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SAREF extension investigation
Requirements for the Smart Grid domain

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The present document was drafted by the SmartM2M ETSI Technical Committee as a starting point for the development of an extension of the SAREF ontology for the Smart Grid domain (SAREF4GRID). The present document gives insights into the current landscape of initiatives in the Smart Grid domain, identifies a set of relevant use cases for such domain, and extracts from those use cases the requirements that should be satisfied by the SAREF4GRID extension.

1 Scope

The present document provides the requirements for an initial semantic model in the Smart Grid domain based on a limited set of use cases and from available existing data models. The present document has been developed in close collaboration with different initiatives in the Smart Grid domain. Further extensions are envisaged in the future to cover entirely such domain. The associated ETSI TS 103 410-12 [i.3] will specify the extension (i.e. the semantic model) for the Smart Grid domain based on the requirements and use cases specified in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document, but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 103 264 (V3.1.1) (2020): "SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping".

[i.2] ETSI TR 103 411 (V1.1.1) (2017): "SmartM2M; Smart Appliances; SAREF extension investigation".

[i.3] ETSI TS 103 410-12: "SmartM2M; Extension to SAREF; Part 12: Smart Grid Domain".

[i.4] ETSI TS 103 410 series (Parts 1 to 11): "SmartM2M; Extension to SAREF".

[i.5] IEC 61970-301 (ed.7.0) (2020): "Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base".

[i.6] IEC 61968-11 (ed.2.0) (2013): "Application integration at electric utilities-System interfaces for distribution management-Part 11: Common information model (CIM) extensions for distribution".

[i.7] IEC SG3 (ed.1.0) (2010): "IEC Smart Grid Standardization Roadmap".

[i.8] IEC 61850 SER Series (ed.1.0) (2022) (all parts): "Communication networks and systems for power utility automation".

[i.9] IEC 62056 (ed.1.0) (2014): "Electricity metering data exchange - The DLMS/COSEM suite - Part 1-0: Smart metering standardisation framework".

[i.10] ISO/IEC 13273-1 (ed.1.0) (2015): "Energy efficiency and renewable energy sources - Common international terminology - Part 1: Energy efficiency".

[i.11] ISO 50001 (ed.2.0) (2018): "Energy management systems - Requirements with guidance for use".

[i.12] ISO 16346 (ed.1.0) (2013): "Energy performance of buildings - Assessment of overall energy performance".

[i.13] ISO/TR 16344 (ed.1.0) (2012): "Energy performance of buildings - Common terms, definitions and symbols for the overall energy performance rating and certification".

[i.14] ISO 16343 (ed.1.0) (2013): "Energy performance of buildings - Methods for expressing energy performance and for energy certification of buildings".

[i.15] ISO 12655 (ed.1.0) (2013): "Energy performance of buildings - Presentation of measured energy use of buildings".

[i.16] IEC 61499-1 (ed.2.0) (2012): "Function blocks - Part 1: Architecture".

[i.17] IEC 62746-10-1 (ed.1.0) (2018): "Systems interface between customer energy management system and the power management system - Part 10-1: Open automated demand response".

[i.18] A solid foundation for smart energy futures (USEF): "USEF: the framework explained", May 2021.

[i.19] E. Association: "Energy@home Technical Specification", October 2015.

[i.20] IEC 62325-301 (ed.2.0) (2018): "Framework for energy market communications - Part 301: Common information model (CIM) extensions for markets".

[i.21] IEC 61131 (2013): "Programmable controllers".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

ontology: formal specification of a conceptualization, used to explicit capture the semantics of a certain reality

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BT	Technical Board
CAPEX	Capital Expenditure
CEM	Customer Energy Manager
CEN	Comité Européen de Normalisation
CG	Coordination Group
CG-SG	CEN-CENELEC-ETSI Coordination Group on Smart Grids
CIM	Common Information Model
CO_2	Carbon Dioxide
DER	Distributed Energy Resource
DLMS	Device Language Message Specification
DR	Demand Response
DSO	Distribution System Operator
E.DSO	European Distribution System Operators
E4S	Edge for Smart Secondary Substation Systems
EEPSA	Energy Efficiency Prediction Semantic Assistant
EM	Energy Management
HV	High Voltage
ICT	Information and communications technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
ISO	International Organization for Standardization

KPI	Key Performance Indicator
kWh	Kilowatt-hour
LS	Line Supervision
LV	Low Voltage
MAC	Media Access Control
MV	Medium Voltage
NIST	National Institute of Standards and Technology
OEO	Open Energy Ontology
OLTC	On Load Tap Changer
OpenADR	Open Automated Demand Response
OPEX	Operating Expense
RDF	Resource Description Framework
RTU	Remote Terminal Unit
SAREF	Smart Applications REFerence ontology
SAREF4ENER	SAREF extension for the Energy domain
SAREF4GRID	SAREF extension for the Smart Grid domain
SCSD	Smart Connected Systems Division
SEAS	Smart Energy Aware System
UEO	Urban Energy Ontology
UML	Unified Modeling Language
USEF	Universal Smart Energy Framework

4 SAREF extension for the Smart Grid domain

SAREF [i.1] is a reference ontology for the IoT that contains core concepts that are common to several IoT domains and, to be able to handle specific data elements for a certain domain, dedicated extensions of SAREF can be created. Each domain can have one or more extensions, depending on the complexity of the domain. As a reference ontology, SAREF serves as the means of connecting extensions in different domains. The earlier document ETSI TR 103 411 [i.2] specifies the rationale and methodology used to create, publish, and maintain the SAREF extensions.

