IEC SRD 62913-2-1

Edition 1.0 2019-05

SYSTEMS REFERENCE DELIVERABLE

colour inside

Generic smart grid requirements –
Part 2-1: Grid related domains

IEC SRD 62913-2-1:2019-05(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 29.020; 29.240; 33.200

ISBN 978-2-8322-6880-3

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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GENERIC SMART GRID REQUIREMENTS –

Part 2-1: Grid related domains

FOREWORD

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IEC SRD 62913-2-1, 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/78/DTS	SyCSmartEnergy/96/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 publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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

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

INTRODUCTION

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 energy.

The purpose of the IEC SRD 62913-2 series is to initiate the process of listing, organizing, making available the Use Cases which carry the smart energy requirements that should 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 technical committees, National Committees and experts, the IEC SRD 62913-2 series should be seen as an illustration and the first stepping stone towards this systems approach implementation. Referencing, naming and grouping Use Cases or requirements will be further developed when tools such as IEC Use Case repository are available (using SGAM and other classification methods). The current content of the IEC SRD 62913-2 series is not exhaustive, but the current content illustrates the priorities for the smart energy domain at the time of publication. It is important that the content in terms of Use Cases, roles and requirements continues to grow to encompass the requirements of the broad smart energy stakeholders (both within the IEC community and more generally the other market stakeholders).

Use Cases are, for now, classified as follows.

- For business Use Cases: SGAM Domain {G|T|D|DER|CP} (multiple domains possible) / B_{Business Use case number}/SB_{ sub BUC Use case number/…}
- For system Use Cases: SGAM Domain {G|T|D|DER|CP} (multiple domains possible) / (sub) Business use Case Ref /S_{ System Use cases number}/SS_{ Sub System Use cases number/…}

The document for each domain is composed as follows.

- Purpose and scope.
- Business analysis: to address the 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 and technical committees.
- 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 2-1: Grid related 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 grid related domains – i.e. grid management regrouping: transmission grid management, distribution grid management, microgrids and smart substation automation domains – based on the methods and tools developed in IEC SRD 62913-1.

The Grid management domain groups Use Cases and associated requirements common to the EHV, HV and MV/LV networks operations and the business analysis of the general electric network life cycle. Use Cases specific to parts of the general electric network are described in transmission grid management, distribution grid management, microgrids and smart substation automation clauses.

This document captures possible "common and repeated usage" of a smart grid system, under the format of "Use 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.

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

Domain	Content	Scope
Grid management	Described with 1 business Use Case	Asset management
Transmission grid management	n/a	
Distribution grid management	Described with 1 business Use Case and 2 system Use Cases	Network operations in real time using new automations / centralized voltage control
Microgrids	Described with 1 business Use Case	
Smart substation automation	Described with 1 business Use Case	

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
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: This definition is based on Eurelectric, Active Distribution System management. A key tool for the smooth integration of distributed generation, 2013.

3.1.2
grid
electrical power system through which power is generated, transmitted, and distributed to the end user

3.1.3
electrical network constraint
network state where the operation requirements are locally not met and which depends on the split between injection and withdrawal, the network topology and random event in a specific area of the distribution network (faults, transmission limitation or transmission outage, and load transfers)

[SOURCE: based on evolvDSO, D2.1 Business Use Cases Definition and Requirements, 2014]

3.1.4
on-load tap-changer
OLTC
switch group allowing transformer tappings to be changed without interrupting the traction circuits

[SOURCE: IEC 60050-811:2017, 811-29-28]

3.1.5
optimization levers
operational solutions or measures to be used by a system operator to operate its network in an optimized way

Note 1 to entry: The access and use of optimization levers, especially those related to flexibilities connected to HV/MV/LV networks, should be coordinated between the system operators operating in the same zone in order to ensure a technical and economic optimum.

Note 2 to entry: Some levers have a global impact on network operations, while others have a localized impact.

Note 3 to entry: Three categories of levers are defined:

– technical levers (HV or MV network reconfiguration, bus-bar voltage regulation in primary substation, etc.);

– market-based and contracted flexibilities for the system operator needs – to be further defined in close coordination with transmission grid management, distribution grid management and market domains;

– emergency levers (targeted power limitation, load-shedding, etc.).

Note 4 to entry: Emergency levers are only used if no other optimization levers are available.

Note 5 to entry: Optimization criteria may embrace many criteria, such as OPEX optimization, CAPEX optimization, customer satisfaction, regulation compliance, environmental impacts, company awareness, etc.

[SOURCE: based on evolvDSO, D2.1 Business Use Cases Definition and Requirements, 2014]

3.1.6
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, serveability performance, service integrity and other factors specific to each service.

Note 2 to entry: ISO defines "quality" as the ability of a product or service to satisfy user's needs.

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

3.1.7
security
<of an electric power system> ability 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

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.

[SOURCE: IEC 60050-191:1990/AMD1:1999, 191-21-03]

3.1.8
work programme
schedule for operations related to the creation, maintenance, and repair of network assets on the transmission or distribution grid

[SOURCE: evolvDSO, D2.1 Business Use Cases Definition and Requirements, 2014]

3.2 Abbreviated terms

BRP Balance Responsible Party
CAPEX CAPital EXpenditure
DER Distributed Energy Resources
DGA Dissolved Gas Analysis
DMS Distribution Management System
DR Demand-Response
DSO Distribution System Operator
EES Electrical Energy Storage
EHV Extremely High Voltage
EV Electric Vehicle
FCR Frequency Control Reserve
FLISR Fault Location, Isolation, and Service Restoration
FPI Fault Passage Identification
FRR Frequency Restoration Reserve
HV High Voltage

HVDC	High Voltage Direct Current
IED	Intelligent Electronic Device
ICT	Information and Communication Technologies
LV	Low Voltage
MEMS	Microgrid Energy Management System
MV	Medium Voltage
OPEX	OPerational EXpenditure
RR	Restoration Reserve
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition System
SGAM	Smart Grid Architecture Model
TSO	Transmission System Operator

4 Grid management

4.1 Purpose and scope

4.1.1 Objective

The purpose Clause 4 is to present a business analysis of the grid management, and more specifically to describe some smart grid requirements using the Use Case approach as defined in IEC SRD 62913-1.

This analysis is based on existing materials, including user stories, set of Use Cases, and architectures.

4.1.2 Informative general context of grid management

4.1.2.1 General context and challenges facing grid management domains

Grid management domains today face several challenges, which tend to significantly change the way their actors operate. These challenges are the following:

- a continuous growth of the peak load in most countries, both at system and local levels, and in some cases the increase of the annual demand for electricity;
- the integration of a fast growing number of distributed energy resources (DER), mostly connected to MV/LV networks, variable and uncertain by nature;
- new and changing usages of electricity, with the development of demand response (DR), the growth of electric vehicles (EV), the implementation of energy demand management policies and customer empowerment initiatives;
- the evolution of electricity markets and the creation of new ones, such as flexibility and ancillary services markets, which tend to operate ever closer to real time;
- modifications in the regulatory frameworks and the strong expectations from regional and national regulatory authorities, which aim at managing or facilitating these transformations with the overall goal of promoting a sustainable, secure, and competitive energy supply;
- technological developments and innovations, which represent both opportunities and constraints for the different actors and stakeholders of the electric power system;
- development of individual and/or collective strategies of electrical grid users (or sets of electrical grid users) in relation with the electricity management, possibly leading to unexpected behaviour changes;
- increased cyber-threats impacting the grid operation, made possible by the increased use of “public” telecommunication means or technologies.

These changes and their combination contribute to transform in depth system operators. They have already started to and will continue to impact their business model and business processes.

4.1.2.2 The responsibilities of system operators in a changing environment

As indicated above, there are different types of networks: EHV, HV, MV, and LV networks and different boundaries between voltage levels which vary from country to country and system to system. MV/LV networks are generally operated with a radial grid topology, while EHV and HV networks are mainly operated with a mesh grid topology. They are usually operated by different system operators:

- Transmission system operators generally operate EHV and in some cases HV networks.
- Distribution system operators generally operate MV and LV networks, and potentially HV networks as well depending on the system.

Concerning the roles, the terms EHV, HV, and MV/LV system operators are used in this document.

System operators' responsibilities have fundamentally not been modified by the challenges facing the electric power system. Their core duties remain to develop, operate and maintain the network in order to deliver high-quality services to grid users and other stakeholders of the electric power system, while ensuring safety of people, most efficient use of assets, and system security. Each system operator remains responsible for managing the constraints of its own network (voltage regulation, reactive power, power quality, etc.). The coordination of the frequency remains in the hands of the transmission system operators in close cooperation with the other TSOs and all other actors connected on the same frequency area. More recently, the contribution to the transition towards a sustainable economy has emerged as an additional mission of system operators, along with other actors of the electric power system. These responsibilities are shared by all system operators and do not vary according to regional and national regulations or market models – only the way they exercise those may differ from one country to another and one system operator to another.

However, the challenges previously stated have a strong impact on the capacity of system operators to carry out their responsibilities. More precisely, they impact the way they design, operate, and maintain their networks. The integration of variable and uncertain generation capacities, combined with increased peak demand as well as other key factors, tends to intensify the need for network reinforcements and add complexity to the supervision and control of the electrical grid. These consequences may ultimately undermine system operators' ability to provide electrical grid resiliency, reliability of supply and quality of service in a cost-effective way.

The impact of these challenges may be different for system operators, depending on the network(s) they are responsible for managing.

The topology has consequences on the nature and criticality of the impacts induced by the challenges stated above, but also on the methods and tools used by system operators to manage their electrical grid.

For instance, the development of electric vehicles and the associated deployment of public and private EV charging stations will mostly have a significant impact on LV networks, to which they are connected.

Operational planning activities have already been developed in most systems for HV networks and implemented by EHV and HV system operator, while they have generally not been developed for MV/LV networks management.

4.1.2.3 The current design of electricity networks, its limits, and new possibilities

EHV, HV and MV/LV system operators have historically designed and operated their network according to a "networks follow demand" paradigm, by delivering energy flows in one direction from EHV centralized generations to the end users. Up until now, EHV, HV and MV/LV system operators prevented local constraints (function of protection systems, overcurrent, voltage limits) and congestions by planning network investments and adjusting the configuration of the electrical grid, in order to accommodate energy flows and meet peak loads. This method is known as the "fit and forget" approach as potential operational problems are solved in the planning phase.

Nonetheless, increased penetration of DER – which are in majority connected to the MV/LV network –, the rise of peak demand, and the development of new usages such as demand response programmes or electric vehicles, contribute to dramatically transform the power grid. Power flows are indeed operating in two directions and between a growing number of connected actors and devices. They become as a result less predictable. If the "network follows demand" approach does not require sophisticated control and supervision systems, it implies substantial network investments to integrate high shares of variable generation/load capacities and absorb peak demand, which constitutes one of the major drivers for network costs. With the transformations previously stated, connection costs and delays will potentially significantly rise as the extension and the maintenance of the networks are becoming more complex. Besides, the variability of power flows will increase the need for improved real-time monitoring and control tools. Such investments will turn out to be too heavy to be borne by system operators, customers, or decentralized producers.

Besides, constraints will occur more frequently, and are likely to be more critical and more complex to manage at both local and system levels (Eurelectric, 2013, ENTSO-E). More particularly, the occurrence, duration, and depth of faults, variations in voltage, and network perturbations such as flickers will continuously increase. Congestions or bottlenecks, which may lead to generation feed-in or supply interruptions, will also appear more frequently. The growing number and diversity of production and consumption installations connected to the MV/LV grid will heighten the variability of power flows and increase the system frequency variability. Ensuring grid connection and access and restoring power supply after a fault on the network will therefore become more complex and require more precaution and time.

As traditional means will no longer be technically sufficient or economically viable, EHV, HV and MV/LV system operators need to find new solutions to continue ensuring quality and security of supply at an affordable cost and in a non-discriminating way. In addition to necessary investments on the network, the transformations previously stated urge the need for the development of a more active system management approach. This approach, opposed to the purely passive one previously described or a 'reactive' one consisting of managing problems only in the operational phase, would allow for interaction between the network's different timeframes (Eurelectric, 2013):

- planning and connection, with a range of network planning and access options enabling EHV, HV and MV/LV system operators to optimize their investments and the most efficient use of network assets – including decisions regarding asset renewal priorities and maintenance programmes optimization;
- operational planning, with technical tools allowing EHV, HV and MV/LV system operators to prepare network operations in advance;
- real-time operations, with the optimization of demand and generation management and improved handling of emergency and fault situations;
- evaluation and ex-post control, to facilitate electricity markets via data management and provision, but also to improve network planning and operation processes using processed data.

It includes business Use Cases and system Use Cases related to:

- the long-term planning and development of the electricity system, including connection and access;

- the operational planning and scheduling of the electricity system, across all voltage levels;
- the operation and maintenance of the electricity system;
- the facilitation of electricity markets, which will be described within the market domain in close coordination with the transmission and distribution grid management domains;
- new connection (generation, consumption, high-voltage direct current (HVDC));
- emergency and restoration of supply;
- load, frequency control and reserve.

Microgrids and private networks are out of the scope of the domain. They are considered in the microgrids domain.

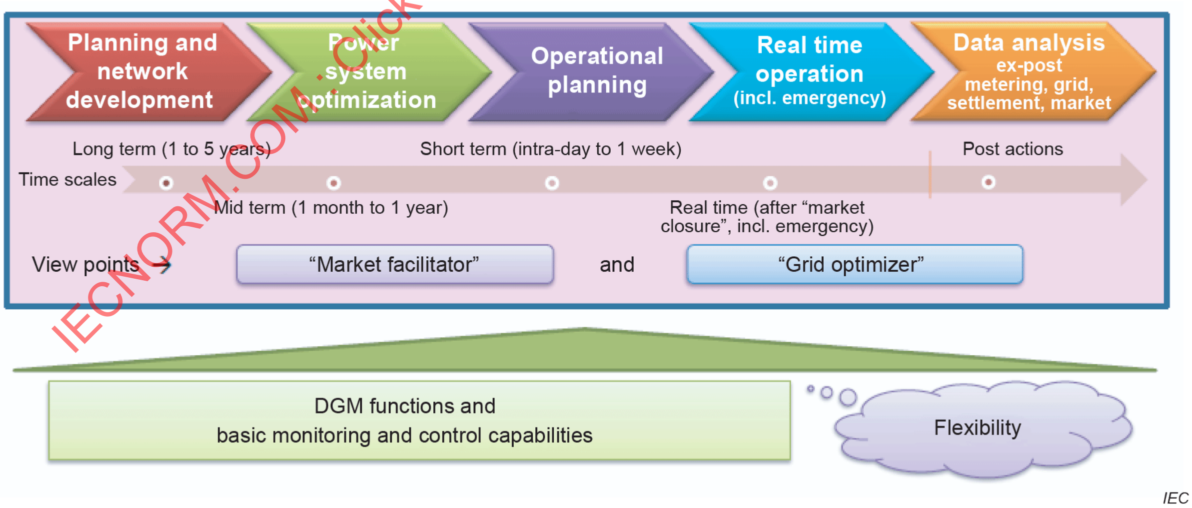
4.2 Business analysis

4.2.1 General overview

4.2.1.1 General

The transition from passive to active networks relies on the deployment of smart grid technologies including smart metering systems, as well as on the modification of existing roles and business processes of the EHV, HV and MV/LV system operators. Such evolutions will also tend to modify the relations between EHV, HV and MV/LV system operators as well as the other actors of the electric power system, such as grid users, regulators, balance responsible parties, retailers, or flexibility operators.

This new approach and associated smart grid solutions offer new solutions (distribution grid management (DGM) functions, monitoring and control capabilities) for system operators to further optimize the management and operation of their grid as described in Figure 1. They could be considered in some cases as cost-effective complement levers to traditional investment strategies – with the goal of bringing value for the society and taking into account global cost-benefits analysis – and may be used to improve grid reliability of supply and quality of service while optimizing network investments without de-optimizing the global network chain.



SOURCE: evolvDSO, 2014.

Figure 1 – New smart business processes enhanced by smart grid functions

The path towards an active approach includes the following opportunities:

- the improvement of network planning, operation and maintenance processes, in order to optimize network investments;
- the intensified cooperation between EHV, HV and MV/LV system operators, as well as generators, consumers, contractors, manufacturers and retailers throughout market mechanisms as much as possible;
- the need to contract and activate flexibilities at different timeframes to optimize network design and operations and solve specific electrical network constraints – in coordination with existing market principles/rules and in a neutral and transparent way;
- the ability to facilitate and enable electricity markets in a neutral and transparent way;
- the possibility to provide data-based services to facilitate national and local public policies and enable customer empowerment in compliance with the regulatory framework;
- the increasing share of data between system operators (EHV, HV and MV/LV system operators, microgrids operators), retailers and other service providers;
- the multiplication of command levers between system operators, retailers and other service providers.

4.2.1.2 The improvement of network planning, operation and maintenance processes

The ongoing development of smart grid technologies including the roll-out of smart metering systems will allow EHV, HV and MV/LV system operators to improve their use of the network.

It will thus contribute to ensuring the sustainability of the system, by managing/facilitating the growing peak load, the integration of more renewable energy sources into the grid, and new usages of electricity among others. More especially, network planning, operation and maintenance processes will significantly evolve and be improved with information and communications technology (ICT) and the relevant data EHV, HV and MV/LV system operators will collect, process, and store.

The processing and management of the data obtained via smart metering systems, combined with network supervision and control systems, will allow EHV, HV and MV/LV system operators to improve the development of the grid while limiting network costs. For instance, they will be able to analyse and modify the balance of single-phase meters, for meters already connected to the grid as well as for future connections. Time-of-use tariffs may also be implemented and optimized to reduce consumption during peak period and shift it to off-peak period.

Advanced analytics and extensive real-time supervision and control systems will enable EHV, HV and MV/LV system operators personnel or their automated information systems to anticipate operational problems, and take faster and more relevant decisions. More accurate generation and load forecasts at both local and national levels, combined with operational planning tools, will help anticipate constraints with a high degree of certainty. With ICTs, EHV, HV and MV/LV system operators will have a better knowledge of the grid state and be able to detect and locate faults on the network with more accuracy and reactivity.

In addition to that, smart grid technologies will allow EHV, HV and MV/LV system operators to optimize their maintenance processes, by deciding and modifying asset renewal priorities, maintenance programmes and operations. Instead of only relying on pre-defined maintenance cycles, EHV, HV and MV/LV system operators will dynamically update asset management programmes via the collection and analysis of network data. Supported by forecast information, they can plan maintenance tasks considering $N-1$ criteria, and may also decide to carry out urgent maintenance operations based on real-time data analysis.

However, the opportunities brought by smart grid functions including smart metering data management will not resolve in the planning phase all of the issues facing the HV and MV/LV grid management domain.

4.2.1.3 The intensified cooperation between EHV-HV, and HV–MV/LV system operators to improve system security

The increased penetration of generation capacities, mostly connected to the MV/LV networks, as well as the development of new usages of electricity will tend to intensify the need for cooperation between system operators at distribution and transmission level. If EHV and HV system operators were traditionally responsible for the overall system stability and EHV, HV and MV/LV system operators for operating their respective network, they will need to strengthen their coordination at different timeframes in order to ensure the security of the system.

More precisely, exchange of structural and operational information between system operators, as well as between system/grid operators and other actors (end-customers, flexibility operators, etc.) will be necessary. EHV, HV and MV/LV system operators will also have to manage the requests of other EHV and HV system operators at different timeframes, including network development, operational planning, and real-time operations, by exchanging structural and forecast data according to relevant grid codes. They will also contribute to system security by delivering regulated services to EHV and HV system operator according to a cascading communication process, including services in case of emergency situations when market-based solutions cannot be used or turn out to be insufficient.

Provision of load and generation forecasts at primary substations and advanced ancillary services such as control of reactive power at the HV and MV/LV system operator – EHV and HV system operator interface are examples of new services that HV and MV/LV system operator could deliver to EHV and HV system operator.

The increased complexity of the MV/LV networks highlights the need for EHV, HV and MV/LV system operators to control that the activity of resources connected to their electrical grid is compliant with its capacity and to obtain flexibilities from local resources to solve constraints on their networks. In order to enable a level playing field for all market participants and ensure the overall efficiency of the system, this would require an intensified coordination between system operators and electricity markets. More specifically, such cooperation should allow system operators:

- to settle cases where actors would compete for the use of shared resources connected to the networks;
- to prevent the situation where the activation of flexibilities by one actor would generate an unacceptable constraint for one of the system operators.

Different HV and MV/LV system operator models may be considered to allow renewable energies connected to the MV/LV network to participate to the market, while ensuring the operational security of both transmission and distribution networks. The global efficiency of the system should be targeted. Different models will be defined in close coordination with the market domain

4.2.1.4 The need to contract and activate flexibilities to optimize network design and operations and solve specific electrical network constraints

In order to efficiently prevent/solve local operational problems and therefore fulfil their core responsibilities, EHV, HV and MV/LV system operators should be able to obtain flexibility from DER resources and consumers to solve electrical grid constraints.

Flexibilities could be obtained at different stages to solve specific electrical grid constraints (network development and planning stage, operational planning and real-time operations stage). They could allow the EHV, HV and MV/LV system operators to prevent and treat constraints (function of protection systems, overcurrent, and voltage, and quality) or a fault on their network.

Via the analysis of data they have collected and processed, such as data collected from sensors on the network and/or smart metered data if available and data from the different markets, EHV, HV and MV/LV system operators could determine, depending on the timeframe and the nature of the constraints, what solution is the most cost-efficient for the community to ensure the stability of the network and quality of supply.

All of these flexibilities should meet strict requirements. Furthermore, their access and use would have to be coordinated between all system operators in order to target the overall efficiency and optimization of the electric power system.

4.2.1.5 The ability to facilitate and enable electricity markets in a neutral and transparent way

EHV, HV and MV/LV system operators are key contributors to the functioning of the electricity markets. As independent parties which have non-discrimination and transparency objectives, EHV, HV and MV/LV system operators are legitimate entities to deliver services based on network and metered data in order to ensure a 'level playing field' for market participants. More precisely, EHV, HV and MV/LV system operators may be involved in different timeframes of the market, according to the applicable market rules and regulatory framework – to be detailed within the market domain:

- pre-qualification;
- technical validation/activation of bids;
- settlement.

System operators could collaborate at every voltage and market level to manage the participation of flexibility operators in the market when their perimeter include sites connected to their network, by ensuring that they respect certain administrative and/or technical Requirements for instance.

In order to fully contribute to a technical and economic optimization for all of the actors of the system, EHV, HV and MV/LV system operators would also collaborate to the technical validation of flexibilities proposed or activated on electricity markets. They would therefore be able to manage the impact of the activation of flexibilities across all electrical grid levels.

The simultaneous activation of flexibilities connected to the same feeder or secondary substation may generate constraints (function of protection system, overcurrent, voltage limits) on the network and force system operators to take emergency actions in order to prevent faults. In business as usual situation, this scenario would have no consequences for some actors but would not be economically optimal from a system perspective.

MV/LV system operators would be legitimate to propose adjustments regarding the conditions of activation of flexibilities including sites connected to their network. These adjustments, which would need to comply with the operational security requirements of the system, will be defined within the market domain and in close coordination with transmission grid management and distribution grid management domains.

4.2.1.6 The possibility to provide regulated services based on data management

Smart grid technologies including smart metering systems will allow EHV, HV and MV/LV system operators to collect and process higher volumes of data, with more accuracy and more reactivity:

- effective consumption and production data;
- load and generation forecasts;
- data related to quality of supply (power outages, voltage violations, etc.);
- network data (network state, asset use, etc.).

EHV, HV and MV/LV system operators will therefore be able to respond to the demands of external actors according to regulated services. For instance, they could transmit processed incentive regulation data to conceding authorities and/or to the regional or national regulator. They could also contribute to the transition towards a carbon-free economy, by providing local authorities with data.

These data would support sustainable development and energy demand management public policies, urban planning and territorial energy transition, urban renovation, or fight against fuel poverty. EHV, HV and MV/LV system operators may also enable third parties authorized by clients to access their individual consumption and/or production data or publish relevant data on a public platform if required by the regulatory framework.

4.2.2 List of business Use Cases and business roles of the domains

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:

- to improve the resiliency of the electrical grid;
- to contribute to system security;
- to improve continuity of supply and manage energy flows on the network with the increasing presence of DER;
- to minimize delays in service restoration in case of faults on the network;
- to facilitate energy demand management services and sustainable development policies.

Table 2 lists the business roles that have been identified so far either in the business Use Cases provided in Clause B.1 or in 4.2. This list is not exhaustive.

Table 2 – Business roles of the electrical grid-related domains

Business role	Definition
Grid asset owner	Regulatory[Distribution][Market-Enterprise] Own a grid and delegate its operation to a grid operator A party that owns (a part of) the distribution electrical grid and delegates its operation to a HV and MV/LV system operator in a system where electricity distribution is operated as a concession.
Customer	Customer support [Transmission][Enterprise] or Customer support [Distribution][Enterprise] A party that consumes electricity. It may be “passive” in the sense that it determines its consumption entirely with respect to its own needs, or “active” in the sense that it can interact with other players to determine or alter its consumption. Certain consumers may also have their own production and/or storage capacity. Different customers can be identified according to the voltage levels of the electricity supplied: – HV customer – MV customer – LV customer

Business role	Definition
EHV/HV system operator	Network Operation [Transmission][Enterprise-Operation] A party that is responsible for a stable power system operation (including the organization of physical balance) through a transmission electrical grid in a geographical area. The system operator will also determine and be responsible for cross border capacity and exchanges. If necessary, he/she may reduce allocated capacity to ensure operational stability. Transmission as mentioned above means the transport of electricity on the extra high or high voltage network with a view to its delivery to final customers or to distributors. Operation of transmission includes as well the tasks of system operation concerning its management of energy flows, reliability of the system and availability of all necessary system services. [Definition taken from the ENTSO-E RGCE Operation handbook Glossary].
Flexibility aggregator	A party which aggregates flexibilities for its customers. May activate flexibility sites.
Flexibility operator (FO)	A party which technically operates flexibilities for its customers.
Grid asset maintainer	A party in charge of keeping operational a specific asset.
Grid operator	Network Operation [Distribution][Enterprise-Operation] or Network Operation [Transmission][Enterprise-Operation] A party that operates one or more electrical grids. [SOURCE: ENTSO-E, EFET, and ebIX, 2014]
Grid user	A party connected to the electrical grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers. Equivalent to party connected to the grid.
Metered data user	Meter data management [Customer Premises][Enterprise] Party that is authorized to acquire energy usage information from the metering data manager.
Metering data manager	Meter data management [Distribution][Enterprise-Operation] The metering data manager is a macro-role, including: Metered data aggregator: A party responsible for the establishment and qualification of metered data from the metered data responsible. This data is aggregated according to a defined set of market rules. Metered data responsible: A party responsible for the establishment and validation of metered data based on the collected data received from the metering system operator. The party is responsible for the history of metered data for a metering point. Metering point administrator: A party responsible for registering the parties linked to the metering points in a metering grid area. He/she is also responsible for maintaining the metering point technical specifications. He/she is responsible for creating and terminating metering points. Other metered data user relationship manager: Respond to regulatory changes and expand the range of smart-related services offered to actors of the electric power system (not grid users/ suppliers/BRPs). The possibility to provide regulated services based on data management and provision in order to facilitate national and local public policies and enable customer empowerment. [SOURCE: ENTSO-E role model]
System operator	Network Operation [Distribution][Enterprise-Operation] or Network Operation [Transmission][Enterprise-Operation] Party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system. [SOURCE: IEC 60050-617:2009, 617-02-09]

Business role	Definition
Producer	Power system [DER][Market-Operation] Produce Electricity Party generating electric energy. Additional information: This is a type of grid user. [SOURCE: based on IEC 60050-617:2009, 617-02-01] Different producers can be identified according to the voltage levels supplied to the network: – HV producer – MV producer – LV producer
Regulator	Regulatory[Generation-Distribution][Market-Enterprise] Prepare and adopt regulations over electricity markets Authority that is responsible for preparing or adopting regulations. May be responsible for exercising autonomous authority over electricity markets and the associated synchronous electrical grids. Equivalent to Regulatory Authority. [SOURCE: based on IEC 60050-901:2013, 901-03-11]
(Electricity) supplier	Power system [DER][Market-Operation] Sell Electricity Party having a contract to supply electric power and energy to a customer. [SOURCE: IEC 60050-617:2009, 617-02-08] Suppliers can generate flexibilities through modulation of electricity prices (Time-of-Use, Critical Peak Prices, etc.), flexibilities which can have value on energy markets and/or for network operations. The supplier may also deliver energy-related services.

