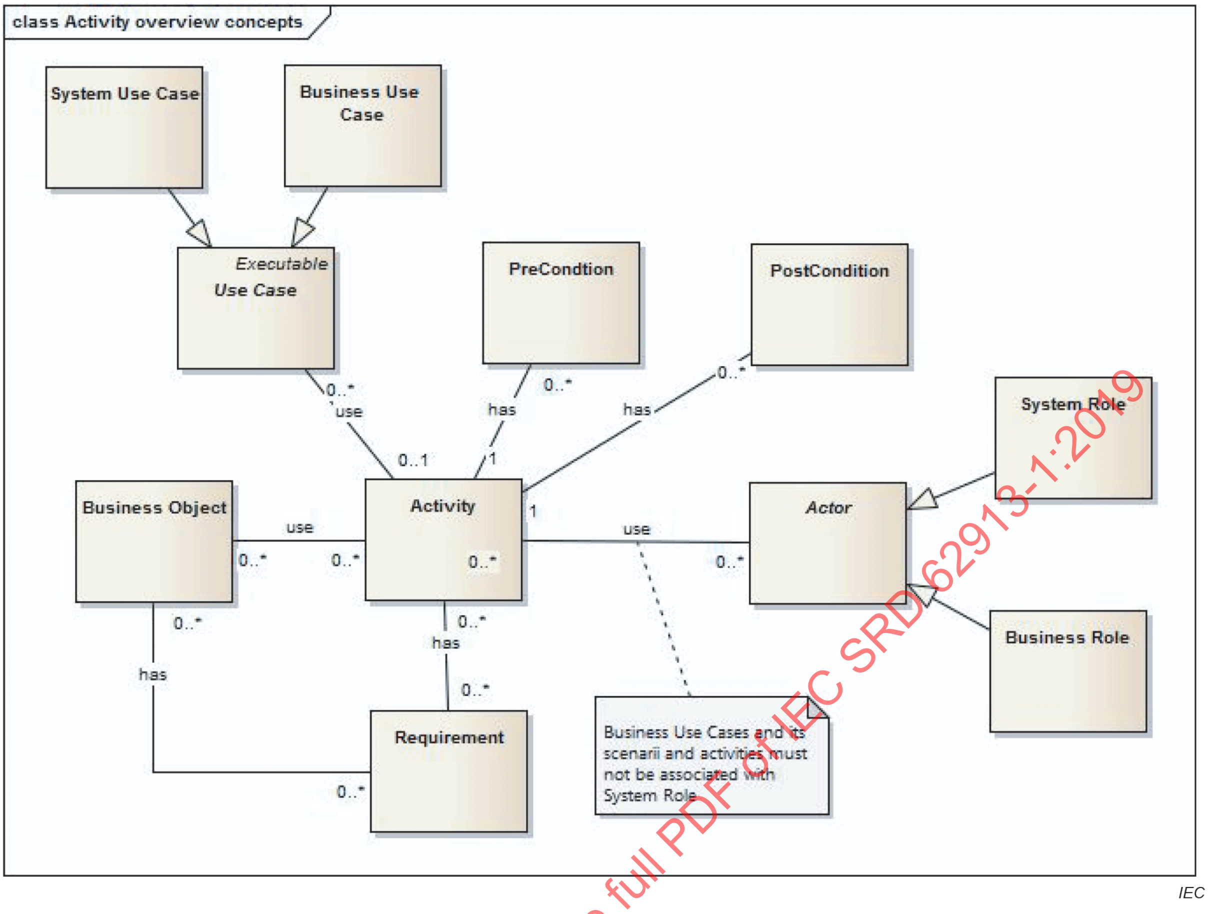


Figure 23 – Activity overview concepts UML model

Annex A
(informative)

Existing actors lists

– CEN/CENELEC/ETSI Actors List from CEN-CENELEC-ETSI Smart Grid Coordination Group – Sustainable Processes (2012), based on:

- IEC 61968 Interface Reference Model (which is described in IEC 61968-1);
- ENTSO-E Role Model. Based on ETSO, EFET, EbiX role model;
- SMCG: Smart Meter Coordination Group associated to M441 mandate.

– NIST IKB Actor List (draft in progress, v1.1.3 last updated on 8 August 2013), document consolidating and harmonizing Actors from:

- Energy Information Standards (EIS) Alliance Customer Domain Use Cases Version 3.01 (21 May 2010);
- NIST's Framework and Roadmap Version 1.0: Conceptual Model (10 August 2009);
- NIST's Framework and Roadmap Version 1.0 – Chapter 4 + two new areas AMI (10 August 2009);
- NAESB;
- NIST's CSWG NISTIR (July 2009);
- IEEE P2030 Draft3.0, Chapter 6 Power System Actors (July 2009);
- SGAC Conceptual Architecture – Interaction Diagrams (1 March 2012).

Annex B
(informative)

Content of the Use Case mapped on IEC 62559-2 template

B.1 Description of the use case

B.1.1 Name of use case

Use case identification		
ID	**Area / Domain(s)/ Zone(s)**	**Name of use case**
Use case overview / BUC or SUC / tagged value(identifier)	Domain overview / each domain associated through business cases / name	Use case overview / BUC or SUC / name

B.1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**
Documentation / Versions / name of the attribute	Documentation / Versions / tagged value(date)	Documentation / Versions / tagged value(authors)	Documentation / Versions / note of the attribute	Documentation / Versions / tagged value(status)

B.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Documentation / Narrative / note of attribute scope
Objective(s)	Use case overview / each objective / name: note (one line per objective)
Related business case(s)	Domain overview / each associated business case / name: note (one line per business case)

B.1.4 Narrative of use case

Narrative of use case
Short description
Use case overview / BUC or SUC / note
Complete description
Documentation / Narrative / note of attribute completeDescription <u>Summary of use case</u> • Each Scenarios flowchart / each scenario / name <u>Description</u>: note • Each activities flowchart / each activity / name <u>Description</u>: note • Each activities flowchart / each activity / name …