The present document specifies the requirements for an initial SAREF extension for the Smart Grid domain based on a limited set of use cases and from existing available data models. The present document has been developed in collaboration with the Edge for Smart Secondary Substation Systems (E4S) association.

The extension of SAREF for the smart grids domain, which will result in a new ontology called SAREF4GRID, will be published in the companion ETSI TS 103 410-12 [i.3] as part of the series of SAREF extensions ETSI TS 103 410 [i.4].

5 Related initiatives

5.1 Introduction

In this clause, some of the main related initiatives in terms of modelling and standardization in the Smart Grid domain are reviewed. Existing efforts range from national or international norms to data models and ontologies. Therefore, the potential stakeholders identified for this SAREF extension could be classified as: public administrations, associations related to the Internet of Things and Smart Grid domains, European projects, platforms for IoT data processing, and standardization bodies.

In the following clauses, the initiatives that have been considered are described alphabetically. First, initiatives are presented that aim to develop standards for the Smart Grid. Then, different standards related to the present document are described. Next, different published ontologies whose domain includes the Smart Grid are analysed. Finally, different associations related to the development of smart grids are presented.

5.2 Standardization initiatives

CEN-CENELEC-ETSI CG on Smart Grids (CG-SG): When the European Commission issued the mandates M/441 (utility meters) and M/490 (smart grid), CEN and CENELEC BTs and the ETSI Board decided to merge both groups in CG-SG (https://www.etsi.org/technologies/smart-grids-and-meters) coping with both Smart Energy Grids and Smart Meters. The CG-SG advises on European standardization requirements relating to smart electrical grid and multicommodity smart metering standardization, including interactions between commodity systems (e.g. electricity, gas, heat, water), and assesses ways to address them. This includes interactions with end users, including consumers/prosumers.

International Electrotechnical Commission (IEC): The IEC (https://iec.ch/) is an international standard organization that prepares and publishes international standards for all electrical, electronic, and related technologies (electrotechnology). IEC standards cover power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, solar energy, nanotechnology, and marine energy, as well as many others. The IEC also manages four global conformity assessment systems that certify that equipment, system, or components comply with its international standards.

ISO/TC 301: ISO/TC 301 (https://www.iso.org/committee/6077221.html) is an ISO technical committee whose objective is standardization in the field of energy management and energy savings. At this time, there are 21 standards under the direct responsibility of this committee. Moreover, there are six standards under development which are under the direct responsibility of ISO/TC 301.

ISO/TC 163: ISO/TC 163 (https://www.iso.org/committee/53476.html) is an ISO technical committee whose objective is standardization in the field of thermal performance and energy use in the built environment. At this time, there are 144 standards under direct responsibility of this committee. Moreover, 17 standards are under development that are under direct responsibility of ISO/TC 163.

OpenADR Alliance: The OpenADR Alliance (https://www.openadr.org/) was formed in 2010 by industry stakeholders to build on the foundation of technical activities to support the development, testing and deployment of commercial OpenADR and facilitate its acceleration and widespread adoption. This approach engages service providers within the domain of the Smart Grid that publish OpenADR signals, as well as the facilities or third-party entities that consume them to manage electric loads.

Universal Smart Energy Framework (USEF) Foundation: The goal of USEF (https://www.usef.energy/) is to accelerate the establishment of an integrated smart energy system that benefits all stakeholders, from energy companies to consumers. USEF delivers a flexible market design for the trading and commoditization of energy flexibility and the architecture, tools, and rules to make it work effectively. It fits on top of most market models and has been adopted across Europe to accelerate and futureproof smart energy projects.

5.3 Standards

Common Information Model (CIM): CIM was approved and maintained under the International Electrotechnical Commission (IEC) as a standard of a common definition for transmission systems, which is IEC 61970-301 [i.5]. IEC 61968-11 [i.6] extends the CIM to cover the components of the distribution system and other aspects of application data exchange for utility management. The CIM for Weather, Electricity Markets (IEC 62325-301 [i.20]), Power System Dynamic, and Planning extends the CIM modelling and application domain. The CIM is the cornerstone of the IEC standards for the smart grid [i.7]. The CIM is currently maintained as a UML model (https://cimug.ucaiug.org/) and can be transformed into RDF using a specific tool (https://wiki.cimtool.org/Download.html).

Communication networks and systems for power utility automation: IEC 61850 [i.8] is an international standard that defines communication protocols for intelligent electronic devices in electrical substations. It has been produced by the International Electrotechnical Commission (IEC) Technical Committee 57 Reference architecture for electric power systems.

Electricity metering data exchange - The DLMS/COSEM suite: IEC 62056 [i.9] is a set of international standards that specify the exchange of data from the electricity meters. It has been produced by the International Electrotechnical Commission (IEC) Technical Committee 13 Reference electrical energy measurement and control.

Energy efficiency and renewable energy sources - Common international terminology - Part 1: Energy efficiency: ISO/IEC 13273-1:2015 [i.10] contains transverse concepts and their definitions in the subject fields of energy efficiency. This horizontal standard is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 108.

Energy management systems - Requirements with guidance for use: ISO 50001:2018 [i.11] is the international standard for energy management systems and is a globally recognized and certifiable standard for the introduction and maintenance of an energy management system. The orientation provided by the standard allows companies to optimize their energy-related performance and make targeted improvements on an ongoing basis.