Table 3 lists and provides a brief description of the business Use Cases that have been identified so far (they do not cover the entire domain business Use Cases).

Table 3 – Identified business Use Cases of the domain

Index of the business Use Case	Identified business Use Case	Associated domain	Brief description	Level of maturity
UC62913-2-1-B001	Carry out definition and optimization of maintenance and asset renewal priorities programmes	Grid management	TD/B_UC62913-2-1-B001 The business Use Case describes how the system operator decides asset renewal priorities and carries out maintenance programmes in the planning phase, based on the network assets analysis and the development of failure predictive and condition-based maintenance models.	Already implemented/Incomplete due to uncertainty (Regulatory, etc.) /Emerging

Index of the business Use Case	Identified business Use Case	Associated domain	Brief description	Level of maturity
UC62913-2-1-B002	Carry out urgent maintenance operations	Distribution grid management	D/B_UC62913-2-1-B002 The business Use Case describes how the HV and MV/LV system operator analyses network assets health indexes using archived data (assets use, maintenance operations, faults, voltage excursions, etc.) and real-time data monitoring. Based on this information, the HV and MV/LV system operator evaluates the risk of default and carries out urgent maintenance operations to prevent faults.	Emerging
UC62913-2-1-B003	Elaborate the distribution network multiannual masterplan	Distribution grid management	D/B_UC62913-2-1-B003 The business Use Case describes how the HV and MV/LV system operator elaborates the network multiannual masterplan by simulating constraints likely to appear on the network and prioritizing network investments.	Adjustments in progress
UC62913-2-1-B004	Load management, frequency control and reserve	Transmission grid management	T/B_UC62913-2-1-B004 Use Case based on ENTSOE network codes with the aim of – achieving and maintaining a satisfactory level of system frequency quality and efficient utilization of the power system and resources; – ensuring coherent and coordinated behaviour of the transmission systems and power systems in real-time operation; – determining common requirements and principles for FCR, FRR and RR; determining common requirements for cross-border exchange, sharing, activation and sizing of reserves.	Already implemented/Incomplete due to uncertainty (Regulatory, etc.) /Emerging
UC62913-2-1-B005	Manage the connection (generation, consumption, HVDC)	Transmission grid management	T/B_UC62913-2-1-B005	Already implemented/Incomplete due to uncertainty (Regulatory, etc.) /Emerging
UC62913-2-1-B006	Operate meshed network in real time	Transmission grid management	T/B_UC62913-2-1-B006	Already implemented/Incomplete due to uncertainty (Regulatory, etc.) /Emerging

Index of the business Use Case	Identified business Use Case	Associated domain	Brief description	Level of maturity
UC62913-2-1-B007	Operate the MV network in real time	Distribution grid management	D/B_UC62913-2-1-B007 The business Use Case describes how the MV/LV system operator manages the MV network in real time by optimizing the configuration of the network, while ensuring coordination with the EHV-HV system operator, maintaining voltage profile within acceptable limits, preventing critical situations using emergency levers, and restoring supply in case of faults.	Already implemented
UC62913-2-1-B008	Operate the LV network	Distribution grid management	D/B_UC62913-2-1-B008 The business Use Case describes how the MV/LV system operator manages the LV network in real time in normal conditions and in case of faults to maintain quality and continuity of supply.	Already implemented
UC62913-2-1-B009	Optimize network operations in operational planning based on a schedule	Distribution grid management	D/B_UC62913-2-1-B009 The business Use Case describes how the HV and MV/LV system operator anticipates / optimizes network operations in medium-term (month and week ahead) and short-term (day ahead and intraday) operational planning. It consists in: – anticipating the operating points based on local load and generation forecasts, identifying and qualifying risks of constraints on the network (primary substation, MV network, and HV network if managed by the HV and MV/LV system operator); – defining the network configuration in order to satisfy the contractual commitments, with the use of several optimization levers which aim at solving detected electrical network constraints in optimizing many criteria including OPEX, CAPEX, customer satisfaction, regulation compliance, environmental impact; – taking into consideration for all timeframes the work programmes; – taking into consideration real-time electrical network constraints (faults, transmission limitation or transmission outage, load transfers) and evaluating the impact on the operating points.	Adjustments in progress

Index of the business Use Case	Identified business Use Case	Associated domain	Brief description	Level of maturity
UC62913-2-1-B010	Optimize work programmes (EHV and HV system operator, producers, and HV and MV/LV system operator works)	Distribution grid management	D/B_UC62913-2-1-B010 The business Use Case describes how the HV and MV/LV system operator optimizes work programmes on the HV and MV networks, i.e. schedules for operations related to the creation, maintenance, and repair of network assets – including works determined by the EHV and HV system operator, HV and/or MV producers, and the HV and MV/LV system operator – in order to optimize many criteria including OPEX, CAPEX, customer satisfaction, regulation compliance, environmental impact.	Adjustments in progress
UC62913-2-1-B011	Optimize grid operating conditions using available levers	Distribution grid management	D/B_UC62913-2-1-B011 The business Use Case describes how the HV and MV/LV system operator performs load flow calculations based on all archived data which may include archived metered, network and weather data and optimizes: – the set point of the off line local voltage setting device; – the electrical grid connection requirements; – the electrical grid connection phase of single-phase meters which are already connected or to be connected to the LV network. This allows the HV and MV/LV system operator to prevent electrical network constraints and increase grid capacity.	Adjustments in progress
UC62913-2-1-B012	Manage faults on the MV network	Distribution grid management	D/B_UC62913-2-1-B07/B_UC62913-2-1-B012 The business Use Case describes how the MV/LV system operator manages to restore supply in case of faults.	Already implemented

4.2.3 List of system Use Cases and system roles

Table 4 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 in future editions of IEC SRD 62913-2-1. It should also be noted that business as usual functions have not been listed.

Table 4 – Identified system Use Cases of the domain

Index of the system Use Case	Identified system Use Case	Brief description
UC62913-2-1-S001	Perform centralized voltage control based on state estimation	D/B_UC62913-2-1-B007/S_UC62913-2-1-S001 The system Use Case describes how network automated functions: – estimate the state of the MV network in real time; – regulate the MV network voltage profile by defining optimal voltage set points at the primary substation using OLTC.
UC62913-2-1-S002	Manage faults on the MV network using advanced FLISR system	D/B_UC62913-2-1-B07/B_UC62913-2-1-B012/S_UC62913-2-1-S002 The system Use Case describes how the advanced FLISR system: – detects an incident, analyses it and makes a diagnosis: • determines the origin of the fault and analyses potential anomaly of the control command linked to fault management, • confirms the presence of a permanent fault on the MV network; – locates and isolates faulty sections; – defines and implements a restoration plan (automatically or manually); – ensures power restoration on the MV network.

4.3 Generic smart grid requirements

4.3.1 Requirements extracted from Use Cases

Grid management requirements in 4.3 have been extracted from the following Use Cases described in Annex B according to the IEC 62559-2 Use Case template:

- Carry out planned maintenance operation.

The IEC core standards shall support the following needs and requirements listed in Table 5.

Table 5 – Requirements extracted from grid management Use Cases

Requirement ID	Requirement description	Link to Use Cases
R62913-2-1-001	To decide asset renewable priorities and optimize maintenance programme, grid asset maintainer produces a consequential cost definitions in order to evaluate the impact of failures on their stakes (financial, safety, reliability, legal, reputation, regulatory, environment, etc.)	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-002	To decide asset renewable priorities and optimize maintenance programme, grid asset maintainer identifies the incidents that may occur on the network, evaluates the consequences and the probability of these events, identifies the acceptability thresholds and builds the criticality matrix	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-003	To decide asset renewable priorities and optimize maintenance programme, grid asset maintainer assesses the consequences of a network asset failure and determines asset criticality	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-004	Grid asset maintainer evaluates the consequences in cross-analysing data: direct failure cost (equipment replacement or equipment repair), customer outage cost (loss of customers impacted by the outage, time duration), cost of the urgent repair, cost of triggered network-backup plan and cost of failure on adjacent equipment	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-005	The grid asset maintainer estimates the failure probability of the equipment	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-006	Grid asset maintainer defines a schedule-based maintenance programme for an equipment type on the basis of the vendor's recommendations, the network assets analysis and the criticality analysis	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-007	Grid asset maintainer defines condition-based maintenance programmes, performs reliability-centred analyses and elaborates/improves failure predictive models	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-008	The grid asset maintainer identifies the early signs of internal defects to be monitored on the network, especially defects affecting the most critical equipment	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-009	The data measured on the MV/LV transformers under study to elaborate failure predictive models includes load current, oil temperature, oil humidity, dissolved gas analysis (DGA), condition monitoring crossings and partial discharge analysis	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-010	To define maintenance programme of a set of equipment types installed on the network, the grid asset maintainer collects data to be used as inputs for the analysis, such as: inventory and features of the installed equipment, ex-post data (history of documented events, example of documentation associated with an event and history of network operations real-time data from real-time monitoring tools), network topological data and economic data	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-011	For a multiannual maintenance programme/long-term maintenance scheduling, the grid asset maintainer collects data to be used as inputs for the analysis, such as: multiannual network masterplan and maintenance strategy	UC62913-2-1-B001 Narrative of the UC
R62913-2-1-012	To define the annual maintenance programme / medium-term maintenance scheduling, the grid asset maintainer collects data to be used as inputs for the analysis, such as: multiannual maintenance programme, multiannual network developments masterplan and annual work programme (EHV, HV, MV/LV system operators and producers work)	UC62913-2-1-B001 Narrative of the UC

5 Transmission grid management

5.1 Purpose and scope

See 4.1.

5.2 Business analysis

5.2.1 General

See 4.2.

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

See Table 3.

6 Distribution grid management

6.1 Purpose and scope

See 4.1.

6.2 Business analysis

6.2.1 General

See 4.2.

6.2.2 Regional options

The business analysis of this domain and the identified Business and system Use Cases apply to the European region.

6.2.3 List of business Use Cases and business roles of the domains

See Table 3.

6.2.4 List of system Use Cases and system roles

Table 6 lists the system roles which have been identified so far. The list is non-exhaustive and will be updated in future editions of IEC SRD 62913-2-1.

Table 6 – System roles of the domain

System role	Type	Description
Advanced FLISR system	System	Electric Network Fault location [operation]…FLISR application module FLISR automates the management of faults in the distribution grid. It supports the location of the fault, the isolation of the faulty equipment(s) from the healthy equipment and the restoration of the healthy equipment. During disturbances the automatic fault handling shortens outage time and offloads the operators in the distribution control centre for more complicated situations. Therefore, FLISR may help to improve performance indexes like SAIDI (System Average Interruption Duration Index). [SOURCE: CEN, CENELEC, ETSI, 2011]
Centralized voltage control function	Information system	Electric Network Assisted control [operation]…VVC application module DMS function allowing to calculate optimal voltage set points at the primary substation to maintain the MV voltage profile within contractual limits
Field actuators	System	Power system /Electric Network Operation [process]…switching equipment actuator Primary equipment switches which are located along the electrical grid lines to enable the operator or the system to isolate faulty section. They can be manually operated or remotely operated. In this Use Case we will restrict our analysis to remotely controllable switches. Such communicating devices are inherited from generic architectural component that communicates with control centre based on IEC 61850.
Field detection device	System	Electric Network Fault location [field-process]…fault detector … feeder Function located along the feeder and capable of detecting and indicating a fault passage (FPI). It includes the sensors needed to perform the function. Such communicating devices are inherited from generic architectural component that communicates with control centre based on IEC 61850.
HV/MV transformer equipped with on load tap changers	Equipment	Power system [process] Electric Network Operation process]… Power transformer .. Tap Tap actuators on transformer windings that change the turns ratio of the transformer without supply interruption
MV network	System	Power system [process]… distribution … feeder MW network represents the set of conducting equipment used to conduct electricity at medium voltage level
SCADA system	Information system	Electric Network Operation [operation-field] … Supervisory Control And Data Acquisition System. Different cases can be found: – MV/LV SCADA system: SCADA system of the MV/LV system operator. – MV SCADA system: SCADA system of the MV system operator. – DER SCADA system: SCADA system of the MV producer.
Sensors	Equipment	Electric Network Operation [substation].. .gateway … remote terminal Device which, when excited by a physical phenomenon, produces a signal characterizing the physical phenomenon
State estimation function	Information system	Electric Network Assisted control [operation]…VVC application module … calculate in real time the voltage profile Function allowing to calculate in real time the MV voltage profile
Substation	System	Facility equipment that steps up or steps down the voltage in utility power lines. Voltage is stepped up where power is sent through long distance transmission lines, and stepped down where the power is to enter local distribution lines. They can be classified as normal outside substation, armoured substation and underground substation. [Source: ENTSOE, Glossary Index – 2015]

System role	Type	Description
Substation control and monitoring system	Equipment/ information system	Electric Network Assisted Control [substation]…controller … substation …distribution Digital control system for substation automation, which may replace conventional remote terminal unit (RTU) in primary substations
Substation protection device	System	Electric Network Protection /Electric Network Operation[field]…Protection function … Feeder Protection function Function which is located at the primary substation, in charge of protecting downstream assets by eliminating fault current and having communicating capability to indicate trip conditions to upper levels. This device has also the ability to be remotely controlled (closed) to re-energize the protected feeder. Such communicating devices are inherited from generic architectural component that communicates with control centre based on IEC 61850.

6.3 Generic smart grid requirements

Distribution grid management requirements in 6.3 have been extracted from the Use Cases listed in 6.2.3 and 6.2.4.

These distribution grid management Use Cases are associated to the business case manage real-time network operations.

The IEC core standards shall support the needs and requirements listed in Table 7.

Table 7 – Requirements extracted from distribution grid management Use Cases

Requirement ID	Requirement description	Link to Use Cases
R62913-2-1-013	The MV/LV system operator has load and generation forecasts at the primary substation level	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-014	The MV/LV system operator has operational planning tools that integrate real-time data related to the state of the network	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-015	The SCADA system accesses information related to the state of the network and updated short-term local load and generation forecasts	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-016	The MV/LV system operator has a simulation tool in order to validate the use of optimization levers before activating them	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-017	Coordination procedures between the MV/LV system operator and the EHV/HV system operator exist in order to ensure that the measures to be engaged by the MV/LV system operator or the EHV/HV system operator do not generate constraints on one or both networks or the overall system and that operating requirements on the distribution and the transmission networks are met	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-018	In order to maintain voltage within contractual limits, the MV/LV system operator has tools allowing continuous monitoring and optimization of the voltage profile of the distribution grid	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-019	According to requirements related to the transmission network access, the MV/LV system operator has coordination procedures with the EHV/HV system operator	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-020	Emergency measures to safeguard the network are described in a regulatory framework	UC62913-2-1-B007 Narrative of the UC
R62913-2-1-021	Technical rules describe the optimization levers that the MV/LV system operator may use to solve electrical network constraints, as defined and/or validated by regulation	UC62913-2-1-B007 Use case conditions of the UC
R62913-2-1-022	The MV network is equipped with sensors measuring current and voltage values at all critical points: primary substations, MV feeders, secondary substations and connection points of producers.	UC62913-2-1-S001 Narrative of the UC

Requirement ID	Requirement description	Link to Use Cases
R62913-2-1-023	HV/MV transformers at the primary substation are equipped with on-load tap changers	UC62913-2-1-S001 Scenario step by step analysis of the UC
R62913-2-1-024	The state estimation function integrates in its calculations the real-time network topology (position of switches) and impedances	Use case conditions section of UC62913-2-1-S001
R62913-2-1-025	The averages used to run the state estimation function are synchronous in accordance with IEC 61000-4-30 (dating of measurements)	Use case conditions section of UC62913-2-1-S001
R62913-2-1-026	Feeders have remotely controlled breakers at the main substations and several remotely monitored fault passage indicators located at suitable points along the feeders	Scope and objectives of use case section of UC62913-2-1-S002
R62913-2-1-027	The location function of the advanced FLISR system communicates with the MV SCADA system in order to isolate the fault	Narrative section of UC62913-2-1-S002
R62913-2-1-028	The primary substation is equipped with a protection device	Use case conditions section of UC62913-2-1-S002
R62913-2-1-029	The feeder has remotely controlled breakers located at the main substations and several remotely monitored fault passage indicators located at suitable points along the both parts of feeder	Use case conditions section of UC62913-2-1-S002
R62913-2-1-030	A tie switch separates the feeders into two individually radially operated parts that never are electrically connected during normal and abnormal operation	Use case conditions section of UC62913-2-1-S002
R62913-2-1-031	Field actuators installed along the grid lines are remotely controllable to enable the operator or the system to isolate faulty section	Actors section of UC62913-2-1-S002
R62913-2-1-032	Field detection devices are spread on the grid lines to detect fault passage	Actors section of UC62913-2-1-S002

7 Microgrids

7.1 Purpose and scope

7.1.1 Objective

The purpose of Clause 7 is to address a business analysis of microgrids, and further describe some of the requirements of the domain.

This analysis is based on the inputs from domain experts and feedbacks from existing projects as well as existing materials in a smart grid environment.

In this document, the technical possibilities of microgrids, and their relationship with other smart grid domains will be considered. The microgrid domain is strongly related to the following domains.

- Distribution grid management: connected microgrids can be seen as a controllable entity and flexibility by the distribution system operator, among all concerned parties (DSO, TSO, BRP, etc.).
- Distributed energy resources: microgrids contain DER, and some of the energy services described in this domain can apply to microgrids too.
- Energy storage: storage systems are the heart of most microgrids, as they are used to balance consumption and production when the microgrids are islanded.
- Market: microgrids can participate in electricity markets (or be required to do so), by trading energy-related services.

7.1.2 General context

According to IEC 60050-617:2017, 617-04-22, the definition of a microgrid is: “group of interconnected loads and distributed energy resources with defined electrical boundaries … that acts as a single controllable entity and is able to operate in both grid-connected and island mode”. It is further added that in grid connected mode, a microgrid acts as a single controllable entity, and that this definition is intended to cover both (utility) distribution microgrids and (customer owned) facility microgrids.

We can thus identify three types of microgrids:

- Isolated microgrid is never connected to another electrical grid, and comprises several customers, DER possibly including Electrical Energy Storage (EES) systems.
- Distribution microgrids form a part of the utility distribution grid which is connected to the rest of it called the main grid. The microgrid can contain several customers, DERs (generation/controllable load and EES systems). The microgrid is able to disconnect from the main grid and operate in island mode for a given period of time, maintaining the power for all or part of its loads. When connected, the microgrid acts as a single controllable entity, which means that an entity must have control over the main DER, EES systems, controllable loads and other flexibilities through a Microgrid Energy Management System (MEMS).
- Facility microgrids are electrical systems owned by a customer, connected to the distribution grid, and able to disconnect from it and operate in island mode for a given period of time, maintaining the power for all or part of its loads.

In this document, we consider the electrical system of the microgrid, the main grid is considered as an exterior entity, exchanging information with the system, and the customers, DER and EES systems inside the microgrid are only considered through the possibility that they offer to control power consumption and production. Using SGAM domains and zones, the microgrids domain can thus be described as the red zone in Figure 2.

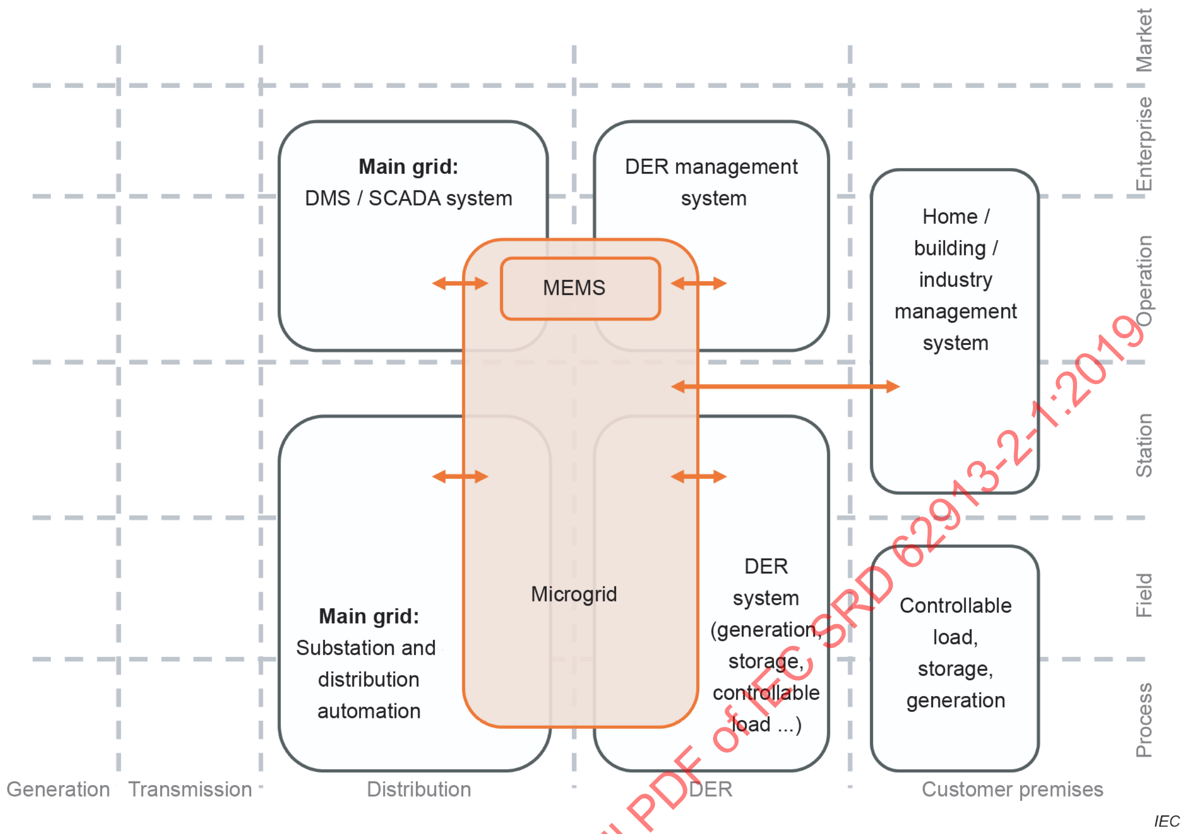


Figure 2 – Non-exhaustive description of the microgrid domain in the SGAM architecture

7.2 Business analysis

7.2.1 General overview

With the progress in DER and EES technologies, it has become more and more feasible to maintain the equilibrium between production and consumption on local systems. Microgrids are the concrete expression of this possibility: local electrical systems that can, for a given time, operate disconnected from the main grid (islanded).

When the main grid is weak (for example, in developing countries with very poor transmission system), and when the growth of the consumption does not justify the development of a reliable network, it can be more interesting to increase the reliability by creating microgrids than to reinforce the grid. In case of major climatic event leading to a blackout, microgrids can enable to maintain a power supply to important loads and to increase the resiliency of the grid. Depending on the customers' requirements and on the main cause of grid outage, three kinds of continuity of service are possible:

- preventive islanding if a supply interruption is planned, or a grid outage is expected;
- automated islanding in case of unplanned grid failure (it is necessary to define what kind of grid failure will trigger the islanding start);
- black start recovery to re-supply loads after grid failure.

Preventive islanding could also be used in anticipation of possible upcoming failure or constraints on the network (storms that could damage overhead lines, voltage limit reached locally due to PV injection, line congestion, etc.) to avoid any interruption of the loads supply.

Furthermore the infrastructures needed for a microgrid, such as DER, EES and energy management systems can be exploited when the microgrid is connected, by providing services to customers inside the microgrid, or to other parties (MV/LV system operator, BRP, aggregators, etc.). Finally, providing locally new infrastructures and decision levers is often socially and politically valued.

The islanding capacity is the main difference between a connected microgrid and a generic smart grid system. However, once the infrastructure needed for islanding is there, it is often used for other services when the microgrid is connected, and these services are often more valued than the islanding capacity itself. These can be grid services (frequency regulation, curtailment, etc.) or customer services (energy optimization, emissions reduction, etc.). As these services are not restricted to microgrids, they are covered in other domains of the smart grid requirements. For this reason, it is very important to establish the relationships between the different smart grid domains, and to define the roles associated with each Use Case.

7.2.2 Isolated microgrids

Isolated microgrid is not a new concept, since every small isolated electric system can enter in this category. The benefits of smart grid technologies are that it is possible to operate such a system with renewable energy sources, EES and load control.

The business application of isolated microgrids concerns the electrification of zones, where an extension of the main grid is impossible or too expensive. Furthermore, in some cases renewable energy sources or hybrid systems can provide a cheaper energy than traditional fossil fuel based generators.

In isolated microgrids, the same roles as in a traditional electrical system are present: DSO, customers, etc.

7.2.3 Facility microgrids

Facility microgrids are owned by a customer, which is willing to maintain the power to all or part of its loads when the main grid is unable to do so, or when market circumstances make it cheaper to be disconnected from the grid and to produce its own power. To be able to island, the customer must have DER, controllable loads, and an EES system is often necessary. Since the customer owns the entire system, he/she is the system operator, and the role associated with this responsibility is the “private network operator”.