Energy performance of buildings - Assessment of overall energy performance: ISO 16346:2013 [i.12] defines the general procedures to assess the energy performance of buildings, including technical building systems, and defines the different types of rating and the boundaries of the building.

Energy performance of buildings - Common terms, definitions and symbols for the overall energy performance rating and certification: ISO/TR 16344:2012 [i.13] provides a coherent set of terms, definitions, and symbols for concepts and physical quantities related to the overall energy performance of buildings and its components, including definitions of system boundaries, to be used in all standards elaborated within ISO on energy performance of buildings.

Energy performance of buildings - Methods for expressing energy performance and for energy certification of buildings: ISO/CD 16343:2013 [i.14] sets out ways of expressing energy performance in an energy performance certificate of a building (including the technical building systems) and ways of expressing requirements for energy performance. This includes an overall numerical energy performance indicator and classes against benchmarks. Additionally, it includes numerical indicators at the system or component level. Moreover, it defines the different types of rating (such as calculated, measured, design, and tailored rating) and the energy used to take into account (such as heating, cooling, domestic hot water, ventilation, and lighting).

Energy performance of buildings - Presentation of measured energy use of buildings: ISO 12655:2013 [i.15] sets out a consistent methodology to present energy use in buildings, which is clearly specified with the energy usage, corresponding boundary, and the energy data (presented with original energy carriers or equivalent energy). Moreover, it is applicable to the presentation of the energy use of civil buildings for data collection, metering, statistics, audit, and analysis.

Function blocks - Part 1: Architecture: IEC 61499-1:2012 [i.16] addresses the topic of function blocks for industrial process measurement and control systems. It defines a generic model for distributed control systems and is based on the IEC 61131 standard [i.21]. It is a part of the International Electrotechnical Commission (IEC).

Open automated demand response (OpenADR): IEC 62746-10-1:2018 [i.17] specifies a minimal data model and services for Demand Response (DR), pricing, and Distributed Energy Resource (DER) communications. Additionally, it specifies how to implement a two-way signaling system to facilitate information exchange between electricity service providers, aggregators and end users. Services do not assume specific DR electric load control strategies that can be used within a DR resource or any market-specific contractual or business agreements between electricity service providers and their customers.

Universal Smart Energy Framework (USEF): Universal Smart Energy Framework (USEF) [i.18] provides a coherent framework of standards to allow seamless energy and flexibility value chains, from prosumers to the transmission network. Additionally, it provides implementation guidelines. Thus, it enables participants to seamlessly co-create a fully functional smart energy system.

5.4 Ontologies

Energy Efficiency Prediction Semantic Assistant (EEPSA): The EEPSA ontology (https://w3id.org/eepsa) focusses on energy efficiency and thermal comfort in buildings, but it aims to be reusable and easily customisable for other use cases in similar domains. It is a modular ontology composed of modules devoted to representing features of interest, qualities, procedures, agents, executions, and expert knowledge.

EM-KPI: The EM-KPI ontology (http://energy.linkeddata.es/em-kpi/ontology) describes the key performance indicators and master data domains (energy, building, utility, occupancy, observation, weather, and location) in energy management at the district and building levels. The purpose of this project is to exchange multilevel performance information between various stakeholders and to exploit cross-domain data to improve energy performance, to improve multilevel energy management. The ontology contains two parts: the Key Performance Indicator (KPI) part and the Energy Management (EM) master data part; these, respectively, represent the multilevel performance information for energy performance tracking and the master data for data exploitation.

MASCEM ontology: The objective of the MASCEM ontologies (http://www.mascem.gecad.isep.ipp.pt/ontologies/) is to study and simulate energy management operations. The following ontologies have been developed:

- Electricity Markets Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/electricity-markets.owl) meets abstract concepts and axioms to the main existing electricity market. This ontology aims to be as inclusive as possible, so that it can be extended and reused in the development of (lower-level) market-specific ontologies.

- MIBEL Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/mibel.owl) is related to the Iberian electricity market.

- EPEX Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/epex.owl) represents the EPEX electricity market.

- Nord Pool Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/nordpool.owl) represents a power market.

- Call For Proposal Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/call-for-proposal.owl) is intended for use by market operators to ask player agents for bids to be placed in the market and for players to send their proposals to the respective market operators.

- Electricity Markets Results Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/electricity-markets-results.owl) is used by market operator agents to inform player agents about their results and outcomes in the market. This ontology has been developed considering the output data that each market provides its players.

- AiD-EM Ontology: This ontology (http://www.mascem.gecad.isep.ipp.pt/ontologies/aid-em.owl) has been developed to provide interoperability between AiD-EM and any electricity market player of any agent-based simulation platform.

Open Automated Demand Response (OpenADR): The OpenADR ontology (https://w3id.org/def/openadr) aims to model the OpenADR protocol, an internationally recognized standard for automated demand response used by many utilities to communicate with equipment at customer facilities to automatically drop demand during demand response (DR) programme events. OpenADR provides a nonproprietary open standardized DR interface that allows electricity providers to communicate DR signals directly to existing customers using a common language and existing communications such as the Internet.

Open Energy Ontology (OEO): The OEO ontology (http://openenergy-platform.org/ontology/oeo/) is an ontology for all aspects of the energy modelling domain. It is developed in different modules and represents all entities related to the world of energy and energy generation, as well as all relevant social and economic aspects of the energy domain.

SAREF4ENER: SAREF4ENER (https://saref.etsi.org/saref4ener/) focusses on demand response scenarios, in which customers can offer flexibility to the Smart Grid to manage their smart home devices by means of a Customer Energy Manager (CEM). It is an extension of SAREF that was created in collaboration with Energy@Home and EEBus, which are the major Italian and German industry associations, to enable the interconnection of their (different) data models.

Smart Energy Aware System (SEAS): The objective of the SEAS ontology (https://w3id.org/seas/) is to enable energy, ICT and automation systems to collaborate at consumption sites, and to introduce dynamic and refined ICT-based solutions to control, monitor, and estimate energy consumption. This ontology addressed the problem of inefficient and unsustainable energy consumption, which is due to a lack of sufficient means to control, monitor, estimate, and adapt energy usage of systems in response to dynamic situations and circumstances that influence them. It is a modular ontology and one of its modules (i.e. ElectricPowerSystemOntology) aims to model electric power systems and their connections.

RESPOND Ontology: The RESPOND project aims to deploy an interoperable energy automation, monitoring, and control solution to deliver Demand Response (DR) programmes at the dwelling, building, and district level. The RESPOND solution (https://w3id.org/respond) being developed is expected to be flexible and scalable, thus capable of delivering a cooperative DR both at the building and district levels. Furthermore, to enable the integration of the DR enabling elements and ensure a high replicability, RESPOND is based on open standards. Likewise, the use of these open standards enables the interoperability with smart home devices and automation systems, as well as the connectivity and extendibility towards smart grid and third-party services such as weather forecasting services and energy price providers.

ThinkHome: The vision of ThinkHome is to create a comprehensive knowledge base that includes all the different concepts needed to realize energy-efficient, intelligent control mechanisms. In the energy information branch (https://www.auto.tuwien.ac.at/downloads/thinkhome/ontology/EnergyResourceOntology.owl) there are different available energy providers and their trading conditions. This information is especially valuable when envisioning the integration of energy management systems into a smart grid, as the ontology can, for example, provide the momentarily best option for energy consumption or recovery. Furthermore, it is important to have an idea of the building automation services provided, as well as the available equipment in the smart home.

Urban Energy Ontology (UEO): The SEMANCO Energy Model (http://semanco-tools.eu/ontology-releases/eu/semanco/ontology/SEMANCO/SEMANCO.owl) is a formal ontology comprising concepts captured from various sources, including standards, use cases and activity descriptions, and data sources related to the domains of urban planning and energy management. In particular, it contains the terms and attributes that describe regions, cities, neighbourhoods, and buildings; energy consumption and CO_2 emission indicators, as well as climate and socioeconomic factors that influence energy consumption. The ontology enables semantic tools to access data that originate from different domains and applications.

5.5 Associations

European Distribution System Operators (E.DSO): E.DSO (https://www.edsoforsmartgrids.eu/) promotes the increase in the use of clean energy sources through electrification, the development of smart and digital grid technologies in real-life situations, new market designs, and regulation. E.DSO gathers 39 leading electricity Distribution System Operators (DSOs) in 24 countries, including two national associations. Its objective is to ensure the reliability of the electricity supply in Europe for consumers and to enable their active participation in their energy system.

Edge for Smart Secondary Substation Systems (E4S) Alliance: The goal of the E4S Alliance is to accelerate the creation of a standards-based, open, interoperable, and secure architecture that addresses both the technical and business challenges faced by utilities around the world. The consortium is embracing the need for better efficiency by developing a Secondary Substation Platform reference architecture designed to enable lower CAPEX and OPEX as well as faster time to market by digitizing the secondary substations.

Energy@Home: Energy@home (http://www.energy-home.it/) envisions an ecosystem of interoperating devices based on a communication infrastructure that enables provisioning of value-added services in the home area network. In fact, its mission is to develop and promote technologies and services for energy efficiency in smart homes, based on the interaction between user devices and the energy infrastructure. The Energy@home data model [i.19] specifies a representation model for home area networks, including smart appliances, power profiles, renewable energy generation, smart meters, and smart user interfaces. It is based on the CIM approach and is broadly aligned with the OpenADR schema.

IEEE Smart Grid: IEEE Smart Grid (https://smartgrid.ieee.org/) is the professional community and leading provider of globally recognized Smart Grid information. Provides expertise and guidance for individuals and organizations involved in the modernization and optimization of the power grid. IEEE Smart Grid Initiative is intended to organize, coordinate, leverage, and build upon the strength of various entities within IEEE with Smart Grid expertise and interest.

Smart Connected Systems Division (SCSD): SCSD in NIST's Communication Technology Laboratory (https://www.nist.gov/ctl/smart-connected-systems-division/about-scsd) is made up of several groups that were transferred from other NIST Laboratories (Engineering Laboratory and Information Technology Laboratory). SCSD brings significant multi-sector applications and operational systems engineering expertise and standards and measurement capabilities. In general, the division advances measurement science, standards and test methods to support communication networks, reliable Internet of Things (IoT) systems, and critical applications, including smart grid, smart manufacturing, industrial control systems, automated vehicles, and smart cities and communities. Moreover, the Smart Grid Group (https://www.nist.gov/ctl/smart-connected-systems-division/smart-grid-group) is the laboratory's smart grid research firm.