Facilities can be willing to install a microgrid if they have high power quality needs (data centres, specific industries, etc.), or if they provide critical services to society (hospitals, government infrastructures, military bases, etc.). Each type of client will have its specification in terms of reliability of supply and quality of service. Very critical applications may not want to sustain any voltage gap, requiring the use of specific EES systems. Other applications might accept a few minutes cut off, but if the main grid is not powered on after, they will start operating in island mode. Depending on its needs, the facility owner must thus define what kind of power disturbances he/she can sustain, and set up a system to avoid bigger disturbances.

Such systems could interfere with the protection plan of the distribution grid, or even its stability, especially if the facility’s DER are usually injecting power in the grid. Communication between the facility microgrid and the DSO might then be necessary for security.

If a facility is equipped with the infrastructures needed to operate in island mode, it will have interests in making use of them the rest of the time. This can be done through energy-related services, which can be internal (reducing energy costs, reducing emissions, etc.) or external (market signal, grid services like curtailment, voltage and frequency control, losses reduction, etc.). As they are not specific to facility microgrids, these services are developed in other domains of the smart grid requirements, especially DER and EES. The relationships between the domains should however be carefully analysed, and the priorities between the Use Cases should be determined by the facility, as it can impact the dimensioning of the system.

7.2.4 Distribution microgrids

A distribution microgrid is a part of the distribution grid that can operate autonomously for a given time. It is connected to the rest of the distribution grid called the main grid, and it can sometimes feed an entire village, a campus, an activity zone, etc.

Distribution microgrids can be installed to maintain the power locally when the main grid is out, and thus decrease the outage time seen by the clients. It can also be a way to maintain a power supply to important loads in case of major blackout due to climatic events. Depending on the customers in the microgrid, and the disturbances they can sustain, the conditions to start the islanding may vary. It is also possible that different zones exist inside the microgrid, each with different requirements.

In the same way as for facility microgrids, once an area is equipped with the infrastructures needed to operate in island mode, it will have interests in valorising them the rest of the time, through customer-oriented services, or grid-oriented services. The MEMS can be used to aggregate the different generators, electrical energy storage systems, controllable loads and other flexibilities, and make the microgrid appear as a unique entity. The way these services will be valorised (direct contracts between the microgrid operator and relevant parties or through aggregators and markets, etc.) will then strongly depend on the regulations and markets in place.

When connected to the main grid, a distribution microgrid must still operate as a traditional distribution system, as detailed in distribution grid management domain. In the same way, the management of DER and EES systems should follow the smart grid requirements of DER and EES domains. If the system has to be able to island at any moment, however, the different generators, EES systems, controllable loads and other flexibilities should be prepared to do so, for example by keeping a margin in the EES state of charge. This implies that different limits between the Use Cases have to be defined. The relationship between the microgrids domain and other domains is described in 7.2.5, but this analysis is to be pursued when the Use Cases are described.

When in islanded mode, all the different generators, EES systems, controllable loads and other flexibilities should be devoted to maintain the islanding, by keeping the production/consumption balance, and stabilizing the voltage and the frequency. This task is done by the MEMS, which communicates with them, and the role associated with this responsibility is the microgrid operator.

The role of the microgrid operator is thus to:

- monitor the state of the main grid and of the microgrid;
- prepare the different generators, EES systems, controllable loads and other flexibilities for islanding, in the limits established by other Use Cases;
- inform the MV/LV system operator of the microgrid's ability to island or not;
- when islanding is due to start, take control of the different generators, EES systems, controllable loads and other flexibilities and start the islanding;
- maintain islanding by managing the different generators, EES systems, controllable loads and other flexibilities;
- when islanding is over, give back the control of the different generators, EES systems, controllable loads and other flexibilities to the appropriate entities.

7.2.5 Relation with other domains

7.2.5.1 General

Other domains contain descriptions of Use Cases that are applicable to microgrids. These Use Cases are compatible with the ones described in the microgrids domain, but a more detailed version specific to microgrids and with the point of view of the microgrid system will be developed in this domain.

7.2.5.2 Distributed energy resources domain

In this domain, islanding is seen as a customer energy management service. This service is thus included in the BUC “Deliver DER ancillary services and flexibility in providing power for the benefit of the reliability and efficiency of the electric power system”.

A SUC is further described: “Support creation and operation of islanded microgrid: Disconnect from the area electric power system (EPS) while establishing a pre-designed microgrid”.

The role DER operator is defined as “the responsible party for operational aspects of the facilities and their DER systems including real-time microgrid operations”.

In this domain, the MEMS is seen as a DER that, in collaboration with other DER, can deliver an islanding service to improve the system’s reliability. This view is not incompatible with the content of this document, although less complete. To align both domains, it should be noted that the “real-time microgrid operations” is the responsibility of the microgrid operator, which in turn gives instructions to each DER operator within the microgrid.

7.2.5.3 EES domain

In this domain, islanding is also seen as a customer energy management service. It is stated that EES systems that are used for islanding could be owned either by customers or by TSO/DSO. This islanding service is included in the BUC “Help the grid user or the grid operator improve the quality of supply”.

7.2.6 List of business Use Cases and business roles 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 to:

- decrease the outage time;
- valorise the flexibilities.

Table 8 lists the business roles that have been identified so far. This list is not exhaustive and will be updated in future editions of IEC SRD 62913-2-1.

Table 8 – Business roles of the domain

Business role	Definition
DER operator	Responsible party for operational aspects of the facilities and their DER systems including real-time microgrid operations.
Electrical Energy Storage (EES) operator	An entity who uses EES systems to deliver EES utilizing services such as for bulk power services, residential use, grid use or RE.
Microgrid operator	Party responsible for safe and reliable operation of the microgrid [SOURCE: IEC 60050-617:2017, 617-02-19]
MV/LV system operator	Party responsible for the planning, operation and maintenance of the electricity MV and LV networks, which takes part in the management of resources connected to his/her networks in order to ensure their safe and reliable operations. In some countries, the HV and MV/LV system operator may also manage the metering system (this is the case in France for MV/LV).
Private network operator	Responsible for operating and managing a private electrical network (e.g. within a building, factory, etc.)

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

Table 9 – Identified business Use Cases of the domain

Index of the business Use Case	Identified business Use Case	Brief description	System Use Case required to enable/execute the business Use Case
UC62913-2-1-B013	Guarantee a continuity in load service by islanding the microgrid	DDER/B_UC62913-2-1-B013 Islanding is used to guarantee continuity in load service (all or part of them) by islanding the microgrid. Three kinds of continuity of service are possible: – preventive islanding if a supply interruption is planned or a grid outage is expected; – automated islanding in case of unplanned grid failure; – black start recovery to re-supply loads after grid failure. This business Use Case is generic and regional options need to be analysed	– Island the microgrid – Monitor the state of the main grid and of the microgrid and inform the relevant actors about it – Prepare the different generators, EES systems, controllable loads and other flexibilities for islanding – Guarantee in real time generation / consumption equilibrium and frequency and voltage stability

7.2.7 List of system Use Cases and system roles

Table 10 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 in future editions of IEC SRD 62913-2-1. It should also be noted that business as usual functions have not been listed.

Table 10 – Identified system Use Cases of the domain

Index of the system Use Case	Identified system Use Case
UC62913-2-1-S003	DDER/B_UC62913-2-1-B013/S_UC62913-2-1-S003 Guarantee in real time generation / consumption equilibrium and frequency and voltage stability
UC62913-2-1-S004	DDER/B_UC62913-2-1-B013/S_UC62913-2-1-S004 Island the microgrid
UC62913-2-1-S005	DDER/B_UC62913-2-1-B013/S_UC62913-2-1-S005 Monitor the state of the main grid and of the microgrid and inform the relevant actors about it
UC62913-2-1-S006	DDER/B_UC62913-2-1-B013/S_UC62913-2-1-S006 Prepare the different generators, EES systems, controllable loads and other flexibilities for islanding

7.3 Generic smart grid requirements

The microgrids requirements in 7.3 have been extracted from the following Use Cases described in Annex B according to the IEC 62559-2 Use Case template:

- Guarantee continuity in load service by islanding the microgrid.

The IEC core standards shall support the needs and requirements listed in Table 11.

Table 11 – Requirements extracted from microgrids Use Cases

Requirement ID	Requirement description	Link to Use Cases
R62913-2-1-033	Microgrid operator monitors the state of the DER and the EES and computes islanding capability and possible duration of islanding	UC62913-2-1-B013 scenario 1 step 1.1 and 1.2
R62913-2-1-034	In case of a grid outage, if there is no capability to island the microgrid, the microgrid operator asks EES operator and DER operator to prepare the DER/EES for islanding	UC62913-2-1-B013 scenario 1 step 1.3 and 1.4
R62913-2-1-035	In case of a grid outage, if there is a capability to island the microgrid, information about microgrid's capability to island is sent by microgrid operator to the MV/LV system operator, who is required to give an authorization for islanding	UC62913-2-1-B013 scenario 1 step 1.5 and 1.6 and 1.7
R62913-2-1-036	In case of a preventive islanding, information about planned supply interruption is sent by the MV/LV system operator to the microgrid operator	UC62913-2-1-B013 scenario 2 step 2.2 and 2.6
R62913-2-1-037	In case of a preventive islanding, microgrid operator computes best state of DER/EES to achieve islanding, asks the EES operator and DER operator to prepare DER/EES for islanding and informs the MV/LV system operator about microgrid's capability to island including duration	UC62913-2-1-B013 scenario 2 step 2.3 and 2.4 and 2.7
R62913-2-1-038	In case of a preventive islanding, MV/LV system operator receives information of microgrid's capability to island and authorizes the microgrid operator to island	UC62913-2-1-B013 scenario 2 step 2.7 and 2.8

Requirement ID	Requirement description	Link to Use Cases
R62913-2-1-039	In case of a preventive islanding, a request to take control of DER/EES is sent by the microgrid to EES operator and DER operator	UC62913-2-1-B013 scenario 2 step 2.9 and 2.10
R62913-2-1-040	In case of a preventive islanding, microgrid operator disconnects from main grid and starts islanding after EES operator and DER operator accept the Microgrid request of taking control of DER/EES	UC62913-2-1-B013 scenario 2 step 2.11 and 2.12 scenario 3 step 3.5 and 3.6
R62913-2-1-041	If a main grid outage occurs, microgrid operator detects it, verifies capability to island and sends request to take control of DER/EES operation to EES operator and DER operator	UC62913-2-1-B013 scenario 3 step 3.1 and 3.2 and 3.3 and 3.4
R62913-2-1-042	If a main grid outage occurs, microgrid operator informs MV/LV system operator about islanding start and duration	UC62913-2-1-B013 scenario 3 step 3.7 and 3.8
R62913-2-1-043	If a main grid outage occurs and microgrid is unable to automatically island, the microgrid operator detects the outage, verifies capability to perform a black start, sends a request to MV/LV system operator to do it and sends a request to take control of EES/DER operations to EES operator and DER operator	UC62913-2-1-B013 scenario 4 step 4.1 to 4.6
R62913-2-1-044	If a main grid outage occurs and microgrid is unable to automatically island, after the request of taking control of EES/DER operations is accepted by the EES operator and DER operator, microgrid operator disconnects from main grid, starts black start recovery and informs MV/LV operator about the black start status	UC62913-2-1-B013 scenario 4 step 4.7 and 4.8 and 4.9
R62913-2-1-045	Microgrid operator computes islanding duration and informs the MV/LV system operator about it	UC62913-2-1-B013 scenario 4 step 4.10 and 4.11 and 4.12 scenario 5 step 5.3 and 5.4 and 5.5
R62913-2-1-046	Microgrid operator monitors and controls resources to maintain the islanding for the targeted duration	UC62913-2-1-B013 scenario 5 step 5.1 and 5.2 scenario 6 step 6.1 and 6.2
R62913-2-1-047	Microgrid operator asks permission from MV/LV system operator to reconnect to the main grid	UC62913-2-1-B013 scenario 6 step 6.3
R62913-2-1-048	Microgrid operator synchronizes voltage and frequency managing resources after receiving confirmation for reconnection to the main grid, performs the reconnection, informs MV/LV system operator about it and gives back control of DER/EES	UC62913-2-1-B013 scenario 6 step 6.7 to step 6.11

8 Smart substation automation

8.1 Purpose and scope

8.1.1 Objective

The purpose of Clause 8 is to address a business analysis of the smart substation automation, and further describe some of the requirements of the domain.

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

8.1.2 General context

Utilities are facing a need for wider monitoring and control ability of MV networks as DER resources connection is bursting and operations productivity improvement, from investment to maintenance, of substation equipment and control systems is required as smart grid technologies are continuously evolving.

Utilities are seeking solutions to maintain a reliable energy power distribution and address the need for monitoring and controlling the action of DER systems on the MV networks with a real-time information exchange and in a standardized and cyber secured framework. This implies new remote control functions, modified distribution configurations, the increase of intelligent protection systems and a significant use of improved telecommunication and information technologies in substations.

8.2 Business analysis

8.2.1 General overview

Energy transition will be accompanied by a digital transition for network operators who are or will be facing massive roll-outs and refurbishment of their distributed automation to implement deeper monitoring and new smart grid applications.

The new smart substation automation functions are, for example:

- acting on the energy production (scheduling, regulation of active and/or reactive power, etc.);
- bi-directional information exchange and dynamic data collect with DER systems;
- dynamic reactive power and voltage regulation functions.

The new equipment and functions to be deployed in substations in order to solve today's issues (MV voltage and reactive power regulation, for example) will necessarily have to be adjustable and upgradeable in order to face those of tomorrow (for example: electric vehicles massive roll-out, low voltage automation), which will arrive long before the end of its 20 years' service life. Furthermore, there is a necessity for the equipment to adapt to the evolving and growing cybersecurity threats.

Smart substation automation will therefore need remote management of the systems, devices and new smart grid applications it contains. This encompasses a large range of functions including asset management, supervision and evolution capability of a huge quantity of equipment in smart substations.

8.2.2 List of business Use Cases and business roles of the domains

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:

- optimize network operations in real-time.

Table 12 lists the business roles that have been identified so far. This list is not exhaustive and will be updated in future editions of IEC SRD 62913-2-1.

Table 12 – Business roles of the domain

Business role	Definition
Distribution grid operator	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 ESR market through his/her system under regulated conditions by managing constraints, emergency situations and faults in a cost efficient way, using operational planning and scheduling and forecasting tools. In some countries, the distribution grid operator may also manage the metering system (e.g. France).
Equipment manufacturer	Entity that produces and sells electrical devices and electricity management devices.
Grid operator	A party that operates one or more grids. It can be an EHV and HV system operator and/or a HV and MV/LV system operator. [SOURCE: ENTSO-E role model]
IED systems management operator	A party responsible for maintaining IEDs, group of IEDs and automation systems, from commissioning to decommissioning during its service life

Table 13 lists and provides a brief description of the business Use Cases that have been identified so far (they do not cover the entire domain business Use Cases).

Table 13 – Identified business Use Cases of the domain

Index of the business Use Case	Identified business Use Case	Brief description	System Use Case required to enable/execute the business Use Case
UC62913-2-1-B014	Enable automation systems to perform operational functions in best conditions	TDDER/B_UC62913-2-1-B014 It consists in managing the configuration or the firmware of an automation system, live supervision of appropriate operating parameters, retrieving log files and identification data of the equipment in order for the grid operator to ensure the capability to operate its automation systems	– Configure automation systems operational data – Store and provide data about the network – Administrate automation systems firmware – Update the IED's firmware – Update configuration file – Set online configuration parameters – Store and provide automation systems assets information

8.2.3 List of system Use Cases and system roles

Table 14 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 in future editions of IEC SRD 62913-2-1. It should also be noted that business as usual functions have not been listed.

Table 14 – Identified system Use Cases of the domain

Index of the system Use Case	Identified system Use Case
UC62913-2-1-S010	Administrate automation systems firmware
UC62913-2-1-S011	Configure automation systems operational data
UC62913-2-1-S012	Set online configuration parameters
UC62913-2-1-S013	Store and provide automation systems assets information
UC62913-2-1-S014	Update configuration file
UC62913-2-1-S015	Update the IED's firmware

8.3 Generic smart grid requirements

The smart substation automation requirements in 8.3 have been extracted from the following Use Cases described in Annex B according to the IEC 62559-2 Use Case template:

- enable automation systems to perform operational functions in best conditions.

The IEC core standards shall support the needs and requirements listed in Table 15.

Table 15 – Requirements extracted from smart substation automation Use Cases

Requirement ID	Requirement description	Link to Use Cases
R62913-2-1-049	The grid operator remotely configures operational data (For example: grid topology, protection and parameters), whether it be off line or on-line, on its automation systems IEDs	UC62913-2-1-B014 Narrative of the UC
R62913-2-1-050	The grid operator uploads, upgrades and manages the firmware versions of its automation systems IEDs, whether it be off line or on-line	UC62913-2-1-B014 Narrative of the UC
R62913-2-1-051	The grid operator collects data concerning the operational state of the automation systems IEDs or equipment in order to be able to lead predictive analysis, launch maintenance actions and reduce failure probabilities	UC62913-2-1-B014 Narrative of the UC
R62913-2-1-052	The grid operator collects and transfers patrimonial data from its automation systems IEDs or equipment to its information systems in charge of asset management and maintenance	UC62913-2-1-B014 Narrative of the UC
R62913-2-1-053	The grid operator supervises live the smooth running of its automation systems IEDs for identification, diagnostic and correction of deficiencies	UC62913-2-1-B014 Narrative of the UC

Annex A
(informative)

Links with other TCs and gathered materials

A.1 General

In order to capture generic smart grid requirements for their domain, the domain's leader needs to establish contact with the technical committees (TCs) working on topics related to their domain, to gather existing materials (standardization documents, User Stories, Use Cases, and Functional Architectures) and from his starting point coordinate the further work on generic smart grid requirements.

A.2 Distribution grid management

A.2.1 Identified TCs

Below are listed the relevant TCs working on smart grid requirements of the domain.

- IEC TC 57: Power systems management and associated information exchange
  - WG 13: Energy management system application program interface (EMS – API)
  - WG 14: System interfaces for distribution management (SIDM)
  - WG 17: Power system intelligent electronic device communication and associated data models for distributed energy resources and distribution automation

A.2.2 Liaisons from other TCs contributing to the smart grid requirements of the domain

Below are listed the experts and liaisons from other TCs who are contributing to the domain.

- IEC TC 57 WG 13 and WG 14, and SyC Smart Energy WG 6
- IEC TC 57 WG 16 and SyC Smart Energy WG 5

Annex B
(informative)

Use Cases

B.1 Grid management

B.1.1 Business Use Cases

See Table B.1.

Table B.1 – UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

1 Description of the use case

1.1 Name of use case

Use case identification		
ID	**Area /Domain(s)/ Zone(s)**	**Name of use case**
UC62913-2-1-B001	Area: Energy system Domain: Distribution grid management	Carry out definition and optimization of maintenance and asset renewal priorities programmes

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Network investments and maintenance programmes are considered in this Use Case according to two timeframes: – Multiannual (multiannual network masterplan and multiannual maintenance programmes), between 10 and 40 years for instance, – Annual (annual maintenance programmes). They include all of the assets and equipment installed on the network, including telecommunications assets. Maintenance activities which are not evolving or implied by smart grid technologies are out of the scope of the Use Case.
Objective(s)	– Facilitate investment decisions regarding equipment installed on the network (primary substations, secondary substations, LV, MV and HV feeders, remote controlled switches, etc.), – Reduce cost of ownership of this equipment while ensuring network reliability in the long-term.
Related business case(s)	– Network Planning and Connection – Maintenance

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

1.4 Narrative of use case

Narrative of use case
Short description
The business Use Case describes how the grid operator decides asset renewal priorities and optimizes maintenance programmes in the planning phase, based on the network assets analysis and the development of failure predictive and condition-based maintenance models.
Complete description

Investments planning are nowadays essentially based on temporal approaches (i.e. equipment renewal is taking place when the technical life duration of the equipment, given by the vendor, is reached).

With smart grid technologies, grid operators have the opportunity to move gradually from a scheduled maintenance to a preventive and condition-based maintenance, which will evaluate more precisely:

- Real health of the asset,
- Equipment criticality.

In order to develop an efficient maintenance programme, it is necessary to define:

- Its aims,
- The method by which it can be developed,
- Its content.

The common aims of an effective preventive maintenance programme are to:

- Guarantee the defined levels for performance indicators based on the utility stakes
- Maintain the function in terms of the required safety,
- Maintain the inherent safety and reliability levels,
- Optimize the availability,
- Obtain the information necessary for design improvement of items,
- Accomplish these goals at a minimum total life cycle cost, including maintenance costs and the costs of residual failures,
- Obtain the information for improvement of previously defined maintenance tasks.

The state-of-the-art in maintenance management offers at least three basic approaches for making maintenance management decisions:

- Condition-based maintenance (CBM) initiates a maintenance activity when data from equipment monitoring indicates a need,
- Reliability-centred maintenance (RCM) prioritizes maintenance activities based on quantification of probability and consequence of equipment failures,
- Optimization techniques offer methods for maximizing the effectiveness of the maintenance activities subject to constraints on economic resources, available maintenance crews, and restricted time intervals.

The business Use Case includes the following steps:

1 Define maintenance strategy of a set of equipment types installed on the network

The objective is to define how the failures of assets will be managed considering the grid asset maintainer stakes and its performance indicators.

1.1 Identify the utility stakes

The grid asset maintainer produces a consequential cost definition in order to evaluate the impact of failures on their stakes (financial, safety, reliability, legal, reputation, regulatory, environment, etc.).

1.1.1 Identify events

The grid asset maintainer identifies different events (or incidents) that may occur on the network.

1.1.2 Evaluate the consequences in case of failure

The grid asset maintainer then defines the severity of these events by identifying their consequences. More precisely, the grid asset maintainer determines asset criticality by assessing the consequence in

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

case of a network asset failure.

This consequence is evaluated in cross-analysing data such as:

– Direct failure cost (equipment replacement or equipment repair),
– Customer outage cost (loss of customers impacted by the outage, time duration),
– Cost of the urgent repair,
– Cost of triggered network-backup plan,
– Cost of failure on adjacent equipment,
– etc.

The grid asset maintainer stores this information.

1.1.3 Evaluate the failure probability

The grid asset maintainer estimates the probability of the events identified.

Conceptually, the probabilities of equipment failure follow a pattern of failure in "bathtub curve", which is specific to each equipment, see Figure B.1.

Such a generic model may be used in a first phase for different types of equipment installed on the network (without taking into account the actual conditions of use of the equipment).

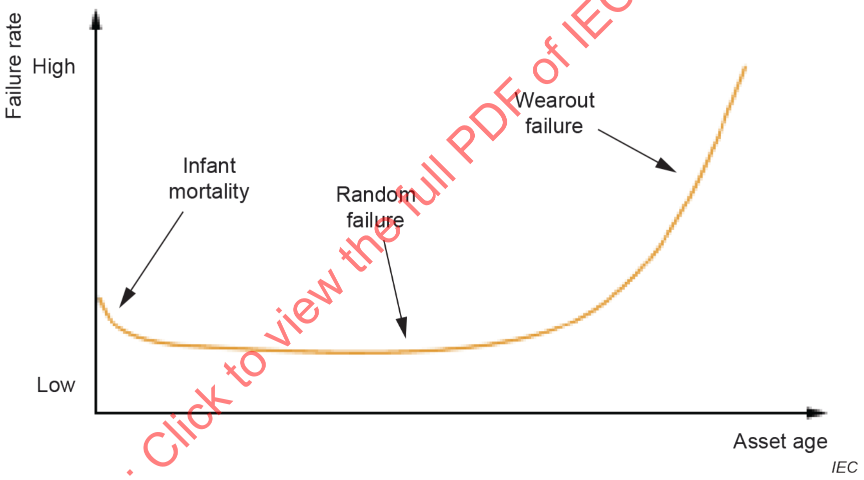


Figure B.1 – Theoretical example of the failure probability of equipment

Advanced maintenance practices may in a second phase take into account the mission profile of the concerned equipment and make a correlation between the index of health equipment (AHI, Asset Health Index) and its failure probability, see Figure B.2.

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

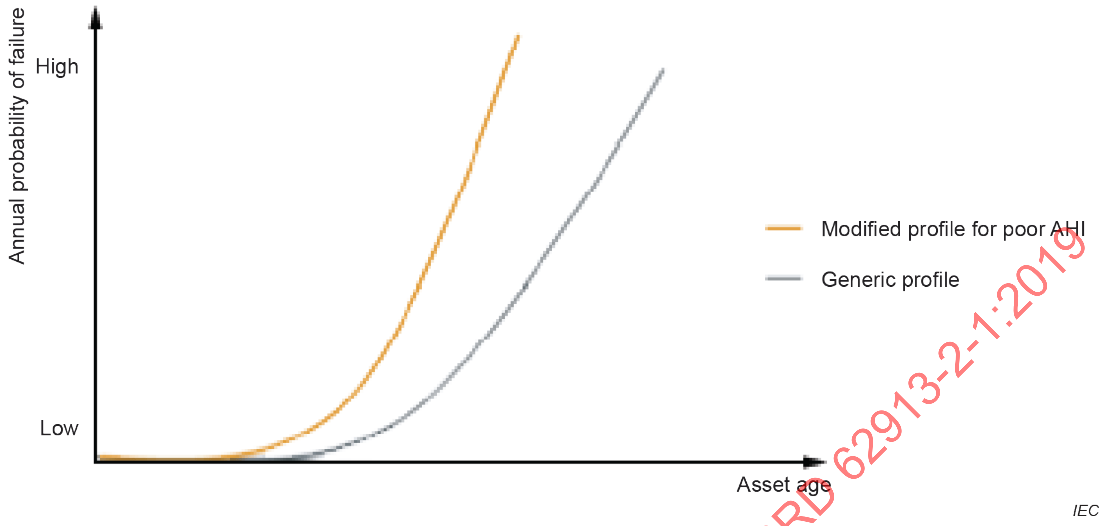


Figure B.2 – Theoretical example of yield curve probability of failure of equipment taking into account a poor AHI

1.1.4 Identify the acceptability thresholds and build the criticality matrix

Based on the list of events, their consequences, and their likelihood, the grid asset maintainer identifies risks.

The tables below are examples of categorization that the grid asset maintainer may use to assess the risks.

Severity	
Rating	**Meaning**
4	Catastrophic
3	Severe
2	Serious
1	Moderate

Probability	
Rating	**Meaning**
4	Very frequent
3	Frequent
2	Occasional
1	Extremely unlikely

To do so, the grid asset maintainer builds a criticality matrix by crossing the probability and the severity of each event. Below is an example of such matrix.

Criticality Matrix				
Probability	**Severity**			
	1	**2**	**3**	**4**
1	1	2	3	4
2	2	4	6	8
3	3	6	9	12
4	4	8	12	16

Thresholds of risk acceptability

The grid asset maintainer determines the risks which are acceptable or tolerable and those which are not. For the latter, the grid asset maintainer defines the most appropriate risk treatment solutions, among the possibilities at his disposal such as:

- Maintenance strategies – corrective, time based, or condition based,
- Asset renewal,
- Insurance,
- etc.