6 Use cases

6.1 Scope

The electric power flow inside the power supply system can be differentiated into three parts:

- Generation, which consists of generating electricity in a generating station. These facilities are located far from the consumption points, so the electricity generated in them has to be transported.
- Transmission, which is performed through the High Voltage (HV) transmission lines. After generating the electricity, its voltage is increased to high voltage in order for the current in the line to be lower and, therefore, to transmit the energy in a more economical way. This transmission line comes from a generating station to a place near and outside the city area. This place is called a receiving station and the voltage is reduced to a Medium Voltage (MV) in it.
- Distribution, which consists of distributing the electricity to the final clients. Lines from the receiving station go to different distribution substations, where the voltage is further stepped down to a Low Voltage (LV). From the substation, the low-voltage network, or secondary network, is the part of the electrical power distribution that carries electricity from the distribution transformers to the end customers.

As depicted in Figure 1, the use cases defined in the present document focus on the management of the low voltage network from the electric power secondary substation, i.e. the distribution substation dedicated to the transformation of medium voltage to low voltage, as well as to the control and the protection of the electricity grid. These use cases are based on the IEC 62056 standard [i.9] (DLMS/COSEM) and cover the following components:

- **Meter**, which is a metering device that remotely records real electricity consumption. This device allows to control all the information regarding consumption for any time range, automatically and remotely.
- **Data concentrator**, whose purpose is to collect, process, and transmit data from multiple sources, such as smart meters and other monitoring devices, to a central control system. The data concentrator acts as a hub for the collected data, receiving and aggregating information from multiple sources and sending it to the central system for analysis and decision-making.
- **Line Supervision card (LS card)** connected to the low voltage line, which is a device used in telecommunication and network systems to monitor the status of a low voltage power supply circuit. It ensures that the voltage levels are within the range required for proper operation of connected devices and can send alarms or take other actions if the voltage goes outside the acceptable range.
- **Remote Terminal Unit (RTU)** connected to the low voltage line, which is a device used in telecommunication and control systems to monitor and control remote equipment and facilities. The low-voltage RTU is typically connected to the low-voltage power supply circuit and is responsible for collecting data, monitoring signals, and controlling the connected devices and systems. The RTU can also send status information back to a central control system and take preprogrammed actions in response to changes in the remote equipment or facilities.

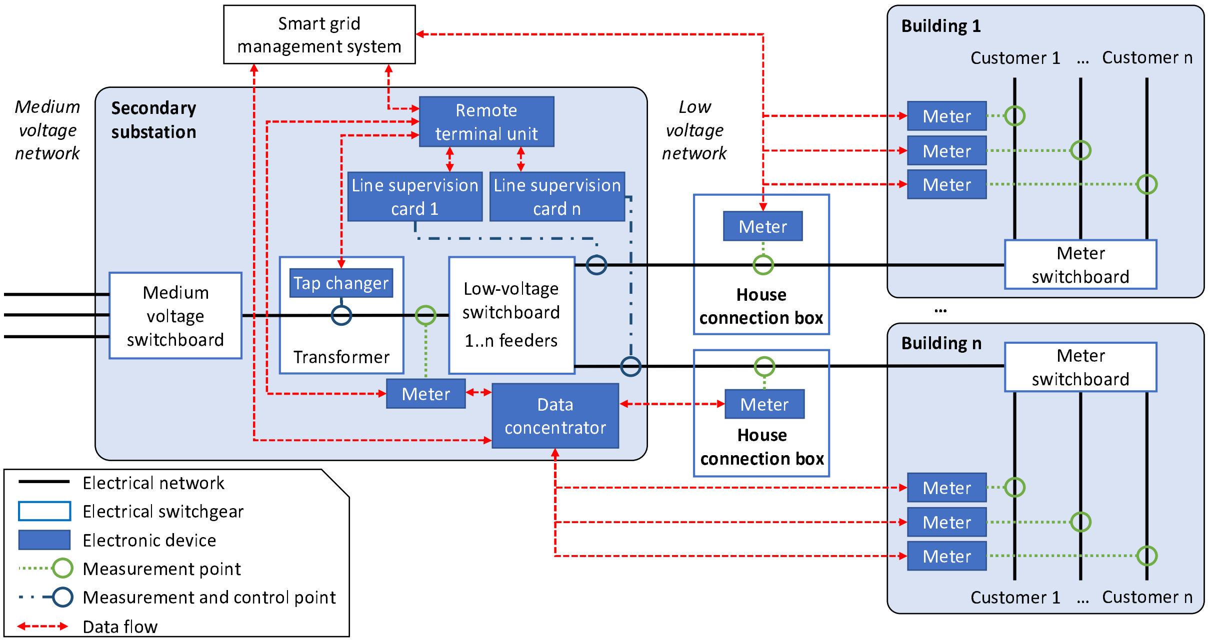

Figure 1: Scope of the SAREF4GRID extension

6.2 Use case 1: Remote management of meters

This use case covers remote management (i.e. send and collecting data) of meters in an electrical secondary substation to ensure correct substation operation. When these management operations are sent, the necessary actions on the meters are performed, and a report is generated (either instantaneously or in scheduled moments of time) about the status of the operations and the overall functioning of the electrical substation.

There are different types of remote management operations:

- **Management of meter configuration**. Meters store different configuration parameters that define the behaviour or performance of the meter; some of these parameters can be updated remotely while others cannot. Such parameters include manufacturer information (e.g. serial number, manufacturer number, etc.), screen display information (e.g. voltage usage, date, time, and other system and diagnostic information), voltage ratio (in which percent the voltage is increased or decreased in a transformer), current ratio (in which percent the current is increased or decreased in a transformer), firmware information (to support firmware updates), and network information (e.g. MAC address or multicast connection identifier).

- **Management of meter connection**. Meters can be manually or remotely connected or disconnected to an individual client (either instantaneously or as a scheduled activity). If a meter is connected, the client is connected to the electrical network and therefore the client is consuming electricity. If the meter is disconnected, the client is not connected to the electrical network, for example due to exceeding a power threshold fixed with the client or for non-payment.

- **Management of billing information**. The billing profile structure for meters is based on contracts. A contract is defined as the set of parameters that structure the measurement process to be performed by a meter in order to reflect the contractual billing arrangements. A contract is represented according to different aspects, such as the type of contract, the activity calendar (i.e. the periods at which a billing rate is applied), or the power limit (i.e. the value of the contracted power in each period by a client).

- **Collection of billing information**. Meters record different electrical magnitudes with the time at which they are measured in order to calculate how much electricity a client is using. Moreover, communication messages are defined to obtain the energy magnitudes recorded in the meter, such as the load profiles (either incremental or absolute values) or the billing information (daily, actual, or at the end of a billing period).

- **Collection of quality reports**. Meters store and generate reports related to power failures and power quality disturbances in each phase of the meter. A power failure is a loss of electric power and is established according to a voltage threshold and a time threshold that indicate how long a power failure has to occur before it is considered a long power failure. Power quality disturbances may be voltage swells (momentary increases of voltage) and sags (momentary decreases of voltage). Voltage swells and sags also have voltage and time thresholds in order to be considered quality disturbances.

6.3 Use case 2: Management of tertiary sensor devices

In this use case, a main equipment (i.e. a data concentrator or remote terminal unit) located in an electrical secondary substation has to manage the tertiary sensor devices (i.e. meters and line supervision cards) present in that secondary substation or in the low voltage network. These tertiary devices will be responsible for containing the sensing and measurement of the parameters both within the electrical substation and the low voltage networks that the substation manages.

The management of tertiary sensor devices covers the following functionalities:

- **Configuration of data concentrators**. The objective of a data concentrator is to collect, aggregate, and forward data from multiple meters to a central location for processing and analysis. They are used to monitor and control various aspects of the low voltage electrical network, such as voltage, current, power, energy, and frequency. Data concentrators store different configuration parameters that define their behaviour or performance; some of these parameters can be updated remotely, while others cannot. Such parameters include manufacturer information (e.g. serial number, manufacturer number, etc.), meter information (e.g. identifier of the meter the data concentrator manages), firmware information (to support firmware updates), network information (e.g. keys to communicate with the meters or communication identifiers), task configuration (e.g. to configure scheduled tasks), and data collection configuration (e.g. the period when information from the meters has to be collected).

- **Management of monitoring and maintenance reports**. A monitoring and maintenance report is a document that provides information about the status, performance, and health of the data concentrator and the meters that it manages. Such reports include communication reports (e.g. statistics about the communication with the meters), performance reports (e.g. history of the tasks executed, tasks being executed, and scheduled tasks), maintenance reports (e.g. parameter modifications, firmware update, etc.), and quality reports (related to power failures and power quality disturbances).

- **Configuration of Line Supervision (LS) cards**. The objective of an LS card is to monitor low-voltage lines in a telecommunications system. It is used to monitor and supervise the state and quality of signals on low-voltage lines, which typically carry voice or data signals between various components of a communication system. LS cards store different configuration parameters that define their behaviour or performance; some of these parameters can be updated remotely, while others cannot. Such parameters include manufacturer information (e.g. serial number, manufacturer number, etc.), firmware information (to support firmware updates) and communication information (e.g. reporting intervals and communication protocols).

- **Configuration of Remote Terminal Units (RTUs)**. The objective of an RTU is to monitor and control low voltage lines in a telecommunications system collecting data through the line supervision cards it manages. RTUs store different configuration parameters that define the behaviour or performance of the RTU; some of these parameters can be updated remotely while others cannot. Such parameters include manufacturer information (e.g. serial number, manufacturer number, etc.), LS card information (e.g. identifier of the LS cards that it manages), firmware information (to support firmware updates), task configuration (e.g. configure scheduled tasks), and data collection configuration (e.g. period when the information from the LS cards has to be collected).

6.4 Use case 3: Management of OLTC transformers

An On Load Tap Changer (OLTC) transformer is a type of power transformer that allows the voltage to be adjusted while the transformer is in operation. It does this using a tap changer to change the number of turns on the transformer winding, which changes the output voltage. This use case manages the calculation of the optimal output voltage that the transformer has to provide. It is also possible to calculate the optimal output voltage locally (without receiving information from the system). This optimal calculation will consider the voltage values of the meters in the low voltage network. Specifically, this use case covers:

- Selection of the meters from which to collect information. The determination of the meters would be made according to the voltages measured by each meter, selecting two lists of meters, those with maximum voltages and those with minimum voltages. This selection is performed through the voltage, voltage amplitude, current, and the active and reactive energies measured by the LS cards. Moreover, communication messages are defined to obtain these measures, such as raw measurements (real time values report) or statistics information with the average, maximum, and minimum values measured (voltage and current profile).