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

Maintenance strategies and asset renewal are the only solutions considered in this business Use Case.

Figure B.3 shows the steps the grid asset maintainer follows to identify the utility stakes, from the identification of events to the elaboration of risk treatment solutions.

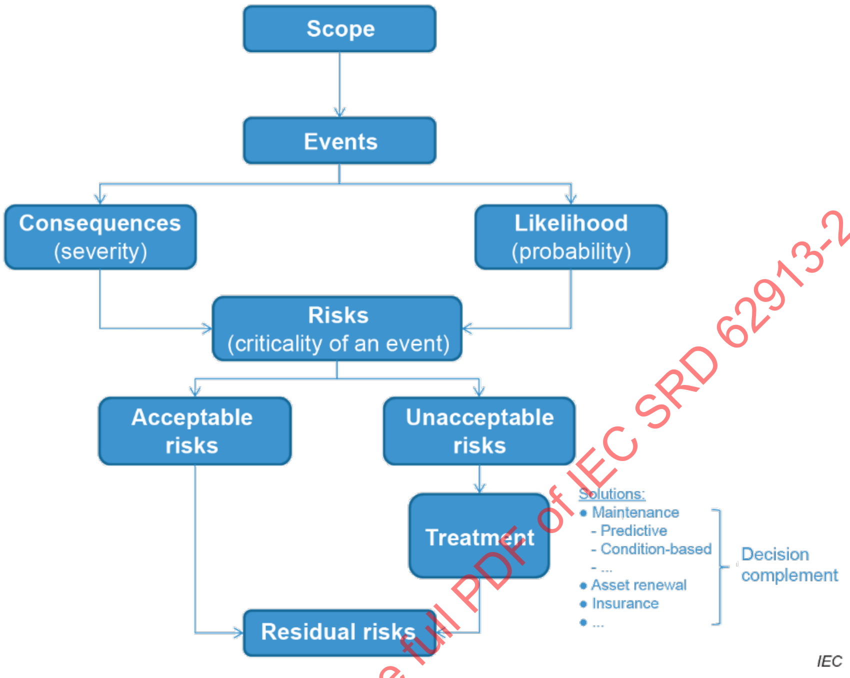


Figure B.3 – Utility stakes definition process

1.2 Define schedule-based maintenance programmes (*)

For instance, the grid asset maintainer defines an inspection schedule (including the frequency of the inspections) for an equipment type on the basis of the vendor's recommendations, the network assets analysis and the criticality analysis.

1.3 Define condition-based maintenance programmes or, more globally, perform reliability-centred analyses and elaborate/improve failure predictive models

The distribution grid asset maintainer identifies, based on the criticality analysis and the analysis of network data it has collected, the early signs of internal defects to be monitored on the network, especially defects affecting the most critical equipment.

This identification is based on historical analysis (such as the analysis of default root causes or the unreliability trend analysis and proposed corrective actions for instance).

The purpose of this step is ultimately to better anticipate the damage and avoid the consequences of faults. To do so, the distribution grid asset maintainer develops the concept of "Asset Health Index, AHI", especially in the case of equipment identified as "critical" in the previous step.

For instance, for the monitoring of MV/LV transformers, the data measured on the transformers under study to elaborate failure predictive models include:

- Load current, oil temperature and oil humidity,
- Dissolved gas analysis (DGA),
- Condition monitoring crossings and partial discharge analysis.

The drift of a leading failure indicator or the use of a default prediction algorithm potentially may lead to generate alerts and reprioritize maintenance actions over the year – Operational planning in the medium-term and short-term, and possibly intraday (BUC "Decide to carry out urgent maintenance operations").

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

1.4 Perform targeted economic analyses and estimate the economic life duration of equipment types

For instance, the grid asset maintainer may:

- Analyse the cost of ownership of certain equipment (net present value, cost of maintenance, cost of corrective actions, etc.) and identify when the economic life duration is less than the technical life duration – or in other words, when the cost of owning the equipment becomes greater than its cost of renewal.
- Perform targeted preliminary studies on extending the life of some equipment (for instance, on the partial renewal and extension of the life of the MV overhead network of 15 years, etc.).

1.4.1 Input data

The grid asset maintainer collects the following data:

- Inventory and features of the installed equipment,
- Ex-post data:
  - History of documented events (failures, corrective actions, maintenance visits / inspections, etc.),
  - Example of documentation associated with an event: what were the conditions of occurrence of the fault (weather data, equipment status data when the fault occurred, etc.)? What root cause analysis was made? What were the consequences of failure? What were the corrective operations?, etc.,
  - History of network operations real-time data (load, voltage, frequency, etc.) from real-time monitoring tools,
- Network topological data,
- Economic data.

These data are used as inputs for the analysis.

1.4.2 Output data

The grid asset maintainer determines the maintenance strategy.
The grid asset maintainer stores the information.

2 Define multiannual maintenance programme / long-term maintenance scheduling (*)

The grid asset maintainer:

- Applies the maintenance strategy on a given stock of installed equipment to derive a multiannual maintenance programme (between 10 and 40 years for instance, depending on the features and the life cycle of the equipment type),
- Elaborates a budget associated with investments to be proposed to internal stakeholders (Finance Department, etc.) and external roles of the electric power system (regulator, grid asset owner, etc.),
- Revises the multiannual maintenance programme depending on the allocated budget.

2.1 Input data

The grid asset maintainer collects the following data:

- Multiannual network masterplan,
- Maintenance strategy.

These data are used as inputs for the analysis.

2.2 Output data

The grid asset maintainer validates the multiannual maintenance programme.

The grid asset maintainer stores the information.

3 Define the annual maintenance programme / medium-term maintenance selection and scheduling (*)

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

The grid asset maintainer:

- Develops the annual maintenance programme taking into account:
  - Multiannual maintenance programme which has been validated in the previous step,
  - The multiannual network developments masterplan (i.e. diagram representing the evolutions of load and generation on the network within the next years) – to be described in BUC-Elaborate the network multiannual masterplan,
  - Annual work programmes (EHV and HV system operator, producers, distribution network works) – described in BUC-Optimize work programmes (EHV, HV, and MV/LV system operators and producers works),
- Elaborates a budget associated with investments to be proposed to different stakeholders (Finance Department, etc.),
- Revises the annual maintenance programme depending on the allocated budget.

3.1 Input data

The grid asset maintainer collects the following data:

- Multiannual maintenance programme,
- Multiannual network developments masterplan,
- Annual work programme (EHV, HV, MV/LV system operators and producers work).

These data are used as inputs for the analysis.

3.2 Output data

The grid asset maintainer optimizes the validated annual maintenance programme.

The grid asset maintainer stores the information.

(*) These activities are traditional activities and not specific to smart grid. Therefore they are not described in the business Use Case.

1.5 Key performance indicators

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
SAIDI	System Average Interruption Duration Index	Sum of durations of all interruptions of supply to individual customers during a time interval, divided by the total number of customers and the duration of that time interval.	
SAIFI	System Average Interruption Frequency Index	Number of interruptions of supply to individual customers during a time interval, divided by the total number of customers and the duration of that time interval.	
CAIDI	Customer Average Interruption Duration Index	Sum of durations of all interruptions to individual customers during a time interval, divided by the number of these interruptions.	
CAIFI	Customer Average Interruption Frequency Index	Number of interruptions of supply experienced by the individual customers affected at least once during a time interval, divided by the duration of that time interval.	
LOLE	Loss Of Load Expectation	Average time in a given period in which the peak load exceeds available generation capacity.	
LOEE	Loss Of Energy Expectation	Expected energy not supplied in a given period due to the loss of generation capacity.	
SM	System Minute	Total unsupplied energy over a given period divided by maximum load of the system.	

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

	Isolation	number of power system separations or isolation from interconnected power system	
	Load Shedding	number of unplanned large load shedding (100 MW and more)	
	Generation Outage	number of unplanned large generation outages (100 MW and more)	

1.6 Use case conditions

Use case conditions
Assumption
Prerequisite
• Elaboration of failure predictive models.
• Availability of methods enabling the grid asset maintainer to evaluate the consequence of an equipment failure and its failure probability.
• Elaboration of condition-based maintenance models per type of equipment.
• Asset failure outage statistics database.

1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
UC62913-2-1-B003: Elaborate the network multiannual masterplan
UC62913-2-1-B010: Optimize work programmes (EHV, HV, and MV/LV system operators, and producers works)
UC62913-2-1-B002: Carry out urgent maintenance operations
Level of depth
White-box
Prioritization
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Further keywords for classification
Network investments, maintenance programmes, condition-based maintenance, failure predictive models

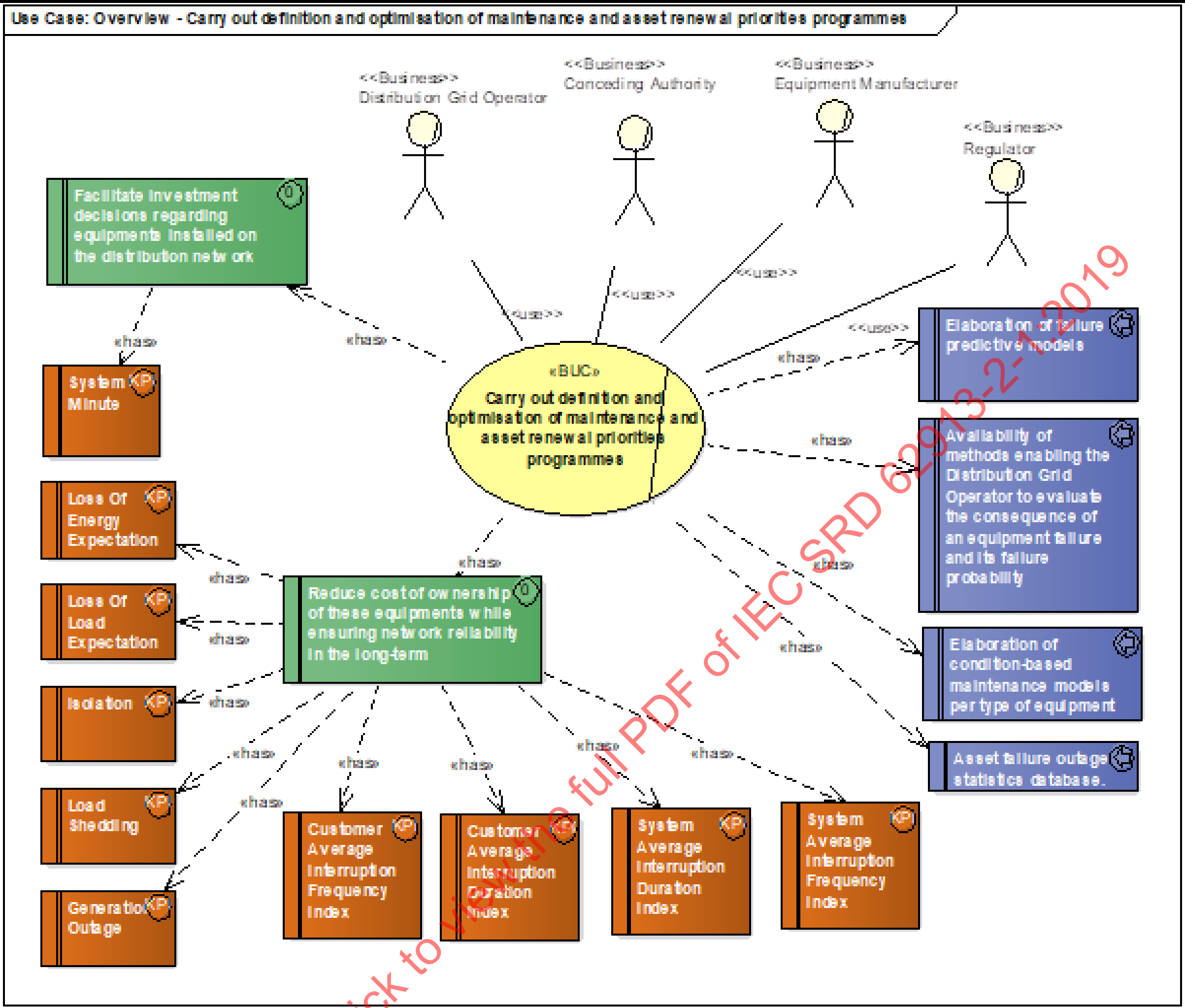
1.8 General remarks

General remarks

2 Diagrams of use case

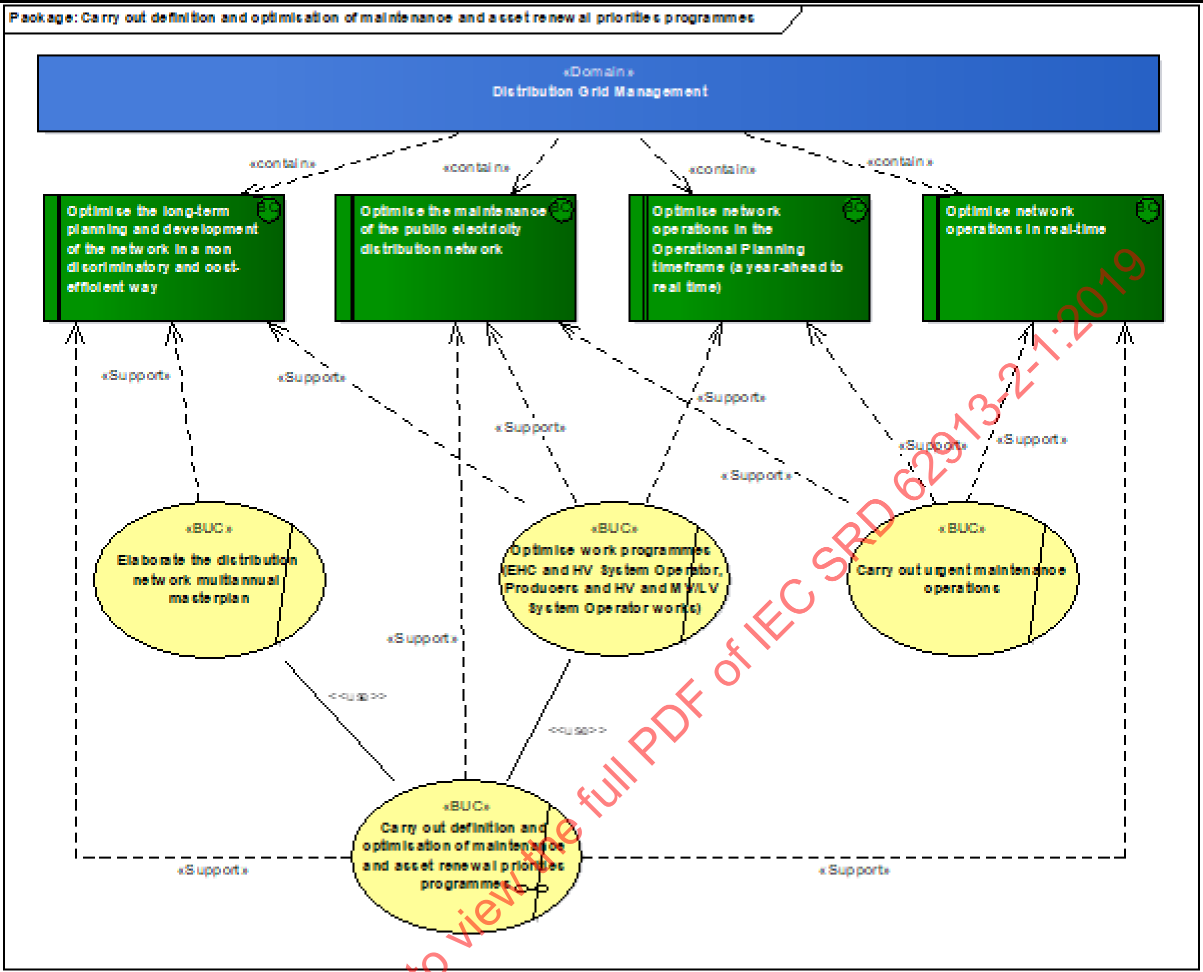
Diagram(s) of use case
Use Case Overview diagram

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes



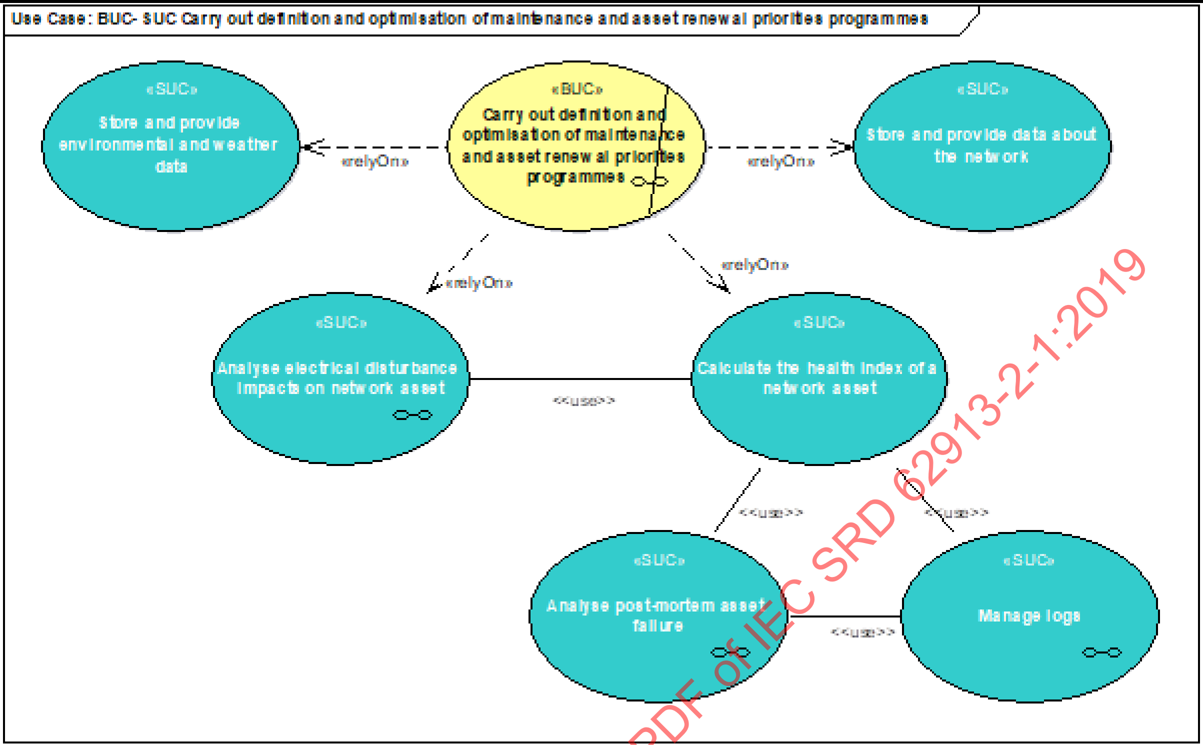
Domain Overview diagram

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes



BUC-SUC Relations diagram

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes



3 Technical details

3.1 Actors

Actors	
Grouping	**Group Description**

Actor name	**Actor type**	**Actor Description**	**Further information specific to this Use Case**
Grid asset maintainer	Business	See Table 2	
Regulator	Business	See Table 2	
Grid asset owner (applicable only in a system with licences)	Business	See Table 2	

3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
1	Standards	IEC 60050-191		International Electrotechnical Vocabulary: Dependability and quality of service	IEC	
2	Standards	IEC 61703:2001		Mathematical expressions for reliability, availability, maintainability and maintenance support terms	IEC	

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes

3	Standards	IEC 60605		Equipment reliability testing	IEC	
4	Standards	ISO 3534-1:2006		Statistics – Vocabulary and symbols – Part 1: General statistical terms and terms used in probability	ISO	
5	Standards	ISO 3534-2:1993		Statistics – Vocabulary and symbols – Part 2: Applied statistics	ISO	
6	Standards	IEC 60812:2006		Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)	IEC	
7	Standards	IEC 60300-3-11: 1999		Reliability Centred Maintenance (RCM) method	IEC	
8	Standards	IEC 61968-1:2012 EN 61968-1:2013	IS	Application integration at electric utilities – System interfaces for distribution management – Part 1: Interface architecture and general recommendations	IEC, CENELEC	
9	Standards	IEC 61968-6:2015	IS	Application integration at electric utilities – System interfaces for distribution management – Part 6: Interfaces for maintenance and construction	IEC	
10	Standards	IEC 61968-4:2007	IS	Application integration at electric utilities – System interfaces for distribution management – Part 4: Interfaces for records and asset management	IEC	
11	Standards	ISO 55000:2014		Asset management – Overview, principles and terminology	ISO	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-Condition**	**Post-Condition**

UC62913-2-1-B001: Carry out definition and optimization of maintenance and asset renewal priorities programmes						

4.2 Scenarios

Scenario name:	**No. 1 –**							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirements R-IDs**

5 Information exchanged

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements IDs**

6 Requirements (optional)

Requirements (optional)		
Category ID	**Categories for requirements**	**Category description**
Requirement ID	**Requirement description**	

7 Common terms and definitions

Common terms and definitions	
Term	**Definition**

8 Custom information (optional)

Custom information (optional)		
Key	**Value**	**Refers to Section**

B.2 Distribution grid management

B.2.1 Business Use Cases

See Table B.2 and Table B.3.

Table B.2 – UC62913-2-1-B007: Operate the MV network in real-time

UC62913-2-1-B007: Operate the MV network in real-time

1 Description of the use case

1.1 Name of use case

Use case identification		
ID	**Area /Domain(s)/ Zone(s)**	**Name of use case**
UC62913-2-1-B007	Area: Energy system Domain: Distribution grid management	BUC-Operate the MV network in real-time

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Real-time network operations on the MV network and primary substations, in normal conditions and in case of fault. The following issues are out of the scope of the Use Case: – Reactive power flows control at the transmission/distribution interface with reactive resources connected to the distribution network, – LV network management, – Active control of local production and consumption flexibility.
Objective(s)	– Monitor primary substations and MV network, – Manage energy flows on the distribution network according to technical constraints (voltage plan control), especially in presence of DER and in coordination with the EHV/HV system operator, – Contribute to system security in coordination with the EHV/HV system operator, – Improve continuity of supply on the distribution network, – Reduce delays in service restoration.
Related business case(s)	– Manage real-time network operations in an optimized way

1.4 Narrative of use case

Narrative of use case

Short description

The business Use Case describes how the MV/LV system operator operates the MV network in real-time operations using smart grid solutions and new and/or enriched data:

- Optimize the configuration of the network in real-time,
- Control the MV voltage profile in real-time,
- Decide to use emergency levers,
- Manage faults and restore power.

Complete description

The process includes the following steps:

Prerequisite: Optimize the configuration of the network before real-time

In day ahead, the MV/LV system operator defines the optimal network configuration (position of switches) by using operational planning tools and load and generation forecasts at the primary substation level. To do so, he also takes into account the works planned on the distribution network and production schedules of Distributed Generators connected to the MV network if available (see BUC-Optimize network operations in operational planning based on a schedule).

In intraday, operational planning tools integrate real-time data related to the state of the network

UC62913-2-1-B007: Operate the MV network in real-time

(position of switches, measurements from remote controlled network components, alarms) in order to update simulations and determine if needed the merit-order of optimization levers at the disposal of the MV/LV system operator (network reconfiguration, etc.).

1 Optimize the configuration of the network in real-time

In real-time operations, the SCADA system may be used to access information related to the state of the network and updated short-term local load and generation forecasts. Using this information, the system analyses the conformity of real-time data with the simulations performed by operational planning tools and alerts the MV/LV system operator if needed:

- Real-time data correspond to the simulations, or
- A deviation occurs.

1 a-Real-time data correspond to the simulations

The optimal network configuration remains in effect.

1 b-A deviation occurs

Two cases can be identified:

- Significant deviation between real-time measurement and latest forecasts,
- A fault has been cleared (see steps 3-Use emergency levers and 4-Manage faults).

The network configuration shall in this case be re-evaluated.

The MV/LV system operator performs a new simulation. He integrates in the input data the modifications identified since the latest simulation. On this basis, he identifies potential constraints on the distribution network (current, voltage) and the optimization levers which may be used to solve them (network reconfiguration, central voltage regulation at the primary substation using On Load Tap Changers, etc.).

The MV/LV system operator validates the use of these levers by performing another simulation. The latest simulation provides a new optimal network configuration, which replaces the previous one.

The MV/LV system operator activates the optimization levers which have been selected.

The MV/LV system operator coordinates with the EHV/HV system operator to ensure that operating requirements on the distribution and the transmission networks are met and that the measures to be engaged by the MV/LV system operator or the EHV/HV system operator do not generate constraints on one or both networks or the overall system.

The free flow of these exchanges allows the MV/LV system operator and the EHV/HV system operator to efficiently face issues related to system security:

- The control of the transmission network voltage plan, and risks of voltage constraints on the EHV and/or the HV network and voltage dips associated with physical flows (especially reactive power flows) on both networks,
- The management of current constraints on the transmission network,
- System security (balance between demand and supply, load-shedding national plan).

2 Control the MV voltage profile in real-time

Voltage profile and power flows in distribution grids are changing dynamically, mainly because of the stochastic nature of consumption and production of renewable sources. The power injected by distributed generators can overload feeder segments or lead the voltage beyond the limits in some parts of the grid. In order to maintain voltage within contractual limits, the voltage profile of the distribution grid is continuously monitored and optimized.

The voltage profile management may impact the reactive power flows at the MV/LV system operator-EHV/HV system operator interface and shall be coordinated with the EHV/HV system operator, according to requirements related to the transmission network access.

Based on the real-time estimation of the state of the network, the MV voltage profile may be controlled via the modification of the voltage set points at the primary substation (see SUC-Distribution grid management domain-Perform centralized voltage control based on state estimation).

3 Use emergency levers to safeguard the network

The MV/LV system operator may, in compliance with the regulatory framework, take emergency measures to safeguard the network.

UC62913-2-1-B007: Operate the MV network in real-time

4 Manage faults on the network

When an incident on a MV feeder or within a primary substation leads to a fault, the MV/LV system operator needs to:

- Restore supply with the shortest outage time,
- Identify assets which have been impacted by the fault and may need to be repaired to finalize service restoration.

To initiate the sequence of actions required to meet these two objectives, the MV/LV system operator may use the SCADA system, real-time information available on his console, and technical staff on the field.

4.1 Detect the incident, locate and isolate the fault, and define a restoration plan

The fault management process is composed of 3 main steps, which are typically highly automated and may be performed by an Advanced FLISR (Fault Location, Isolation, and Service Restoration) system (see SUC-Distribution grid management domain-Manage faults on the distribution network using advanced FLISR system):

- Detection and analysis of the incident,
- Location and isolation of faulty sections or assets,
- Definition and implementation of a restoration plan based on real-time data.

The effects of the determined switching actions for isolation or restoration might be simulated and verified (or even optimized) automatically or by the MV/LV system operator prior to execution.

4.2 Finalize service restoration and secure the power supply

The MV/LV system operator may ask field operators to intervene on the field in order to finalize service restoration, which may require urgent maintenance operations.

The MV/LV system operator (or the operational planning tool) then performs a network simulation based on updated local load and generation forecasts, and tests the resistance of the restoration plan on the short term. The MV/LV system operator may initiate complementary actions in order to optimize network configuration.

1.5 Key performance indicators

Key performance indicators				
ID	**Name**	**Calculation**	**Scope**	**Objective**

1.6 Use case conditions

Use case conditions
Assumption
• The optimization levers that the MV/LV system operator may use to solve electrical network constraints have been defined and/or validated by regulation and described within technical rules.
Prerequisite
• Availability and reliability of local load and generation forecasts.
• Resilience and performance of the telecommunications system.

1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
UC62913-2-1-B009: Optimize network operations in operational planning based on a schedule
UC62913-2-1-S001: Perform centralized voltage control based on state estimation
UC62913-2-1-S002: Manage faults on the MV network using advanced FLISR system
Level of depth
Short version
Prioritization
Needed for systems with high penetration rate of DERs connected to the distribution network

UC62913-2-1-B007: Operate the MV network in real-time

Generic, regional or national relation

Generic (Europe)

Nature of the use case

Business Use Case

Maturity of the Use Case

Technically mature

Further keywords for classification

Network operations, voltage profile, fault management, optimization levers

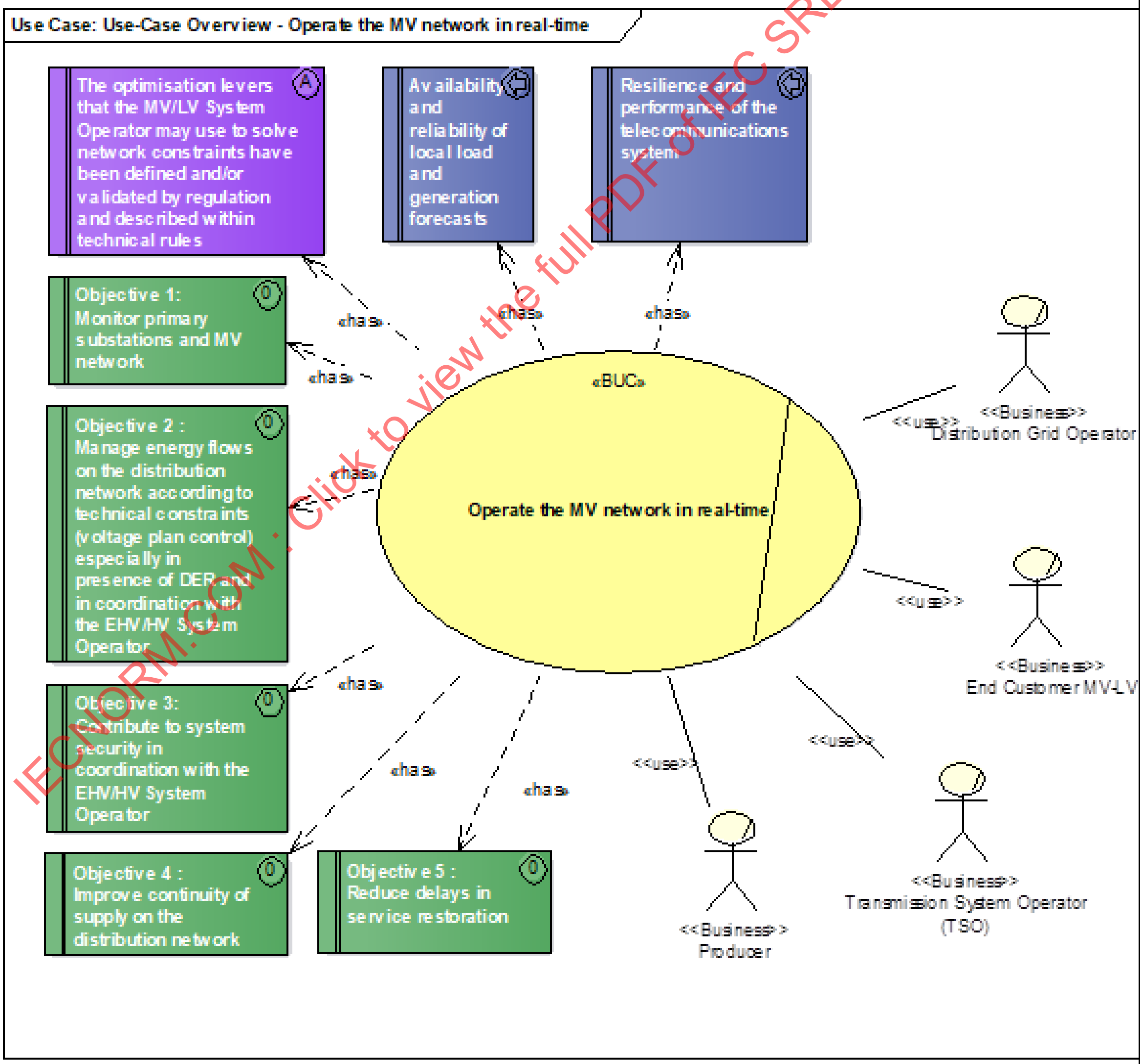
1.8 General remarks

General remarks

2 Diagrams of use case

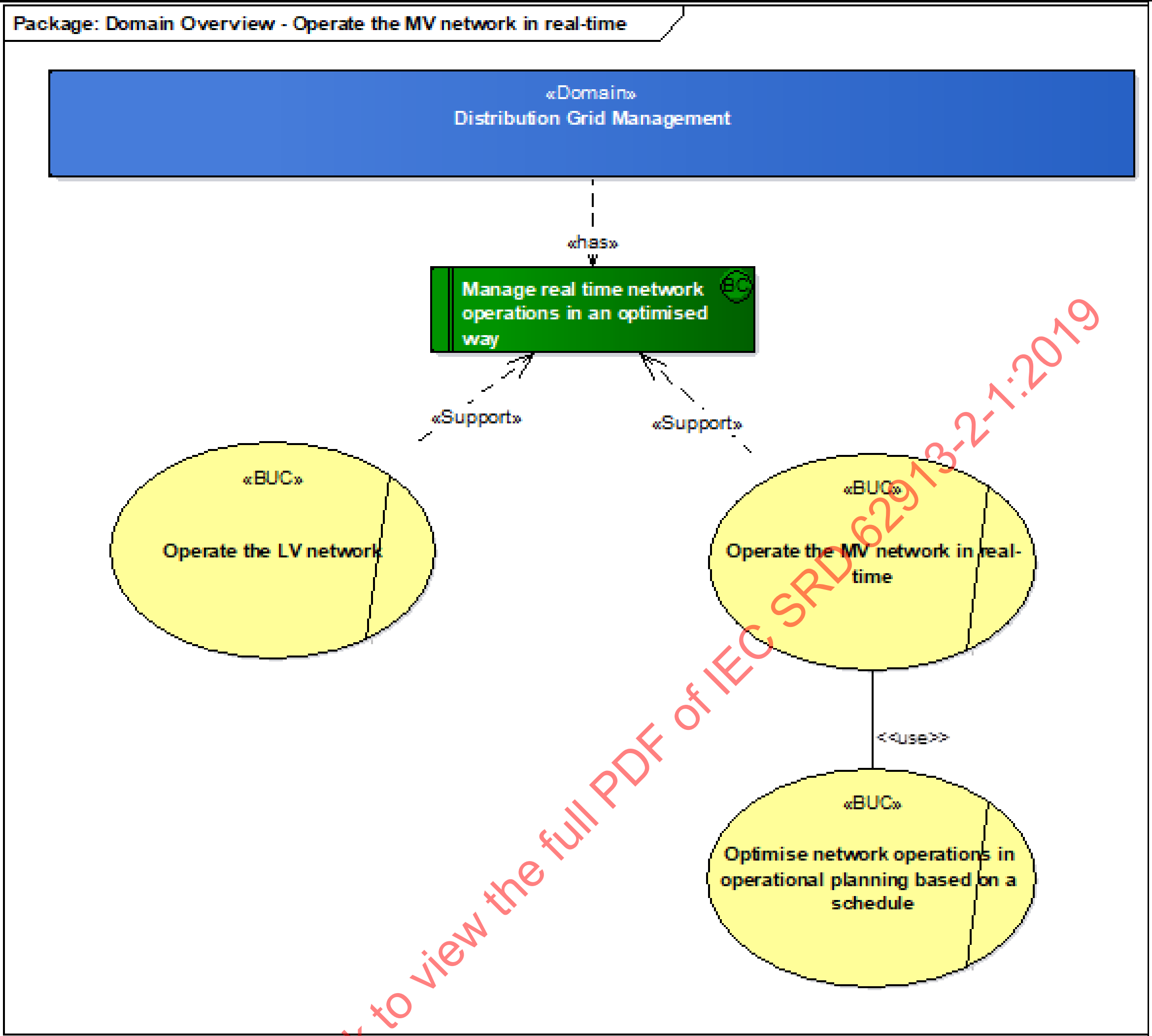
Diagram(s) of use case

Use Case Overview diagram

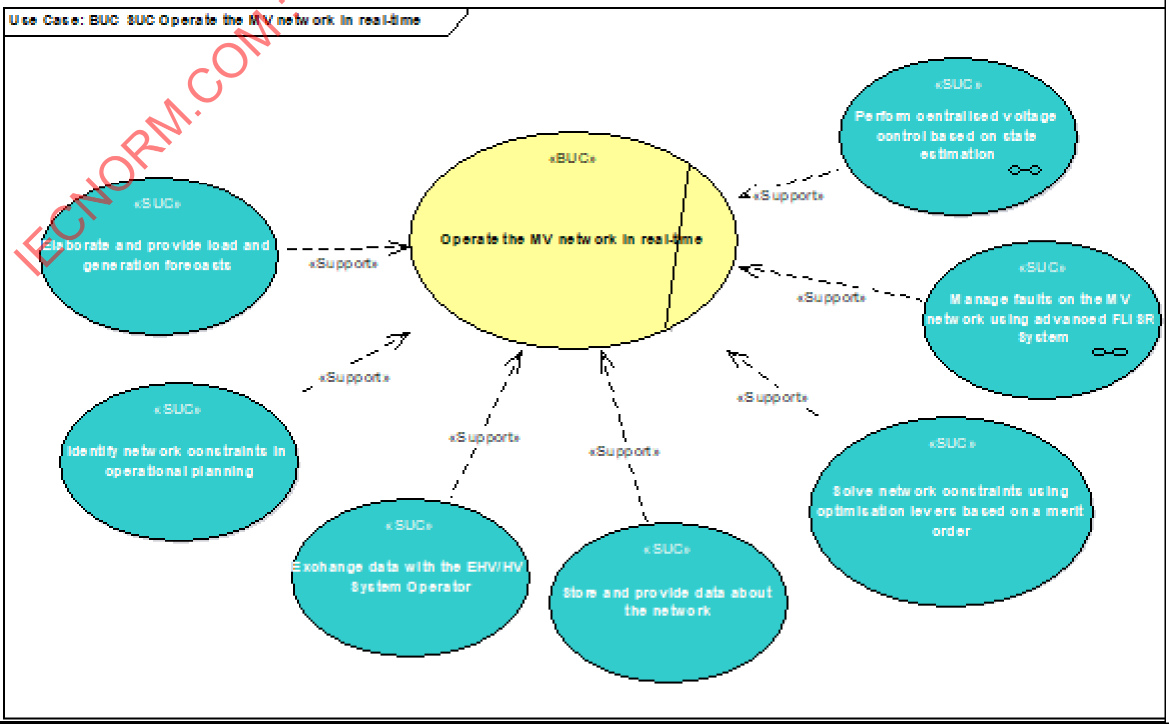


Domain Overview diagram

UC62913-2-1-B007: Operate the MV network in real-time

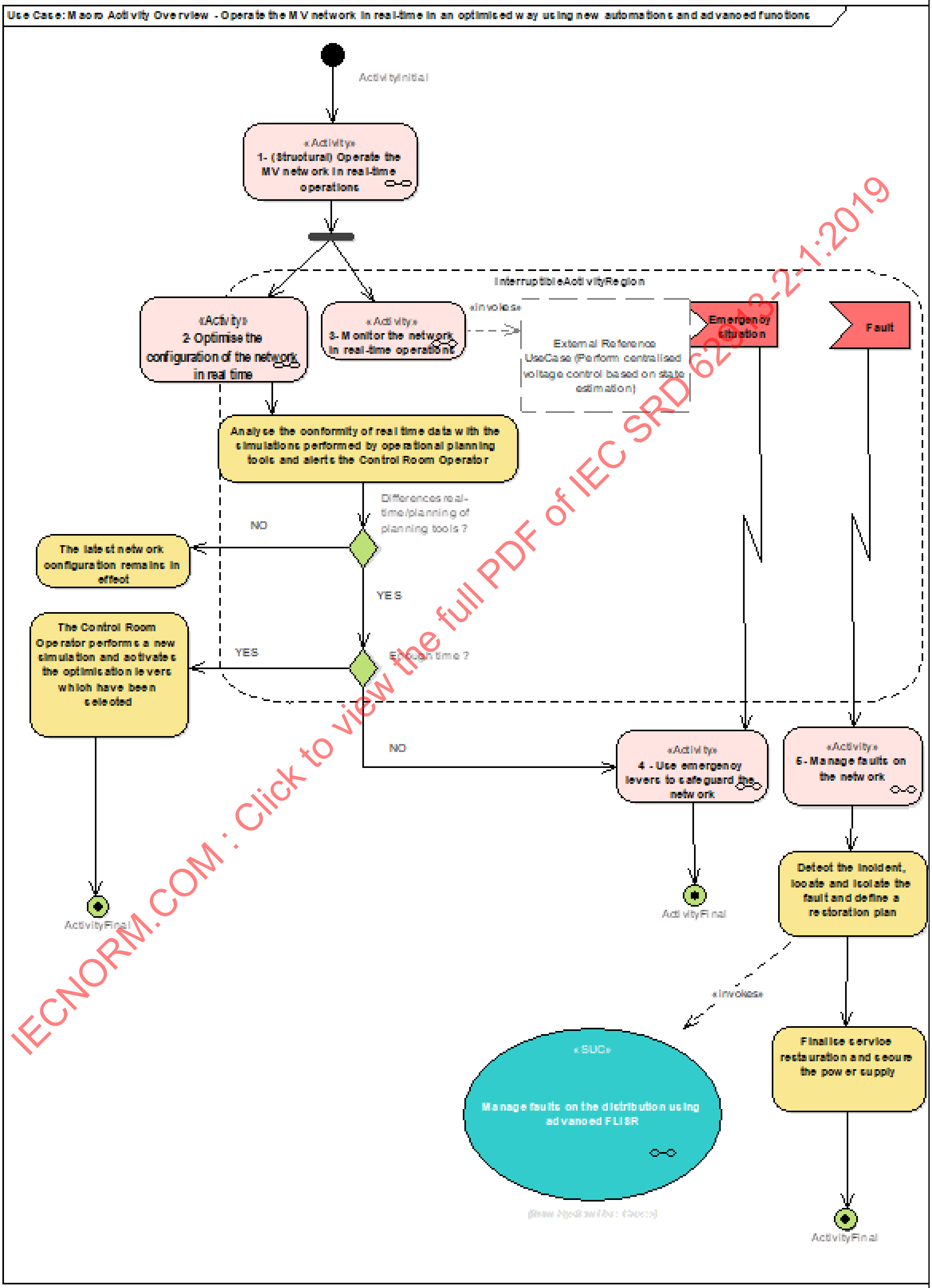


BUC-SUC Relations diagram



UC62913-2-1-B007: Operate the MV network in real-time

Activity diagram



UC62913-2-1-B007: Operate the MV network in real-time

3 Technical details

3.1 Actors

Actors	
Grouping	**Group Description**

Actor name	Actor type	Actor Description	Further information specific to this Use Case
EHV/HV system operator	Role	See Table 2	
MV/LV system operator	Role	See Table 2	
MV producer	Role	See Table 2	
MV/LV customers	Role	See Table 2	

3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-Condition**	**Post-Condition**
1a	Normal condition	Real-time data related to the state of the network and short-term local load and generation forecasts correspond to the latest network simulation; the defined network configuration remains in effect. In order to maintain voltage within contractual limits, the voltage profile of the distribution grid is continuously monitored and optimized.	MV/LV system operator	Definition of an optimal network configuration		
1b	Deviation of	Real-time data	MV/LV			

UC62913-2-1-B007: Operate the MV network in real-time

	real-time data from forecasts	measurements do not confirm the latest network simulation. The MV/LV system operator performs a new simulation and optimizes the network configuration with relevant optimization levers.	system operator			
2	Centralized voltage control	The MV voltage profile may be controlled via the modification of the voltage set points at the primary substation.	MV/LV system operator	Detection of a voltage constraint		
3	Use of emergency levers	The MV/LV system operator may, in compliance with the regulatory framework, take emergency measures to safeguard the network.	MV/LV system operator	Occurrence of an emergency situation		
4	Fault management	When an incident on a MV feeder or within a primary substation leads to a fault, the MV/LV system operator needs to: – Restore supply with the shortest outage time, – Identify assets which have been impacted by the fault and may need to be repaired to finalize service restoration	MV/LV system operator	Occurrence of a fault on the network		

4.2 Scenarios

Scenario	No. 1 –

UC62913-2-1-B007: Operate the MV network in real-time

name:								
Step No.	**Event**	**Name of process / activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirements R-IDs**

Scenario name:	**No. 2 –**							
Step No.	**Event**	**Name of process / activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirements R-IDs**

5 Information exchanged

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements IDs**
		-	

6 Requirements (optional)

Requirements (optional)		
Category ID	**Categories for requirements**	**Category description**
Requirement ID	**Requirement description**	
R-		
R-		
R-		
Category ID	**Categories for requirements**	**Category description**
Requirement ID	**Requirement description**	
R-		
R-		
R-		

7 Common terms and definitions

Common terms and definitions	
Term	**Definition**

8 Custom information (optional)

Custom information (optional)		
Key	**Value**	**Refers to Section**

Table B.3 – UC62913-2-1-B012: Manage faults on the MV network

UC62913-2-1-B012: Manage faults on the MV network

1 Description of the use case

1.1 Name of use case

Use case identification		
ID	**Area /Domain(s)/ Zone(s)**	**Name of use case**
UC62913-2-1-B012	Area: Energy system Domain: Distribution grid management	BUC-Manage faults on the MV network

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Real-time network operations on the MV network and primary substations, in case of fault. The following issues are out of the scope of the Use Case: – Reactive power flows control at the transmission/distribution interface with reactive resources connected to the distribution network, – LV network management, – Active control of local production and consumption flexibility.
Objective(s)	– Improve continuity of supply on the distribution network, – Reduce delays in service restoration.
Related business case(s)	– Manage real-time network operations in an optimized way

1.4 Narrative of use case

Narrative of use case

Short description

The generic business Use Case describes how the MV system operator may operate operates the MV network in real-time operations in presence of a fault on the MV feeder, producing an outage to part of the grid users.

Complete description

The process includes the following steps:

Prerequisite: Optimize the configuration of the network before real-time

In day ahead, the control room operator defines the optimal network configuration (position of switches) by using operational planning tools and load and generation forecasts at the primary substation level. To do so, he also takes into account the works planned on the distribution network and production schedules of Distributed Generators connected to the MV network if available (see GBUC-Optimize network operations in operational planning based on a schedule).

UC62913-2-1-B012: Manage faults on the MV network

In intraday, operational planning tools integrate real-time data related to the state of the network (position of switches, measurements from remote controlled network components, alarms) in order to update simulations and determine if needed the merit-order of optimization levers at the disposal of the control room operator (network reconfiguration, etc.).

1 Manage faults on the network

When an incident on a MV feeder or within a primary substation leads to a fault (i.e. a part of the network is de-energized, the control room operator needs to:

– Restore supply with the shortest outage time,
– Minimize the number of grid users affected by the outage,
– Identify assets which have been impacted by the fault and may need to be repaired to finalize service restoration.

To initiate the sequence of actions required to meet these two objectives, the control room operator may use the SCADA system, real-time information available on his console, and technical staff on the field.

1.1 Detect the incident, locate and isolate the fault, and define a restoration plan

The fault management process is composed of 3 main steps, which may be highly automated and may be performed by an Advanced FLISR (Fault Location, Isolation, and Service Restoration) system (see UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR):

– Detection and analysis of the incident,
– Location and isolation of faulty sections or assets,
– Definition and implementation of a restoration plan based on real-time data, based on many criteria.

The expected effects of the determined switching actions for isolation or restoration might be simulated and verified (or even optimized) automatically or by the control room operator prior to execution.

1.2 Finalize service restoration and secure the power supply

The control room operator may ask field operators to intervene on the field in order to finalize service restoration, which may require urgent maintenance operations.

The control room operator (or the operational planning tool) then performs a network simulation based on updated local load and generation forecasts, and tests the resistance of the restoration plan on the short term. The control room operator may initiate complementary actions in order to optimize network configuration.

1.6 Key performance indicators

Key performance indicators				
ID	**Name**	**Calculation**	**Scope**	**Objective**

1.7 Use case conditions

Use case conditions
Assumption
• The optimization levers that the control room operator may use to solve electrical network constraints have been defined and/or validated by regulation and described within the MV/LV system operator technical rules.
Prerequisite
• Availability and reliability of local load and generation forecasts.
• Resilience and performance of the telecommunications system.

UC62913-2-1-B012: Manage faults on the MV network

1.8 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
UC62913-2-1-B009: Optimize network operations in operational planning based on a schedule
UC62913-2-1-B007: Operate the MV network in real-time
UC62913-2-1-S002: Manage faults on the MV network using advanced FLISR
Level of depth
Short version
Prioritization
Needed for systems with high penetration rate of DERs connected to the MV network
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Maturity of the Use Case
Technically mature
Further keywords for classification
Network operations, voltage profile, fault management, optimization levers

2 Diagrams of use case

3 Technical details

3.1 Actors

Actors	
Grouping	**Group Description**

Actor name	Actor type	Actor Description	Further information specific to this Use Case
MV/LV system operator	Business	See Table 2	
EHV/HV system operator	Business	See Table 2	
MV producer	Business	See Table 2	
MV/LV customers	Business	See Table 2	
Field operators	Business	See Table 2	

3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-Condition**	**Post-Condition**
4	Fault management	When an incident on a MV feeder or within a primary substation leads to a fault, the control room	MV/LV system operator	Occurrence of a fault on the network		

UC62913-2-1-B012: Manage faults on the MV network

			operator needs to: – Restore supply with the shortest outage time, – Identify assets which have been impacted by the fault and may need to be repaired to finalize service restoration				

4.2 Scenarios

Scenario name:	**No. 1 –**							
Step No.	**Event**	**Name of process / activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirements R-IDs**

5 Information exchanged

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements IDs**

6 Requirements (optional)

Requirements (optional)		
Category ID	**Categories for requirements**	**Category description**
Requirement ID	**Requirement description**	
R-		
R-		
R-		
R-		
Category ID	**Categories for requirements**	**Category description**
Requirement ID	**Requirement description**	
R-		
R-		
R-		

UC62913-2-1-B012: Manage faults on the MV network	
7 Common terms and definitions	
Common terms and definitions	
Term	**Definition**

8 Custom information (optional)		
Custom information (optional)		
Key	**Value**	**Refers to Section**

B.2.2 System Use Cases

See Table B.4 and Table B.5.

Table B.4 – UC62913-2-1-S001: Perform centralized voltage control based on state estimation

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

1 Description of the use case

1.1 Name of use case

Use case identification		
ID	**Area /Domain(s)/ Zone(s)**	**Name of use case**
UC62913-2-1-S001	Area: Energy system Domain: Distribution grid management	SUC-Perform centralized voltage control based on state estimation

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	MV centralized voltage regulation system based on a state estimator. The following points are out of the scope of the Use Case: – Local voltage regulation system (although such a system may be coordinated with the centralized voltage regulation system described hereafter), – Reactive power control at the MV/LV system operator-EHV/HV system operator interface. – Active control of local production and consumption flexibility.
Objective(s)	– Maintain the MV voltage profile within contractual limits in order to ensure quality of supply and optimize grid investments.
Related business case(s)	– Manage real-time network operations

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

1.4 Narrative of use case

Narrative of use case

Short description

The system Use Case describes how network automated functions:

- Estimate the state of the MV network in real-time,
- Regulate the MV network profile by defining optimal voltage set points at the primary substation using OLTC.

Complete description

The process includes the following steps:

1 Estimate the state of the network and define optimal values

On a cyclical basis, the state estimation function computes in real-time the voltage values for critical points of the MV network, based on current and voltage measurements collected from sensors and active and reactive power calculations at primary substations, MV feeders, secondary substations, and at the connection point of producers connected to the MV network.

The state estimation function integrates in its calculations load models.

2 Elaborate and issue optimal voltage set points at the primary substation

Based on the calculations of the state estimation function, the MV/LV system operator SCADA system may identify a deviation of the voltage values from contractual limits (over-voltage or under-voltage).

In this case, in order to maintain the voltage within these limits, the centralized voltage control function defines optimal voltage set points at the primary substation and sends the reference values to the primary substation control and monitoring system, which modifies the reference voltage set point of the OLTC.

3 Control the effectiveness and efficiency of the measures

The MV/LV system operator SCADA system monitors the execution of the different orders and the conformity of their effects on the MV voltage profile.

1.5 Key performance indicators

Key performance indicators

ID	Name	Calculation	Scope	Objective
	Accuracy of current and voltage measurements			
	Communication delays between the MV/LV system operator SCADA system and the substation control and monitoring system			

1.6 Use case conditions

Use case conditions

Assumption

Prerequisite

- Deployment of network sensors and availability and accuracy of field measurements.