- Collection of the information necessary to calculate the optimum voltage output. Meters record the voltage, voltage amplitude, current, and power measured in each phase. Moreover, communication messages are defined to obtain these records, such as raw measurements (instantaneous values profile) or statistics information with the average, maximum, and minimum values measured (voltage and current profile).

6.5 Use case 4: Detection of meters connectivity

This use case covers all the information necessary to run a meter connectivity detection algorithm. This algorithm detects the connection of the client to the electrical network. Due to this algorithm, the phase, line, and secondary substation to which each client is connected is precisely known. This topological information is key for network operators to ensure the quality of supply in networks with a strong presence of distributed generation and electric vehicles. This algorithm needs specific information to work; with this objective:

- The connectivity data of each meter is sent. All registered meters will be included, even those for which the connectivity calculation values are not yet available. Connectivity data represent in which phase the meter is connected.

- The actual electricity information from each line supervision card will be sent (e.g. current profile) in order to identify the line at which each client is connected.

- The connectivity event register for each meter will be sent. This register represents the connectivity data of a meter per day.

7 Requirements

7.1 Remote management of meters

Table 1 shows the parameters that are necessary to configure a meter in an electrical secondary substation. These parameters refer to information about the manufacturer of the meter, display configuration, ratio of the transformer, firmware information and network information.

Table 1: Requirements for the management of meter configuration

id	Competency Question/Statement
GRID-1	A meter stores manufacturer information
GRID-2	A meter stores screen display information
GRID-3	A meter stores a voltage ratio
GRID-4	A meter stores a current ratio
GRID-5	A meter has a firmware
GRID-6	A meter stores network information

Table 2 shows the tasks related to the modification and retrieval of the configuration parameters of meter in an electrical secondary substation.

Table 2: Requirements for the tasks related to the management of meter configuration

id	Competency Question/Statement
GRID-7	A meter can send its manufacturer information
GRID-8	A meter can modify and send its network information
GRID-9	A meter can modify and send its voltage ratio
GRID-10	A meter can modify and send its current ratio
GRID-11	A meter can modify and send its display information
GRID-12	A meter can update its firmware

Table 3 shows the parameters that represent the connection of a meter in an electrical secondary substation to the low voltage network. These parameters show if the meter is reconnected or disconnected, which indicates if a client can use electric energy. Moreover, these parameters show the necessary configuration to perform a scheduled reconnection/disconnection.

Table 3: Requirements for the management of meter connection

id	Competency Question/Statement
GRID-13	A meter can reconnect or disconnect a client to the electrical network
GRID-14	A meter has a power threshold
GRID-15	A power threshold is measured as a percentage
GRID-16	A meter stores reconnect or disconnect requests scheduled for a specific time

Table 4 shows the tasks related to the management of meter connection and that modify the state of a meter.
A scheduled reconnection/disconnection task indicates the time at which the meter will be reconnected/disconnected to the electrical network. Moreover, a reconnection/disconnection task can be performed instantaneously.

Table 4: Requirements for the tasks related to the management of meter connection

id	Competency Question/Statement
GRID-17	A meter can be instantly disconnected/reconnected to the low voltage network
GRID-18	A meter can be scheduled to be disconnected/reconnected to the low voltage network at a given time

Table 5 shows the parameters that are necessary to configure to perform a correct billing in meters in an electrical secondary substation. This billing process is defined by contracts. A contract structures the process of the measures to be performed by the meter in order to reflect the contractual billing arrangements. This structure is represented by a calendar that indicates the periods at which a billing rate is applied. In addition, a contract indicates the different power limits that a client has.

Table 5: Requirements for the management of billing information

id	Competency Question/Statement
GRID-19	A meter has different types of contracts
GRID-20	A contract has an activity calendar
GRID-21	A contract has a power limit
GRID-22	The power limit of a contract can be disabled
GRID-23	The power limit of a contract is measured in watts (W)

Table 6 shows the tasks related to the management of billing information of meters in an electrical secondary substation. A power modification modifies the power limits defined in a contract. Moreover, the information of a contract can be modified by changing its activity calendar.

Table 6: Requirements for the tasks related to the management of billing information

id	Competency Question/Statement
GRID-24	A meter can modify the power limit of a contract
GRID-25	A meter can modify the activity calendar of a contract

Table 7 shows the tasks related to the collection of billing information from meters in an electrical secondary substation. These tasks obtain the measures performed by a meter. A monthly billing values profile stores the incremental and absolute values measured in each tariff period of a contract in a month. A daily billing values profile stores the absolute values measured in each tariff period of a contract in a day. Moreover, a reduced version of the daily values profile gets only the absolute values measured in each tariff period of the contract in a day.

Table 7 shows the measures a meter performs to correctly generate billing reports. These measures represent incremental or absolute values of the 6 magnitudes (2 active and 4 reactive).

Table 7: Requirements for the collection of billing information

id	Competency Question/Statement
GRID-26	A meter measures the active energy import in each phase
GRID-27	A meter measures the active energy export in each phase
GRID-28	Active energy is measured in watt hour (Wh) or kilowatt hour (kWh)
GRID-29	A meter measures different types of reactive energy in each phase
GRID-30	Reactive energy is measured in volt-ampere reactive hour (VArh) or kilovolt-ampere reactive hour (kVArh)
GRID-31	A meter stores incremental and absolute values for each active and reactive energy measure
GRID-32	A meter stores a timestamp for each active and reactive energy measure

Table 8 shows the tasks related to the collection of load profiles. These tasks obtain the measures performed by meters and generate a load profile.