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
UC62913-2-1-B007: Distribution grid management domain-Operate the MV network in real-time
Level of depth
Full version
Prioritization
Needed for systems with high penetration rate of DERs connected to the distribution network
Generic, regional or national relation
Generic (Europe)
Nature of the use case
System Use Case
Maturity of the Use Case
Technically mature
Further keywords for classification
Network operations, centralized voltage control, network automated functions, state estimation

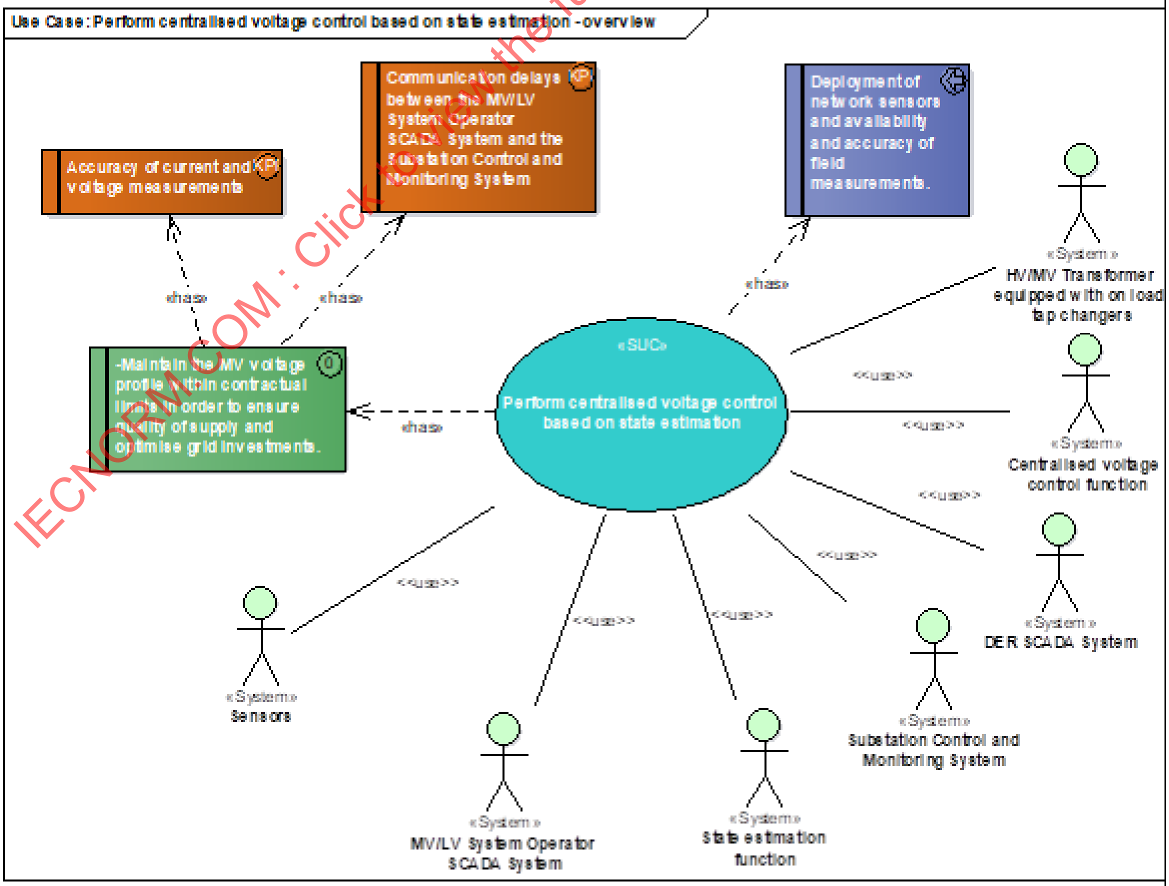
1.8 General remarks

General remarks

2 Diagrams of use case

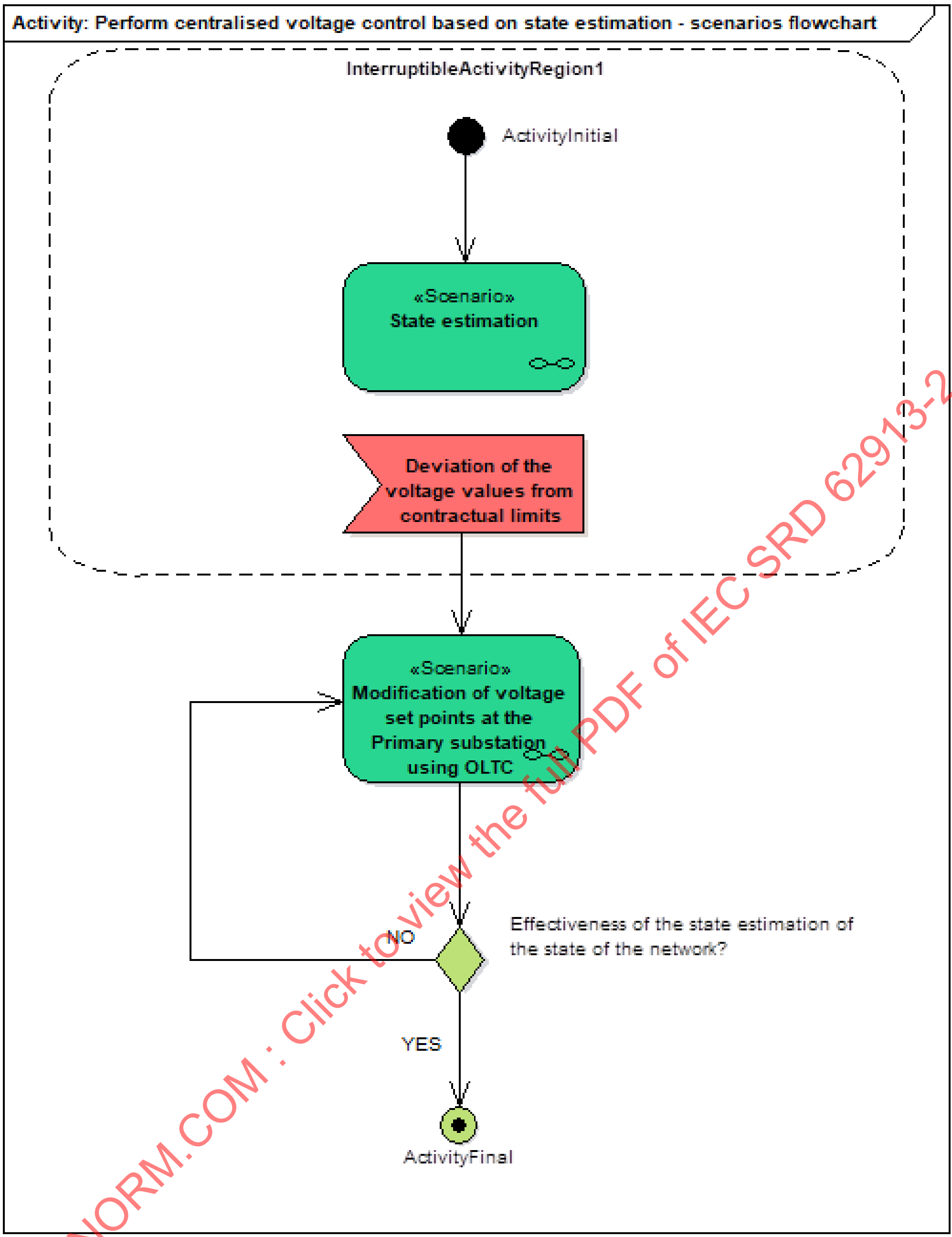
Diagram(s) of use case

Use Case Overview diagram



Activity diagram

UC62913-2-1-S001: Perform centralized voltage control based on state estimation



UC62913-2-1-S001: Perform centralized voltage control based on state estimation

3 Technical details

3.1 Actors

Actors	
Grouping	**Group Description**

Actor name	**Actor type**	**Actor Description**	**Further information specific to this Use Case**
Sensors	System	See Table 6	
MV/LV SCADA system	System	See Table 6	
State estimation function	System	See Table 6	
Substation control and monitoring system	System	See Table 6	
DER SCADA system	System	See Table 6	
Centralized voltage control function	System	See Table 6	
HV/MV transformer equipped with on load tap changers	System	See Table 6	

3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
	Use Case	WGSP-0200 - Voltage control and power flows optimization		Material considered as input	CEN-CENELEC-ETSI Working Group on Sustainable processes, Carlo Tornelli and Gianluigi Proserpio (RSE)	
	Use Case	D2.1- Distribution State Estimator (DSE)		Material considered as input	IGREENGrid (French demonstration description)	
	Use Case	D2.1- Centralized Volt Var Control (VVC)		Material considered as input	IGREENGrid (French demonstration description)	
	Standard	IEC 61850		Electrical substation automation	IEC	
	Standard	IEC 61000-4-30		Measurement methods to obtain reliable, repeatable and comparable results (aggregation methods)	IEC	
	Standard	IEC 61557-2		Accuracy of measurements (calculation of active and reactive power based on current and voltage measurements)	IEC	

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

4 Step by step analysis of use case

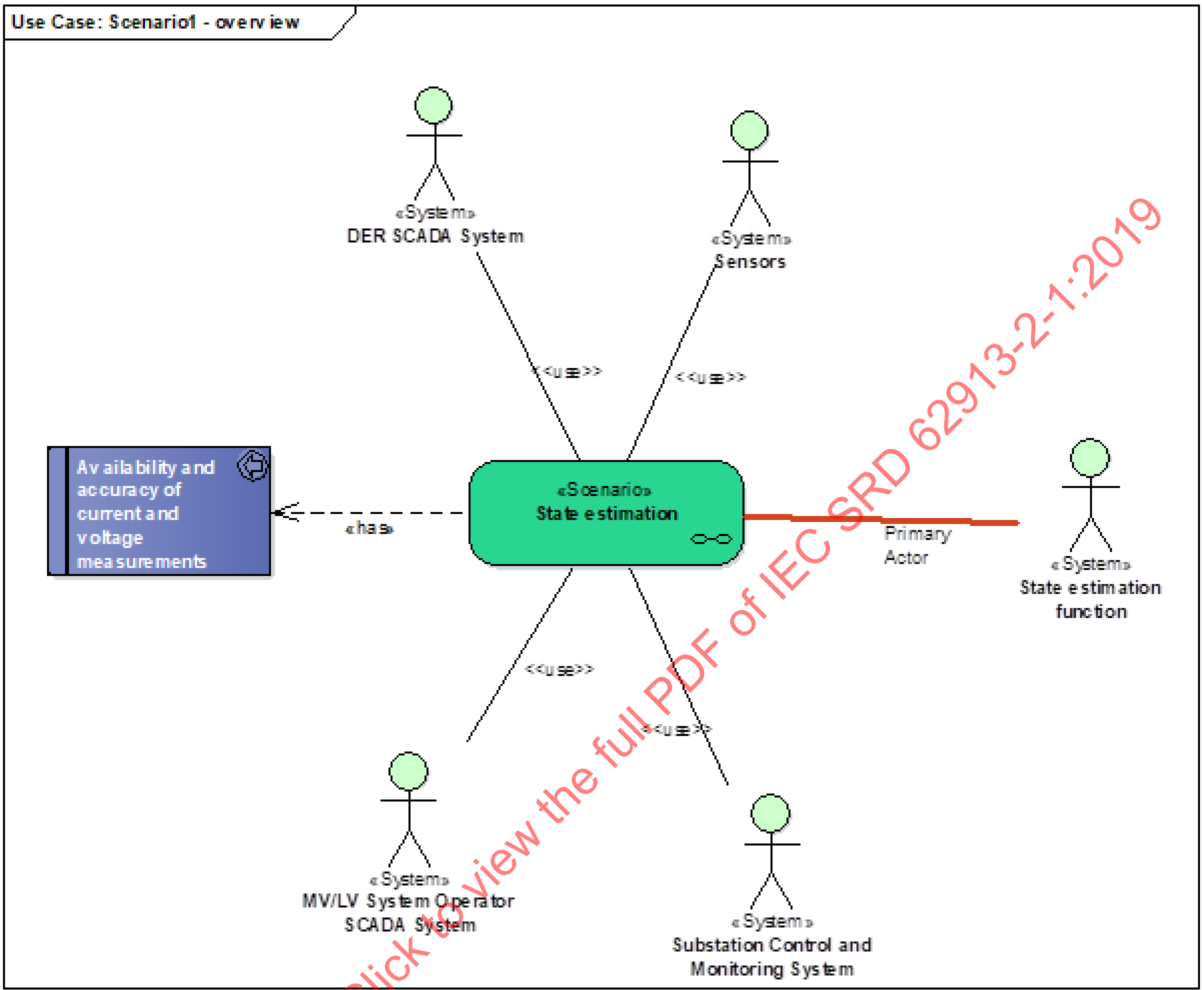
4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-Condition**	**Post-Condition**
1	State estimation	On a cyclical basis, the state estimation function calculates the MV voltage profile using available measurements	State estimation function		Availability and accuracy of current and voltage measurements	
2	Modification of voltage set points at the primary substation using OLTC	In case of deviation of voltage values from contractual limits, the centralized voltage control function calculates optimal voltage set points at the primary substation transformer and sends the new values to the substation control and monitoring system, which modifies the reference voltage set points of the OLTC	Centralized voltage control function	Deviation of voltage values from contractual limits		

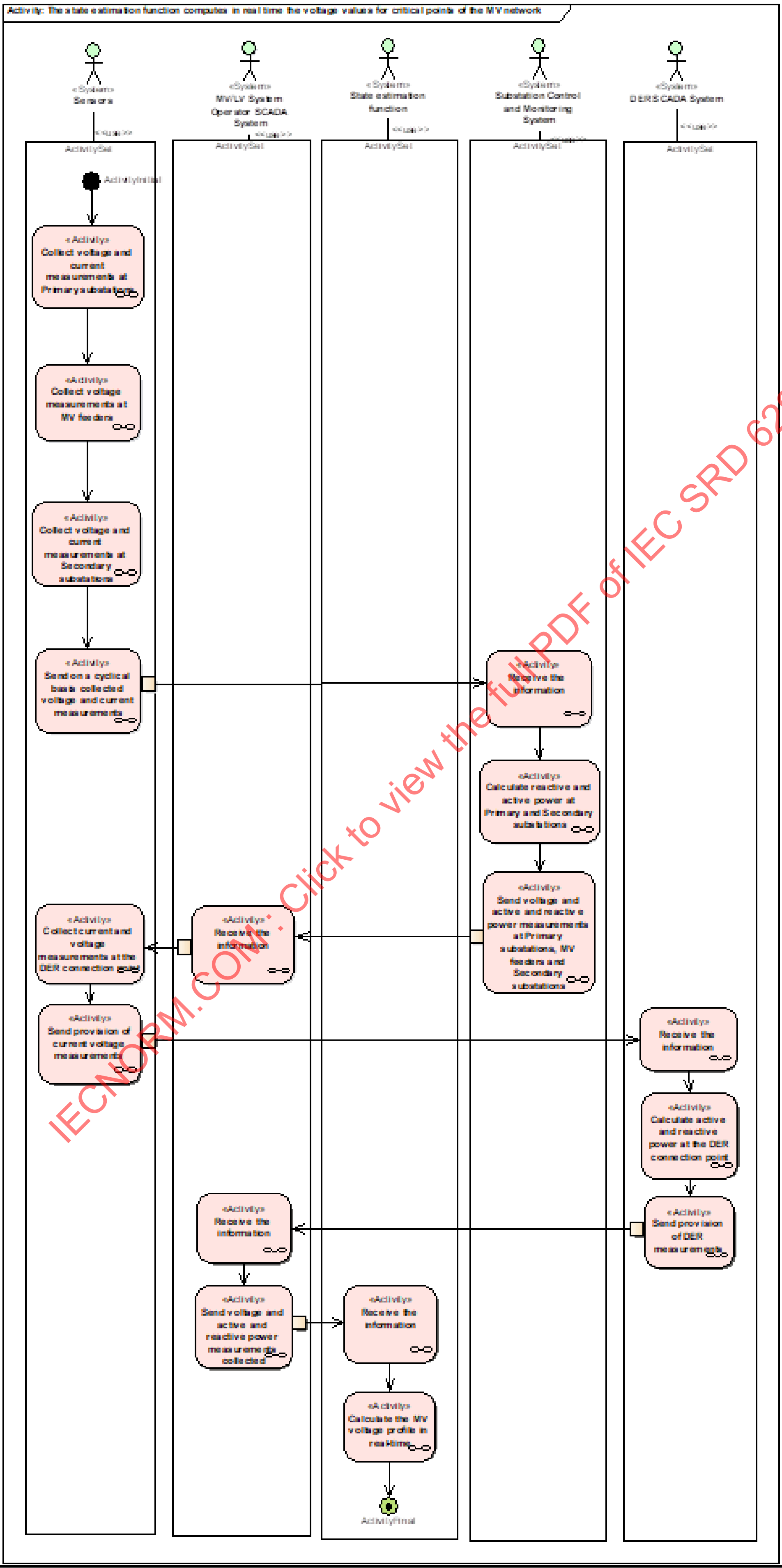
UC62913-2-1-S001: Perform centralized voltage control based on state estimation

4.2 Scenarios

4.2.1 State estimation



UC62913-2-1-S001: Perform centralized voltage control based on state estimation



UC62913-2-1-S001: Perform centralized voltage control based on state estimation

Scenario step by step analysis

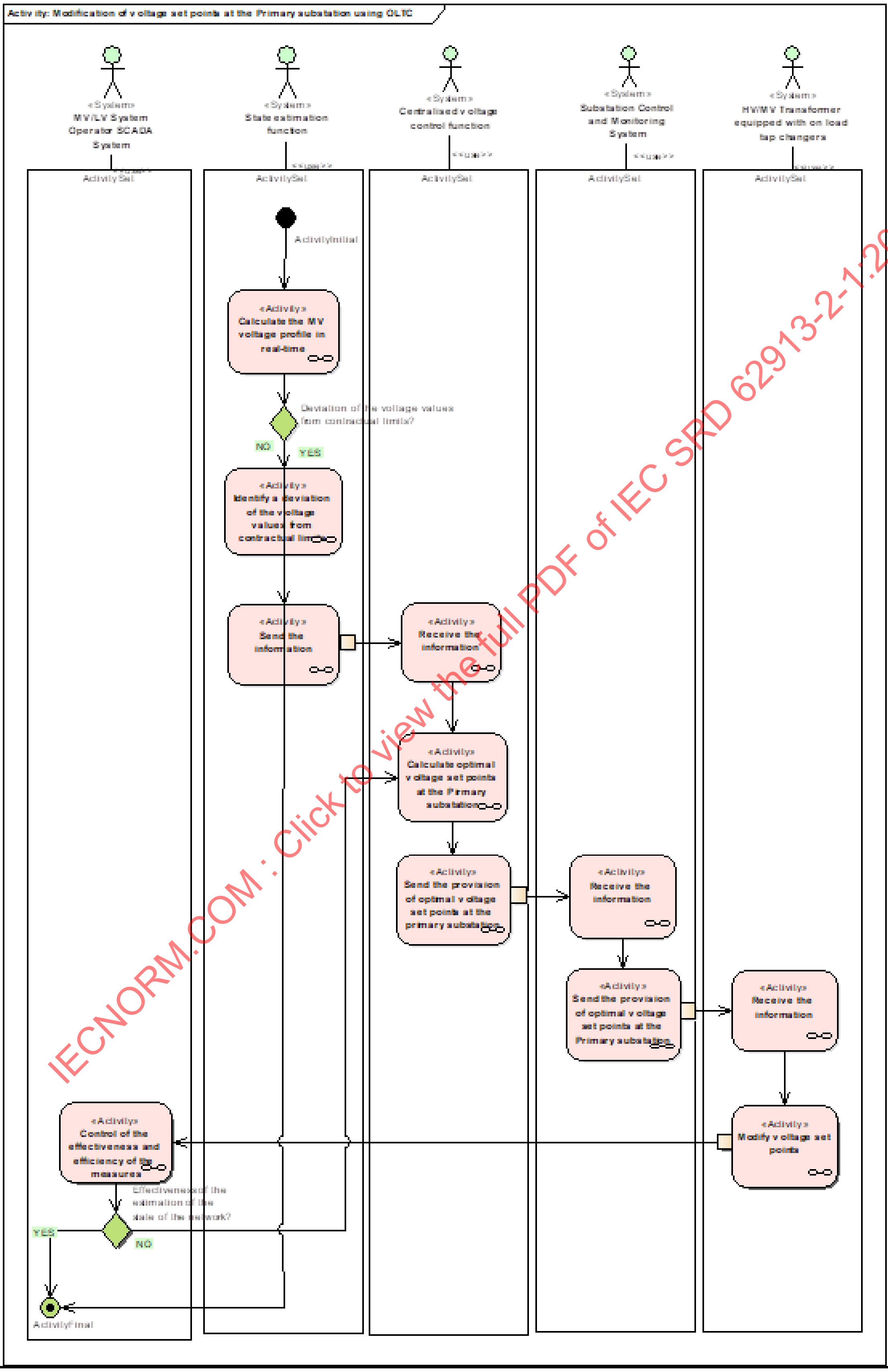
Scenario								
Scenario name	State estimation							
Step No	**Event**	**Name of process/activity**	**Description of process/activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1.1		Collect voltage and current measurements at primary substations			Sensors		VM01, CM01	Req1
1.2		Collect voltage measurements at MV feeders			Sensors		VM02	Req1, Req2
1.3		Collect voltage and current measurements at secondary substations			Sensors		VM03, CM03	Req1
1.4		Send on a cyclical basis collected voltage and current measurements			Sensors	Substation control and monitoring system	VM01, VM02, VM03, CM01, CM03	Req1
1.5		Receive the information			Substation control and monitoring system			
1.6		Calculate reactive and active power at primary and secondary substations			Substation control and monitoring system		AP01, AP03, RP01, RP03	
1.7		Send voltage and active and reactive power measurements at primary substations, MV feeders and secondary substations			Substation control and monitoring system	MV/LV system operator SCADA system	VM01, VM02, VM03, AP01, AP03, RP01, RP03	
1.8		Receive the information			MV/LV system operator SCADA system	Sensors		
1.9		Collect current and voltage measurements at the DER connection point			Sensors		VM04, CM04	Req1
1.10		Send provision of current voltage measurements			Sensors	DER SCADA system	VM04, CM04, AP04, RP04	
1.11		Receive the information			DER SCADA system			
1.12		Calculate active and reactive power at the DER connection point			DER SCADA system			

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

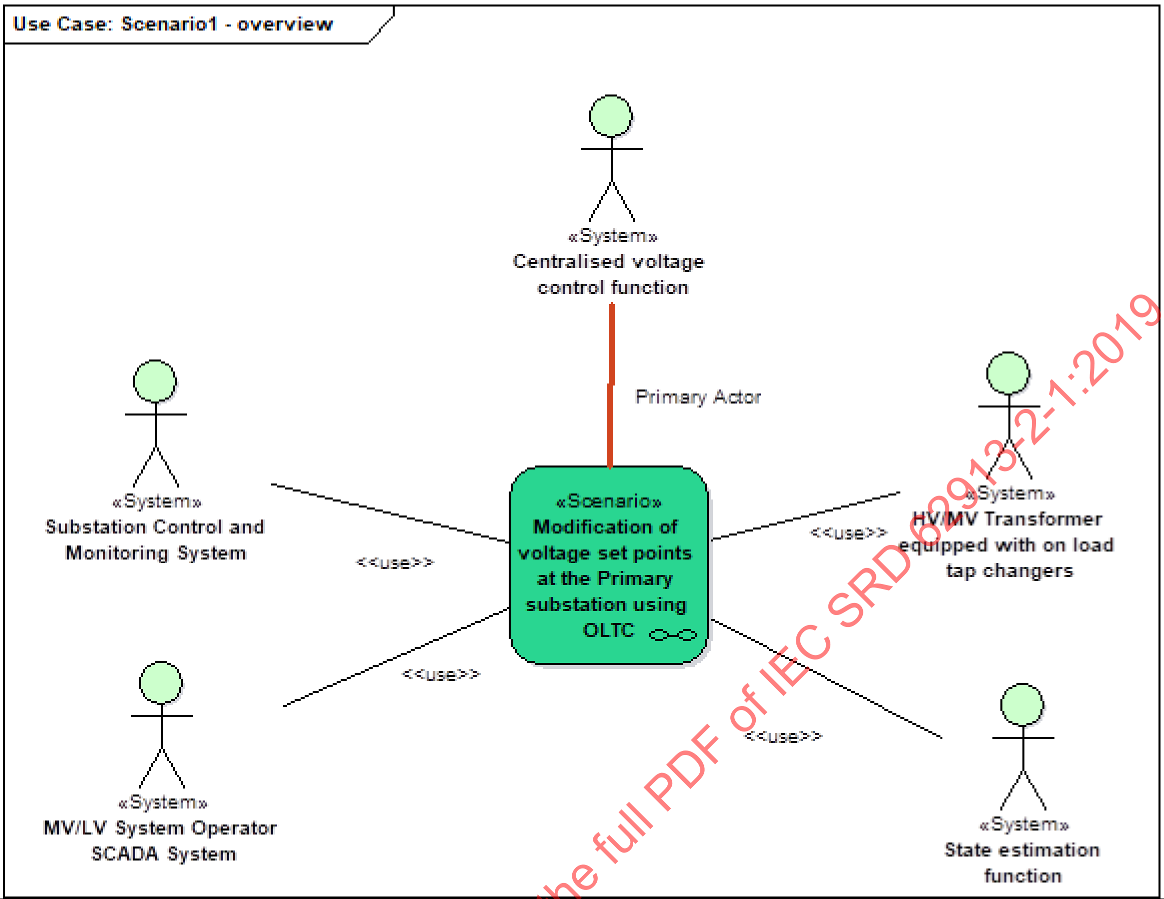
1.13		Send provision of DER measurements			DER SCADA system	MV/LV system operator SCADA system	VM04, AP04, RP04	
1.14		Receive the information			MV/LV system operator SCADA system			
1.15		Send voltage and active and reactive power measurements collected			MV/LV system operator SCADA system	State estimation function	VM01, VM02, VM03, VM04, AP01, AP03, AP04, RP01, RP03, RP04	
1.16		Receive the information			State estimation function			
1.17		Calculate the MV voltage profile in real-time			State estimation function		VSP	Req3, Req4

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

4.2.2 Modification of voltage set points at the primary substation using OLTC



UC62913-2-1-S001: Perform centralized voltage control based on state estimation



Scenario step by step analysis

Scenario								
Scenario name	Modification of voltage set points at the primary substation using OLTC							
Step No	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
2.1		Calculate the MV voltage profile in real-time			State estimation function			
2.2		Identify a deviation of the voltage values from contractual limits			State estimation function		VSP	Req3, Req4
2.3		Send the information			State estimation function	Centralized voltage control function	VSP	Req3, Req4
2.4		Receive the information			Centralized voltage control function			
2.5		Calculate optimal voltage set points at the primary substation			Centralized voltage control function		V-PS	
2.6		Send the provision of optimal voltage			Centralized voltage control function	Substation control and monitoring	V-PS	

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

		set points at the primary substation				system		
2.7		Receive the information			Substation control and monitoring system			
2.8		Send the provision of optimal voltage set points at the primary substation			Substation control and monitoring system	HV/MV transformer equipped with on load tap changers	V-PS	
2.9		Receive the information			HV/MV transformer equipped with on load tap changers			
2.10		Modify voltage set points			HV/MV transformer equipped with on load tap changers		VSP	
2.11		Control of the effectiveness and efficiency of the measures			MV/LV system operator SCADA system			

5 Information exchanged

Information exchanged			
Information exchanged ID	**Name of information**	**Description of information exchanged**	**Requirements IDs**
VM01	Voltage measurement at the primary substation transformer		Req1
VM02	Voltage measurement at MV feeders		Req1, Req2
VM03	Voltage measurement at secondary substations' transformer		Req1
VM04	Voltage measurement at the DER connection point		Req1
CM01	Current measurement at the primary substation transformer (including phase change)		Req1
CM03	Current measurement at secondary substations' transformer (including phase change)		Req1
CM04	Current measurement at		Req1

UC62913-2-1-S001: Perform centralized voltage control based on state estimation

	the DER connection point (including phase change)		
AP01	Active power calculation at the primary substation transformer		
AP03	Active power calculation at secondary substations' transformer		
AP04	Active power calculation at the DER connection point		
RP01	Reactive power calculation at the primary substation transformer		
RP03	Reactive power calculation at secondary substations' transformer		
RP04	Reactive power calculation at the DER connection point		
VSP	Real-time voltage set points		Req3, Req4
V-PS	Optimal voltage set points at the primary substations		

6 Requirements (optional)

Requirements (optional)

Category ID	Categories for requirements	Category description
		Sensors
Requirement ID	**Requirement description**	
R-1	Sensors shall have a high level of accuracy (IEC 61557-12).	
R-2	Sensors shall be installed for all remote controlled substations and switches in order to ensure continuity of measurement for any network configuration possible.	

Category ID	Categories for requirements	Category description
		Calculations for the state estimation function
Requirement ID	**Requirement description**	
R-3	The state estimation function shall integrate in its calculations the real-time network topology (position of switches) and impedances.	
R-4	The averages used to run the state estimation function shall be synchronous in accordance with IEC 61000-4-30 (dating of measurements).	

7 Common terms and definitions

Common terms and definitions

Term	Definition

UC62913-2-1-S001: Perform centralized voltage control based on state estimation		
8 Custom information (optional)		
Custom information (optional)		
Key	**Value**	**Refers to Section**

Table B.5 – UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

1 Description of the use case

1.1 Name of use case

Use case identification		
ID	**Area(s)/Domain(s)/Zone(s)**	**Name of use case**
UC62913-2-1-S002	Area: Energy system Domain: Distribution grid management	System Use Case: Manage faults on the MV network using advanced FLISR system

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	The scope of the Use Case is “Fault management on the MV network and primary substations”. This Use Case describes the functions of the advanced FLISR system that achieve: – Advanced diagnosis in case of fault on the MV network – Fault location and isolation – Service restoration This Use Case assumes that the feeders have remotely controlled breakers at the mains substations and several remotely monitored fault passage indicators located at suitable points along the feeders. The Use Case applies to feeders with sections of overhead line or underground cable or a mixture of both types. Non-permanent faults (i.e. faults which are either temporary or which have been eliminated through the reclosing cycle) are ignored by the advanced FLISR system (not transmitted in this procedure). This Use Case takes the following assumptions into account: – Type of network: phases open loop – Type of equipment: sectionalizer on the feeder which forces to operate them de-energized – Type of system architecture: centralized – Way of operating the network (de)energize in case of fault Currently the Use Case does not consider the impact of DER.

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system	
Objective(s)	Improve continuity of supply on the MV network and reduce delays in service restoration: The MV network does not support the presence of fault. By consequences, advanced FLISR system helps the MV system operator to improve continuity of supply on the MV network and reduce delays in service restoration, in order to impact the minimum of users and to ensure security.
Related business case(s)	

1.4 Narrative of use case

Narrative of use case
Short description
The system Use Case describes how the advanced FLISR system: – Detects an incident, analyses it and makes a diagnosis: • Determines the origin of the fault and analyses potential anomaly of the control command linked to fault management. • Confirms the presence of a permanent fault on the MV network – Locates and isolates faulty sections – Defines and implements a restoration plan (automatically or manually) – Ensures power restoration on the MV network
Complete description
The process includes the following steps: **Prerequisite: An incident occurs on a MV feeder or within a primary substation** When an incident occurs on an MV feeder or within a primary substation, substation protection devices detect it and initiate break tripping. In case of fault accumulation (thunderstorms, lightning, storms, snow, etc.), in an unstable state of the MV network (system disturbance may lead to abnormal ranges of frequency or voltage, loss of power system stability or cascading outages of power transmission circuits and as well wide-spread interruption of customer load), the electric power system may experience cascading/ sequential forced tripping. In this situation, large amounts of data/alarms are sent to the MV system operator, who is quickly overloaded. In case of fault accumulation, the advanced FLISR system provides to the MV system operator many services, among others: – Filter and analyse the large amount of data, – Make a diagnosis of the causes of the sequential forced tripping. This allows the MV system operator to Improve continuity of supply on the MV network and reduce delays in service restoration, in order to impact the minimum of users and to ensure security. **1 Detect an incident, analyse it and make a diagnosis** When an incident occurs on an MV feeder or within a primary substation, substation protection devices detect it and initiate break tripping. Confirmation of a permanent fault: when a permanent fault occurs on a feeder, the main breaker will trip and reclose one or more times but then remains open. The MV SCADA system receives telesignals from the primary substation (substation protection devices) and – in function of the MV network topology – from the secondary substation (field actuators and field detection device).

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

The advanced diagnosis function of the advanced FLISR system automatically analyses the information related to the incident in order to determine:

- The type of trigger (analyse of the resetting cycles),
- The type of fault (single-phase ground fault, multi phase, etc.),
- Potential malfunctions of the substation control system (Recloser, substation protection devices, etc.).
- If the fault is manageable by the advanced FLISR system: the diagnostic is compared with predefined scenarios manageable by the advanced FLISR system.

The advanced diagnosis function detects also potential anomaly of the control command.

If the fault is not manageable by the advanced FLISR system, intervention of the MV system operator is required.

2 Locate and isolate faulty sections

The location function of the advanced FLISR system queries communicating equipment installed on the network (field actuators and field detection device) to complete the analysis in order to locate the faulty section of the network.

The location function of the advanced FLISR system sends the order to the MV SCADA system to open the field actuators located on each side of the faulty section to isolate it. The fault is isolated as closely as possible.

Notes: Protection devices are located at the main substation. If any, distributed energy resources are automatically disconnected to avoid islanding mode, e.g. triggered on under voltage protection type protection.

In case of anomaly of the advanced FLISR system, intervention of the MV system operator is required.

3 Define and implement a restoration plan

The restoration function of the advanced FLISR system computes the optimal restoration plan (sequence of switching actions), based on:

- Topological data and real-time operating conditions,
- Load on network assets and power flows,
- Contextual information.
- Protection plan and electrical network constraints in real time.

In case of anomaly of the advanced FLISR system, intervention of the MV system operator is required.

4 Restoration of the current.

The advanced FLISR system re-energizes under conditions the sections located on each side of the faulty section.

The faulty section is automatically or manually repaired.

The advanced FLISR system re-energizes the repaired faulty section, the MV network is in a secure/normal state.

1.5 Key performance indicators

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

Key performance indicators

ID	Name	Description	Reference to mentioned use case objectives
1	SAIDI: System Average Interruption Duration Index	Sum of durations of all interruptions of supply to individual customers during a time interval, divided by the total number of customers and the duration of that time interval	Improve continuity of supply on the MV network and reduce delays in service restoration
2	SAIFI: System Average Interruption Frequency Index	Number of interruptions of supply to individual customers during a time interval, divided by the total number of customers and the duration of that time interval	Improve continuity of supply on the MV network and reduce delays in service restoration

1.6 Use case conditions

Use case conditions

Assumptions

1	This Use Case assumes that the feeder has remotely controlled breakers located at the main substations and several remotely monitored fault passage indicators located at suitable points along both parts of the feeder: A tie switch separates the feeders into two parts, which are individually radially operated. The position of the tie switch along the feeder may vary during the life of the feeder, however, in all cases, the assumption is made that both parts are never electrically connected during normal and abnormal operation. The Use Case applies to feeders with sections of overhead line or underground cable or a mixture of both types.
2	The MV system operator can, at any moment of the process, interrupt the advanced FLISR system in order to manually operate the system.
3	Protection devices are located at the main substation: If any, distributed energy resources are automatically disconnected to avoid islanding mode, e.g. triggered on under voltage protection type protection.
4	Anti-islanding protection based on communications: In case the feeder circuit breaker opens, an unintentional islanding may have been created. The involved DER in the island has to be forced to stop energizing the feeder for workers' safety, system security and power quality reasons. While the islanding detection methods using local measurements at intertie may have a non-detection zone, the anti-islanding protection can be improved through detecting the tripping of substation breakers and transmitting this information down to the feeder.
5	Restoration plan requiring a load transfer: In case of a restoration plan requiring a load transfer, from one primary substation to another one, greater than a certain threshold, the MV system operator exchanges information with the EHV/HV system operator, in compliance with the network operation contract in force between the two parties.

Prerequisites

1	Consistency between the SCADA system data and the Geographical Information System data
2	Consistency of the real-time teleinformation and the state of the network
3	Uniform teleinformation plan for all the substations
4	The Grid is reacting in the presence of a fault
5	Enough energy is stored and available for communicating
6	The Grid is continuously monitored
7	Communication system between generic architectural component and control centre, where the advanced FLISR system is hosted, is operational
8	The Grid topology is known and reflects the real topology
9	The Grid energy path is known and reflects the real path (effective status of remote monitored and controllable switches)
10	Available energy at the field level to operate the switch while de-energized
11	Consistent settings along the feeder for fault signature detection
12	Absence of manual switches

1.7 Further information to the use case for classification / mapping

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

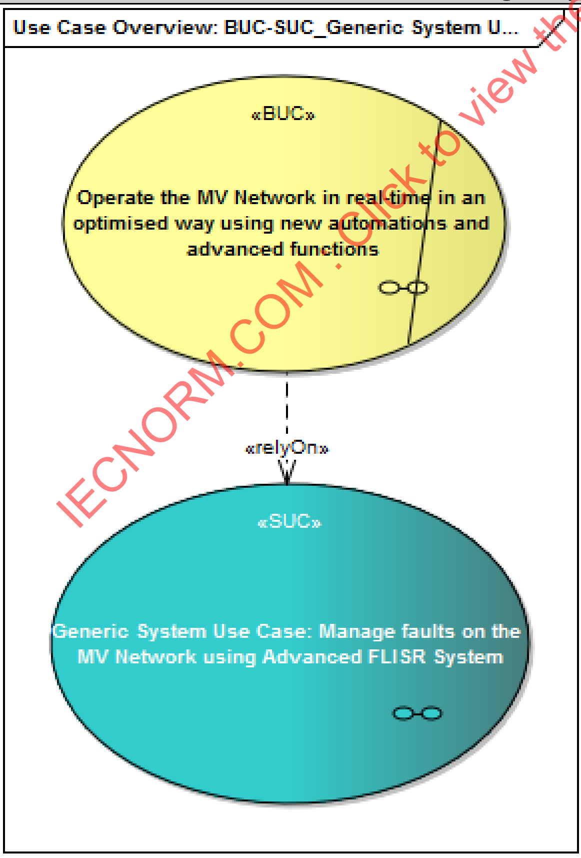
Classification information
Relation to other use cases
<<BUC>> [] Operate the MV network in real-time in an optimized way using new automations and advanced functions
Level of depth
Long version
Prioritization
Generic, regional or national relation
Generic (Europe)
Nature of the use case
SUC
Further keywords for classification
Network operation, Fault management, FLISR

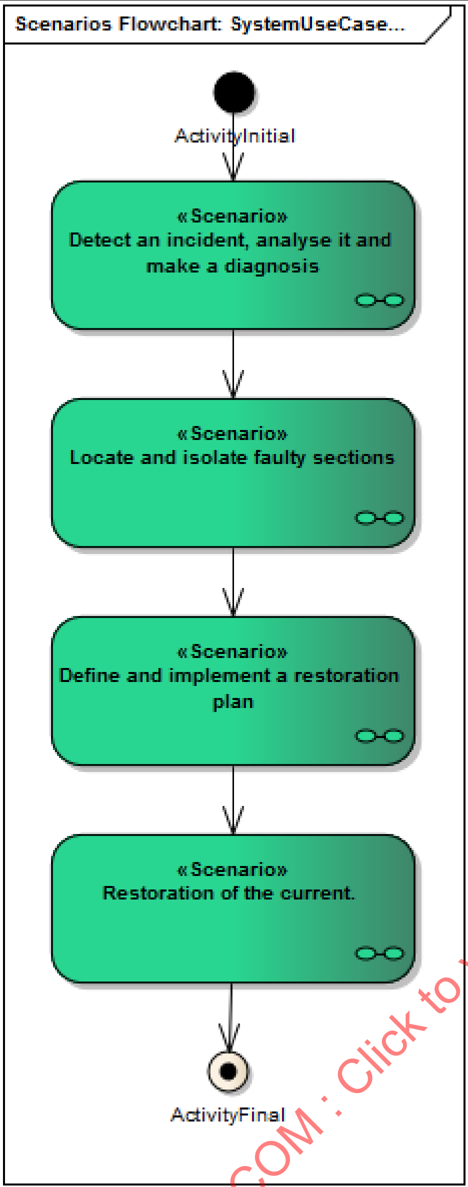
1.8 General remarks

General remarks
This Use Case does not take into consideration all the different network topologies and specifications that can exist.

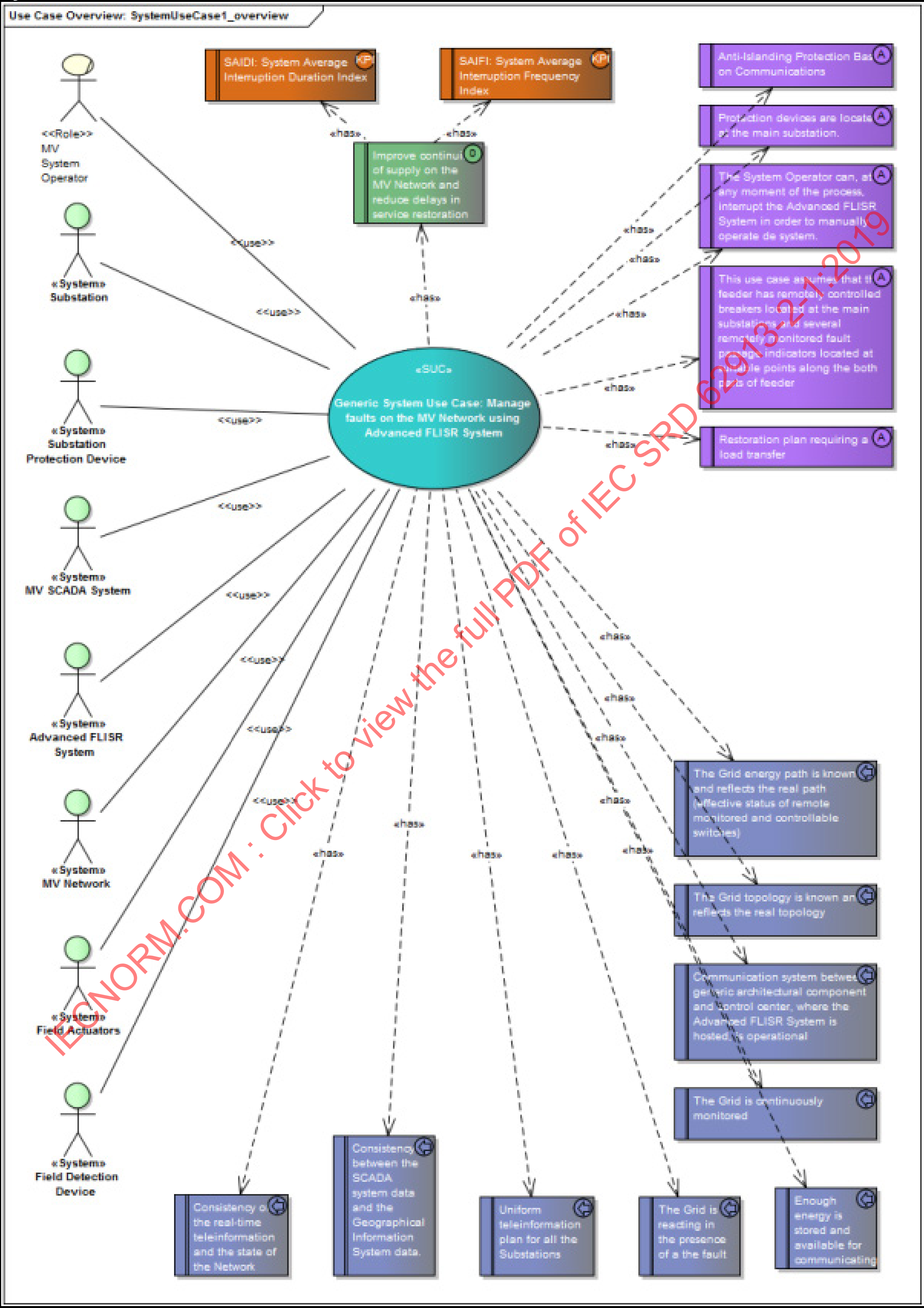
2 Diagrams of use case

Diagram(s) of use case



UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system


UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system



UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

3 Technical details

3.1 Actors

Actors			
Grouping (e.g. domains, zones)	**Group description**		
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
MV system operator	Role	See Table 2	The FLISR function immediately stops in case of human intervention
EHV/HV system operator	Role	See Table 2	
Substation	System	See Table 6	In this Use Case, substations are classified as primary (HV/MV) and secondary (MV/LV) substations
Substation protection device	System	See Table 6	
MV SCADA system	System	See Table 6	
Advanced FLISR system	System	See Table 6	The advanced FLISR system is composed of three functions: – The advanced diagnosis function – The location function (location and isolation) – The restoration function (service restoration)
MV network	System	See Table 6	
Field actuators	System	See Table 6	
Field detection device	System	See Table 6	

3.2 References

References						
No.	**Reference Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organization**	**Link**
1	Standard	IEC 61850		Electrical substation automation	IEC	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Detect an incident, analyse it and make a diagnosis					
2	Locate and isolate faulty sections					
3	Define and implement a restoration plan					
4	Restoration of the current					

4.2 Scenarios

4.2.1 Detect an incident, analyse it and make a diagnosis

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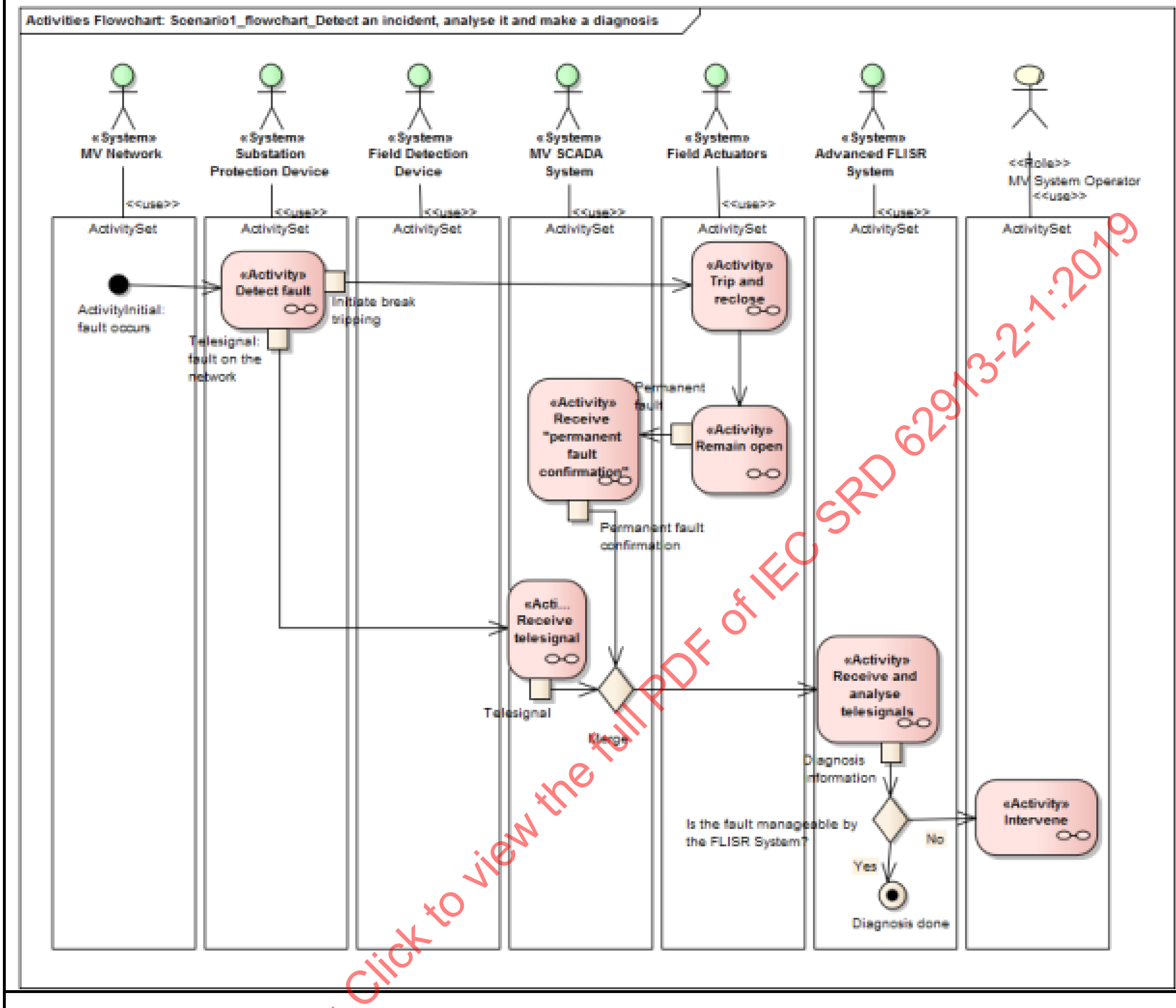

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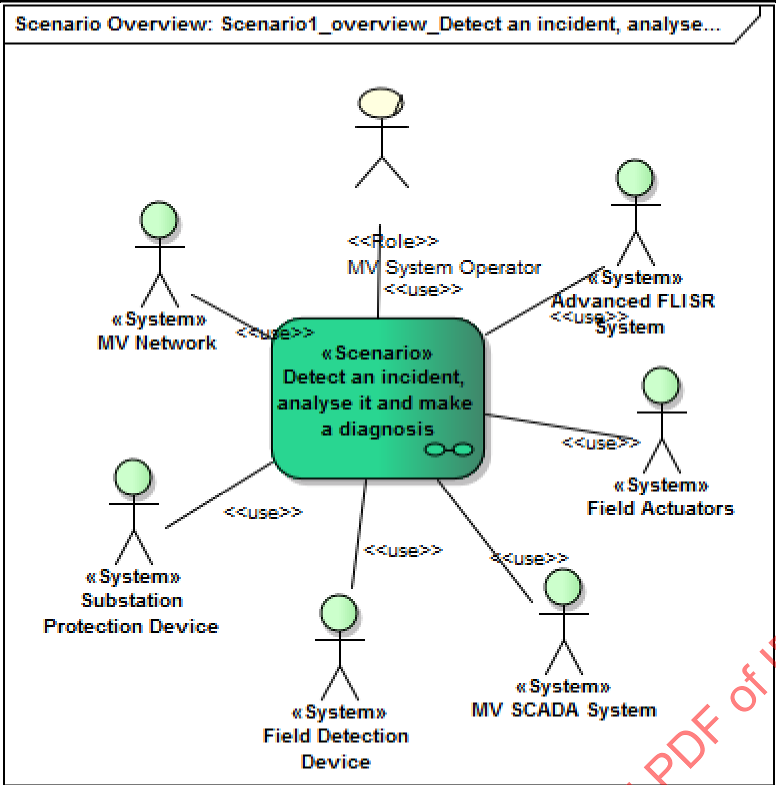


Scenario step by step analysis

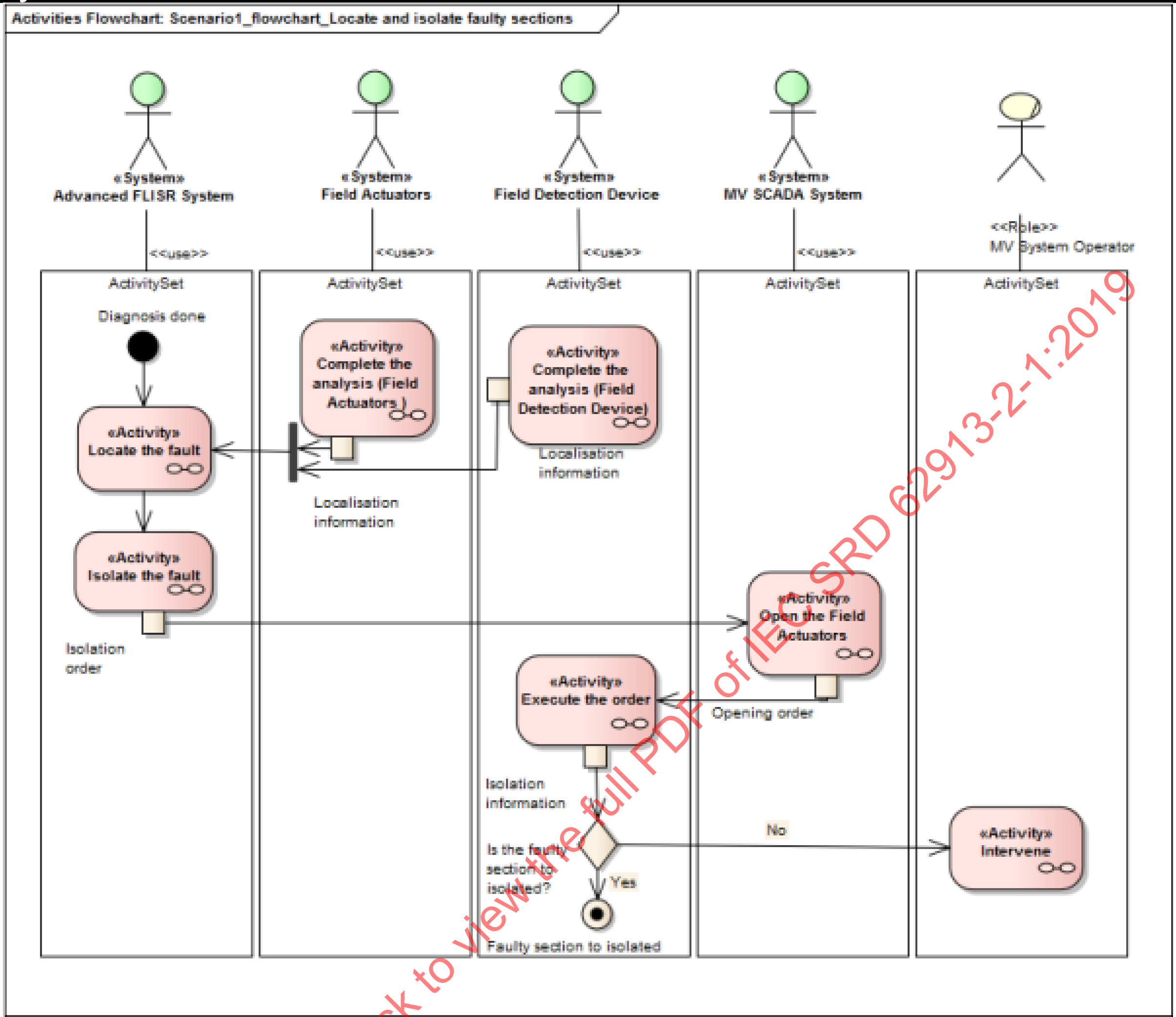
Scenario								
Scenario name	Detect an incident, analyse it and make a diagnosis							
Step No	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1.1		Detect fault	When an incident occurs on a MV feeder or within a primary substation, substation protection devices detect it		Substation protection device	Field actuators	Info1-Initiate break tripping	
1.2		Detect fault	When an incident occurs on a MV feeder or within a primary substation, substation protection devices detect it		Substation protection device		Info2-Telesignal: fault on the network	
1.3		Trip and reclose	Substation protection devices initiate break tripping		Field actuators			
1.4		Remain open	When a permanent fault occurs on a feeder, the main breaker will trip and reclose one or more times but then remains open.		Field actuators	MV SCADA system	Info3-Permanent fault	
1.5		Receive "permanent fault confirmation"			MV SCADA system	Advanced FLISR system	Info4-Permanent fault confirmation	
1.6		Receive	The MV SCADA			Advanced	Info5-	

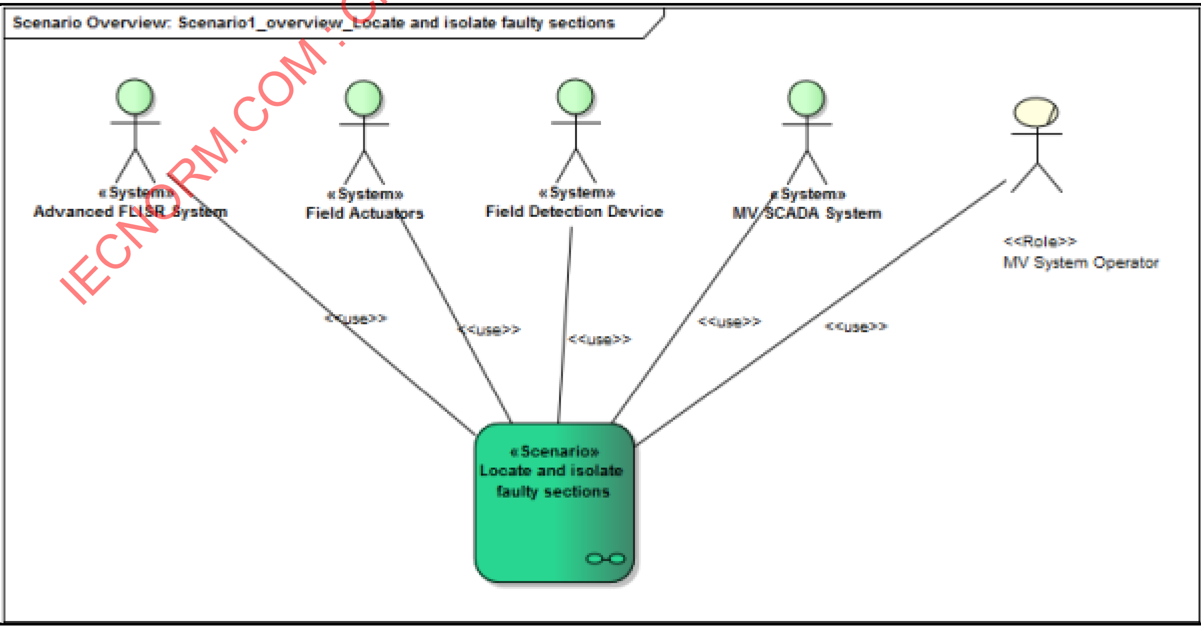
UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

		telesignal	system receives telesignals from the primary substation (substation protection devices) and – in function of the MV network topology – from the secondary substation (field actuators and field detection device).			FLISR system	Telesignal	
1.7		Receive and analyse telesignals	The advanced diagnosis function of the advanced FLISR system automatically analyses the information related to the incident. The advanced diagnosis function detects also potential anomaly of the control command.		Advanced FLISR system	MV system operator	Info6-Diagnosis information	
1.8		Intervene	If the fault is not manageable by the advanced FLISR system, intervention of the MV system operator is required		MV system operator			

4.2.2 Locate and isolate faulty sections

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system





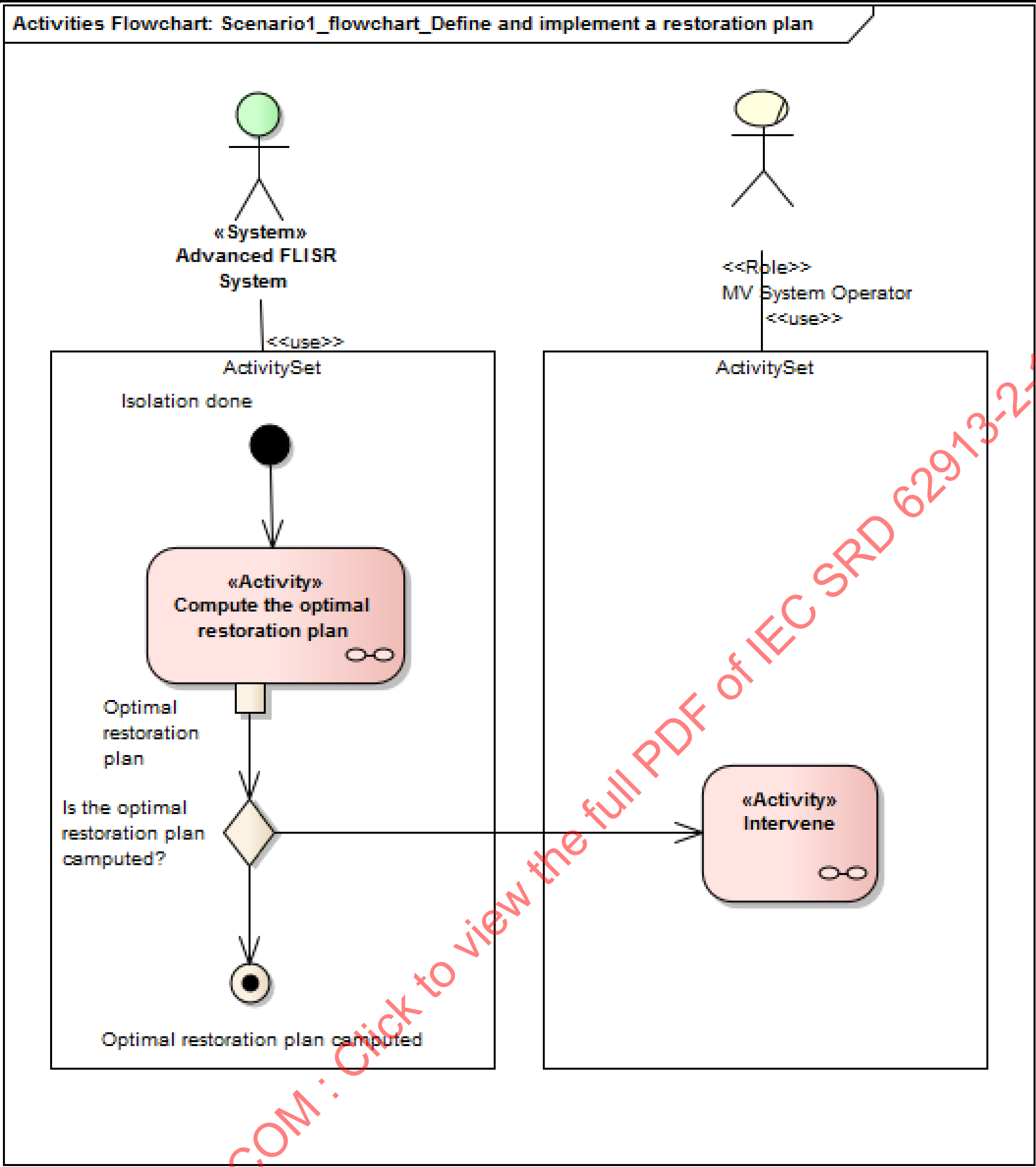
UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

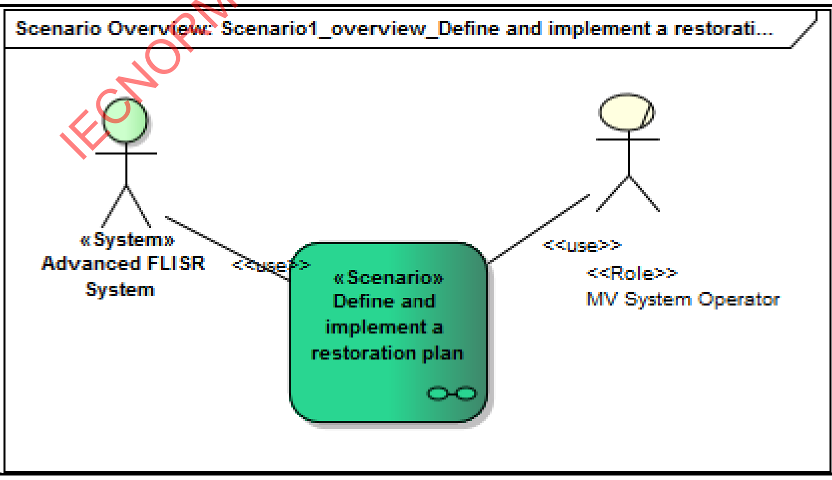
Scenario step by step analysis

Scenario								
Scenario name	Locate and isolate faulty sections							
Step No	**Event**	**Name of process/ activity**	**Description of process/activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
2.1		Locate the fault	The location function of the advanced FLISR system queries communicating equipment installed on the network (field actuators and field detection device) to complete the analysis in order to locate the faulty section of the network.		Advanced FLISR system			
2.2		Complete the analysis (field detection device)			Field detection device	Advanced FLISR system	Info7-Location information	
2.3		Complete the analysis (field actuators)			Field actuators	Advanced FLISR system	Info8-Location information	
2.4		Isolate the fault	The location function of the advanced FLISR system sends the order to the MV SCADA system to open the field actuators located on each side of the faulty section to isolate it. The fault is isolated as closely as possible		Advanced FLISR system	MV SCADA system	Info9-Isolation order	Req1
2.5		Open the field actuators			MV SCADA system	Field detection device	Info10-Opening order	Req1
2.6		Execute the order			Field detection device	MV system operator	Info11-Isolation information	Req1
2.7		Intervene	In case of anomaly of the advanced FLISR system, intervention of the MV system operator is required		MV system operator			

4.2.3 Define and implement a restoration plan

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system





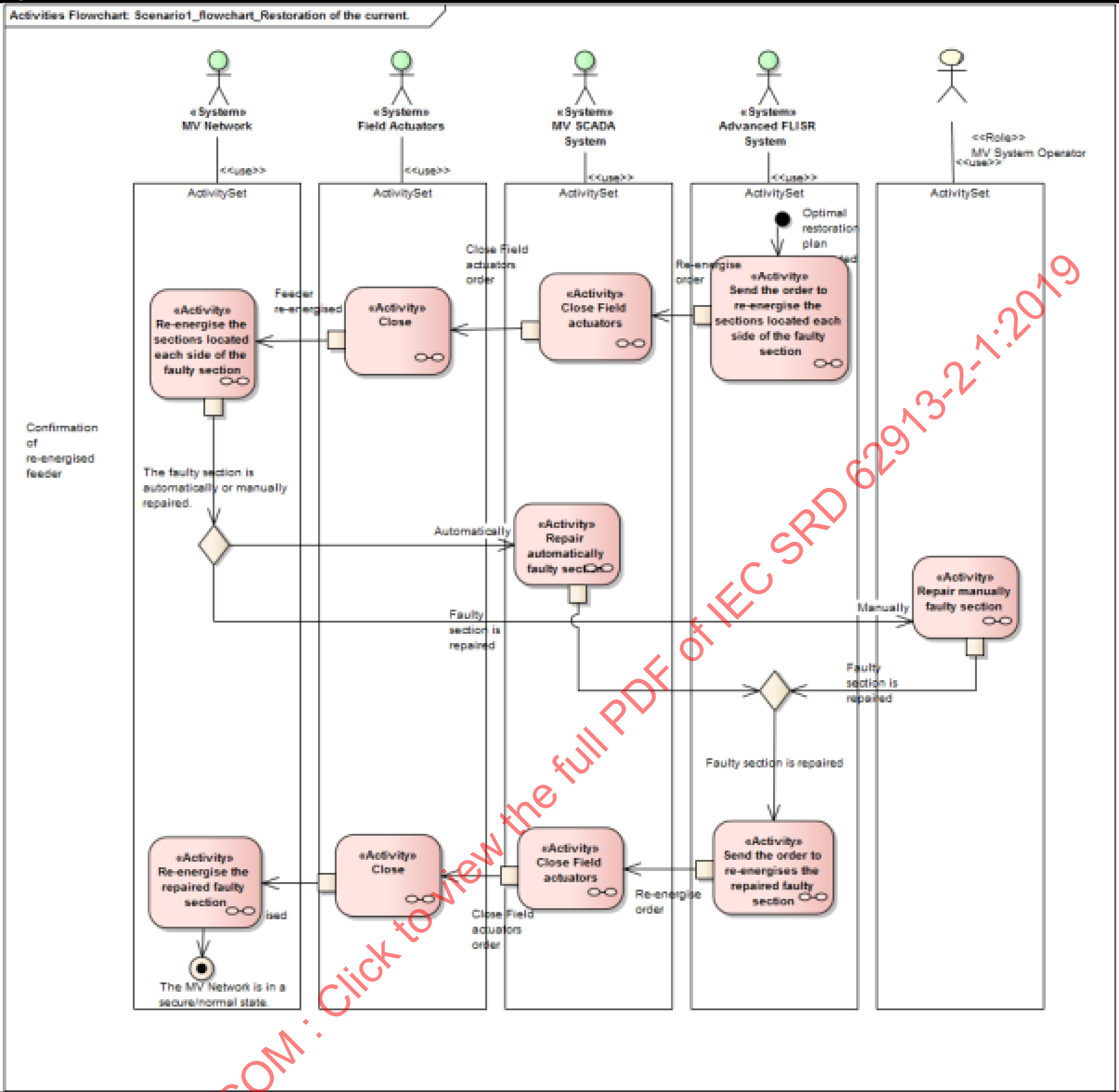
UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

Scenario step by step analysis

Scenario								
Scenario name	Define and implement a restoration plan							
Step No	**Event**	**Name of process/ activity**	**Description of process/activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
3.1		Compute the optimal restoration plan	The restoration function of the advanced FLISR system computes the optimal restoration plan (sequence of switching actions)		Advanced FLISR system	MV system operator	Info12-Optimal restoration plan	Req2
3.2		Intervene	In case of anomaly of the advanced FLISR system, intervention of the MV system operator is required		MV system operator			

4.2.4 Restoration of the current.

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system



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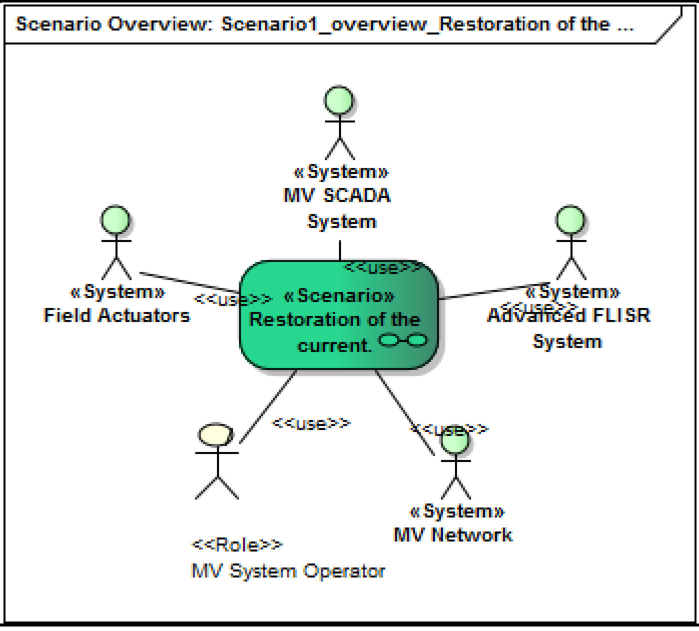

Scenario step by step analysis

Scenario								
Scenario name	Restoration of the current.							
Step No	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
4.1		Send the order to re-energize the sections located each side of the faulty section	The advanced FLISR system re-energizes under conditions the sections located on each side of the faulty section		Advanced FLISR system	MV SCADA system	Info13-Re-energize order	
4.2		Close field actuators	The MV SCADA system re-energizes under conditions the sections located on each side of the faulty section		MV SCADA system	Field actuators	Info14-Close field actuators order	
4.3		Close			Field actuators	MV network	Info15-Feeder re-energized	
4.4		Re-energize the sections located each side of the faulty section			MV network		Info16-Confirmation of re-energized feeder, Info17-Confirmation of re-energized feeder	
4.5		Repair automatically faulty section			MV SCADA system	Advanced FLISR system	Info18-Faulty section is repaired	
4.6		Repair manually faulty section	The faulty section is automatically or manually repaired		MV system operator		Info19-Faulty section is repaired, Info20-Faulty section is repaired	

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

4.7		Send the order to re-energize the repaired faulty section			Advanced FLISR system	MV SCADA system	Info21-Re-energize order	
4.8		Close field actuators			MV SCADA system	Field actuators	Info22-Close field actuators order	
4.9		Close			Field actuators	MV network	Info23-Feeder re-energized	
4.10		Re-energize the repaired faulty section	The advanced FLISR system re-energizes the repaired faulty section, the MV network is in a secure/normal state		MV network			

5 Information exchanged

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Info1	Initiate break tripping		
Info2	Telesignal: fault on the network		
Info3	Permanent fault		
Info4	Permanent fault confirmation		
Info5	Telesignal		
Info6	Diagnosis information	The advanced diagnosis function of the advanced FLISR system automatically analyses the information related to the incident in order to determine: – The type of trigger (analyse of the resetting cycles), – The type of fault (single-phase ground fault, multiphase, etc.), – Potential malfunctions of the substation control system (Recloser, substation protection devices, etc.). – If the fault is manageable by the advanced FLISR system: the diagnostic is compared with predefined scenarios manageable by the advanced FLISR system. The advanced diagnosis function detects also potential anomaly of the control command.	
Info7	Location information		
Info8	Location information		
Info9	Isolation order		
Info10	Opening order		
Info11	Isolation information		

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system

Info12	Optimal restoration plan	The restoration function of the advanced FLISR system computes the optimal restoration plan (sequence of switching actions), based on: – Topological data and real-time operating conditions, – Load on network assets and power flows, – Contextual information. – Protection plan and electrical network constraints in real time	
Info13	Re-energize order	Energized status: Voltage presence	
Info14	Close field actuators order		
Info15	Feeder re-energized		
Info16	Confirmation of re-energized feeder		
Info17	Confirmation of re-energized feeder		
Info18	Faulty section is repaired		
Info19	Faulty section is repaired		
Info20	Faulty section is repaired		
Info21	Re-energize order		
Info22	Close field actuators order		
Info23	Feeder re-energized		

6 Requirements (optional)

Requirements (optional)		
Categories ID	**Category name for requirements**	**Category description**
Requirement R-ID	**Requirement name**	**Requirement description**
Req1	Anti-islanding	Protection devices are located at the main substation. If any, distributed energy resources are automatically disconnected to avoid islanding mode, e.g. triggered on under voltage protection type protection.
Req2	Restoration plan requiring a load transfer	In case of a restoration plan requiring a load transfer, from one primary substation to another one, greater than a certain threshold, the MV system operator exchanges information with the EHV/HV system operator, in compliance with the network operation contract in force between the two parties.

7 Common terms and definitions

Common terms and definitions	
Term	**Definition**

8 Custom information (optional)

UC62913-2-1-S002: Manage faults on the distribution network using advanced FLISR system		
Custom information (optional)		
Key	**Value**	**Refers to section**

B.3 Micrograds

B.3.1 Business Use Cases

See Table B.6.

Table B.6 – UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid

UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid

1 Description of the use case

1.1 Name of use case

Use case identification		
ID	**Area(s)/Domain(s)/Zone(s)**	**Name of use case**
UC62913-2-1-B013	Microgrids	Guarantee a continuity in load service by islanding the microgrid

1.2 Version management

Version management				
Version No.	**Date**	**Name of author(s)**	**Changes**	**Approval status**

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	This BUC concerns connected microgrids (distribution microgrids or facility microgrids) only.
Objective(s)	– Improve resiliency of the grid toward blackouts. – Facilitate maintenance of network assets, by enabling downwards customers to stay supplied during an intervention. – Maintain critical loads supplied during blackouts. – Improve continuity of electricity supply for customers of the microgrid area. – Reduce the outage time for customers of the microgrid area. The following issues are out of the scope of the Use Case: – Active control of local production and consumption flexibility. And islanding's service described below only concerns: – Preventive islanding (to avoid upcoming consumptions cuts) if a supply interruption is planned or a grid outage is expected; – Black start recovery to resupply loads after grid failure; – Automated islanding in case of unplanned grid failure.
Related business case(s)	Decrease the outage time

1.4 Narrative of use case

UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid

Narrative of use case
Short description
Islanding is used to guarantee continuity in load service (all or part of them) in case of grid failure. Three kinds of continuity of service are possible: • Preventive islanding if a supply interruption is planned, or a grid outage is expected • Automated islanding in case of unplanned grid failure • Black start recovery to re-supply loads after grid failure
Complete description
This Use Case can be decomposed in four steps, including a total of six scenarios: • Step 1: Before islanding (scenario 1) • Step 2: Starting the islanding with one of the following scenarios: – Preventive islanding if a supply interruption is planned, or a grid outage is expected (scenario 2), – Automated islanding in case of unplanned grid failure (scenario 3), – Black start recovery to re-supply loads after grid failure (scenario 4). • Step 3: Maintaining the islanding (scenario 5). • Step 4: Reconnection to the main grid (scenario 6). Scenario 2 is only applicable for planned grid outages, which can be planned maintenance of upstream equipment, or anticipation of possible upcoming failure or constraints on the network (storms that could damage overhead lines, voltage limit reached locally due to PV injection, line congestion are non-exhaustive examples). Scenarios 3 and 4 are applicable when an unplanned outage of the main grid occurs. The choice between both scenarios depends on the technical capabilities of the microgrid: automated islanding is better for the clients, as they do not sustain any outage, but is much more technically complicated to achieve, and thus needs more equipment and more investments. The processes before and during the islanding, and for the re-connection to the main grid, are the same in every case. **Before islanding (scenario 1)** When the microgrid is connected to the main grid, in normal operating conditions, the microgrid manager monitors the state of the main grid and of the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities inside the microgrid, to be able to island if an outage occurs, and to assess the possible duration of islanding. The microgrid manager informs in real time the MV/LV system operator about the microgrid's possibility to island. For distribution microgrids, the MV/LV system operator gives an authorization to island in case of outage. The microgrid manager also prepares the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities, so that they are in the optimal state to start islanding if necessary, in coordination with the other Use Cases using them. For example, a certain percentage of a storage system's state of charge could be reserved to enable islanding, and not be used for other Use Cases. To prepare a generator, storage system or controllable loads, the microgrid manager can either have direct control, or pass through a system manager (DER operator or EES operator). The preparation and the assessment of the islanding duration takes into account the forecasting of the consumption and production inside the microgrid. **Starting the islanding** **Preventive islanding (scenario 2)** The preventive islanding can be triggered by one of the following events: For distribution microgrids, the MV/LV system operator informs the microgrid manager that it should perform a preventive islanding due to: • an operation on the network that will cause a supply interruption in the microgrid area, or

UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid
• an expected grid failure due to climatic events or constraints on the network. The MV/LV system operator informs the microgrid manager about the starting time and the duration of this event. For facility microgrids, the private network operator can decide to operate a preventive islanding if one of the following occurs: • The MV/LV system operator informs about an operation on the network that will cause a supply interruption in the facility area; • The MV/LV system operator or a weather forecast provider informs about an expected grid failure due to climatic events; • The MV/LV system operator informs about an expected grid failure due to grid constraints; • The private network operator calculates from market prices that it will be less expensive to island for a given period of time. In coordination with other Use Cases, the microgrid manager prepares the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities, so that the system will be able to island during the entire event. The microgrid manager informs the MV/LV system operator about the microgrid's possibility to island. Before the event starting time (real or expected), the microgrid manager takes control of the operation mode of the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities, and starts the islanding by physically disconnecting the microgrid from the main grid and simultaneously switching the relevant resources to islanding mode. **Automated islanding (scenario 3)** At a given time, an unplanned outage occurs on the main grid, and is detected by the microgrid manager. If the conditions enable it, the microgrid manager takes control of the operation mode of the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities, and starts the islanding by physically disconnecting the microgrid from the main grid and simultaneously switching the relevant resources to islanding mode. The microgrid manager informs the MV/LV system operator about the microgrid's islanding state, and the possible duration of the islanding. **Black start recovery (scenario 4)** At a given time, an unplanned outage occurs on the main grid, and the microgrid is enabled to automatically island, and is thus powered off. The microgrid manager evaluates the possibility to perform a black start recovery, and informs the MV/LV system operator about it. If a black start is possible, the microgrid manager takes control of the operation mode of the different generators, storage systems, controllable loads and other flexibilities, physically disconnects the microgrid from the main grid and simultaneously switches the relevant resources to islanding mode, and performs a black start by managing the energy sources and the other flexibilities. The microgrid manager assesses the duration that it will be able to maintain islanding, and informs the MV/LV system operator about it. **Maintaining the islanding (scenario 5)** Once the islanding is started, the microgrid operator has control over the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities, and manages them to maintain the islanding for the targeted duration. If it is impossible to maintain all the loads supplied for the total duration, the microgrid manager optimizes the supply time of the loads, taking into account eventual priorities between the loads. The microgrid manager regularly assesses the possible duration of the islanding, and informs the MV/LV system operator about it. This assessment takes into account the forecasting of the consumption and production inside the microgrid. If, due to a lack of production, consumption or flexibility, the islanding becomes impossible to maintain, the microgrid manager safely powers out the microgrid area, or reconnects the microgrid to the main grid if it is possible. **Reconnection to the main grid (scenario 6)** When the power on the main grid is back to normal conditions, the MV/LV system operator informs the microgrid manager that it can reconnect the microgrid. The microgrid manager then manages the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities to

UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid
enable a reconnection without perturbation, and physically performs the reconnection. It informs the MV/LV system operator about the reconnection, and gives back the control of the different generators, Electrical Energy Storage systems, controllable loads and other flexibilities to the other Use Cases.

1.5 Key performance indicators

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites

1.7 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
SUC Island the microgrid
Level of depth
Prioritization
Generic, regional or national relation
Nature of the use case
BUC
Further keywords for classification

1.8 General remarks

General remarks

2 Diagrams of use case

Diagram(s) of use case

UC62913-2-1-B013: Guarantee a continuity in load service by islanding the microgrid