Table 8: Requirements for the collection of load profiles

id	Competency Question/Statement
GRID-33	A meter can send an hourly incremental load profile
GRID-34	An hourly incremental load profile is represented by the incremental values of the measures performed by the meter each hour
GRID-35	A meter can send a reduced hourly incremental load profile
GRID-36	A reduced hourly incremental load profile is represented by the incremental active energy values measured by the meter each hour
GRID-37	A meter can send a daily billing values profile
GRID-38	A daily billing values profile is represented by the absolute values of the measures performed by the meter each day
GRID-39	A meter can send a monthly billing values profile
GRID-40	A monthly billing values profile is represented by the absolute and incremental values of the measures performed by the meter each month

Table 9 shows the parameters that are necessary to configure to correctly detect and store quality information. This quality information is the number and duration of the voltage sags, voltage swells, and long power failures in each phase.

Table 9: Requirements for the collection of quality reports

id	Competency Question/Statement
GRID-41	A meter has a threshold for voltage sags, voltage swells, and long power failures
GRID-42	Thresholds are measured as percentages
GRID-43	A meter has a time threshold for voltage sags, voltage swells, and long power failures
GRID-44	Time thresholds are measured in seconds
GRID-45	A meter stores the number of voltage swells, voltage sags, and long power failures that occur in each phase
GRID-46	A meter stores the duration of each voltage swell, voltage sag, and long power failure that occurs in each phase
GRID-47	Durations are measured in seconds

Table 10 shows the task related to the generation of quality reports that a meter can send. A voltage failure report represents the historical register with the information about the power failure suffered in the meter. A power quality report represents the historical register with information on voltage swells and voltage sags in the meter.

Table 10: Requirements for the task related to the collection of quality reports

id	Competency Question/Statement
GRID-48	A meter can send a voltage failure report
GRID-49	A voltage failure report is represented by the time threshold, number, and duration of the long power failures in each phase
GRID-50	A meter can send a power quality report
GRID-51	A power quality report is represented by the number and duration of voltage swells, voltage sags, and long power failures in each phase

7.2 Management of tertiary sensor devices

Table 11 shows the parameters that are necessary to configure in a data concentrator. These parameters refer to information about the manufacturer of the data concentrator, information about the meter it manages, task configuration, firmware information, and network information.

Table 11: Requirements for the configuration of data concentrators

id	Competency Question/Statement
GRID-52	A data concentrator manages a set of meters
GRID-53	A data concentrator stores the identifier of the meters it manages
GRID-54	A data concentrator collects information from the meters it manages
GRID-55	A data concentrator stores manufacturer information
GRID-56	A data concentrator has a firmware
GRID-57	A data concentrator stores network information
GRID-58	A data concentrator stores tasks configuration
GRID-59	A data concentrator stores data collection configuration

Table 12 shows the tasks related to the modification and retrieval of the configuration parameters of a data concentrator.

Table 12: Requirements for the task related to the configuration of data concentrators

id	Competency Question/Statement
GRID-60	A data concentrator can stop managing a meter
GRID-61	A data concentrator can update its firmware
GRID-62	A data concentrator can receive an order to execute a task at the moment
GRID-63	A data concentrator can receive an order to execute a scheduled task
GRID-64	A data concentrator can modify its network information
GRID-65	A data concentrator can send its task configuration
GRID-66	A data concentrator can send the identifier of the meters that it manages
GRID-67	A data concentrator can send its collect configuration
GRID-68	A data concentrator can send its network information

Table 13 shows the tasks related to the management of monitoring and maintenance reports. These include the generation of communication, performance, maintenance, and quality reports.

Table 13: Requirements for the tasks related to the management of monitoring and maintenance reports

id	Competency Question/Statement
GRID-69	A data concentrator can generate a daily communication report
GRID-70	A data concentrator can generate an hourly communication report
GRID-71	A data concentrator can generate a performance report with information about the tasks in progress
GRID-72	A data concentrator can generate a performance report with historical information about the finished tasks
GRID-73	A data concentrator can generate a performance report with information about scheduled tasks
GRID-74	A data concentrator can generate a maintenance report with information about firmware updates performed in the meters that it manages
GRID-75	A data concentrator can generate a historical quality report
GRID-76	A data concentrator can generate a historical maintenance report with information about the parameters modified in the concentrator

Table 14 shows the parameters that are necessary to configure a line supervision card. These parameters refer to information about the manufacturer of the data line supervision card, its firmware information, and its communication capabilities.

Table 14: Requirements for the configuration of line supervision cards

id	Competency Question/Statement
GRID-77	A line supervision card stores manufacturer information
GRID-78	A line supervision card has a firmware
GRID-79	A line supervision card stores communication information

Table 15 shows the tasks related to the modification and retrieval of the configuration parameters of a line supervision card.

Table 15: Requirements for the tasks related to the configuration of line supervision cards

Id	Competency Question/Statement
GRID-80	A line supervision card can send its manufacturer information
GRID-81	A line supervision card can send its firmware information
GRID-82	A line supervision card can update its firmware
GRID-83	A line supervision card can send its communication information
GRID-84	A line supervision card can modify its communication information

Table 16 shows the parameters that are necessary to configure in a remote terminal unit. These parameters refer to information about the manufacturer of the data concentrator, information about the line supervision cards it manages, firmware information, task configuration, and the collect information.

Table 16: Requirements for the configuration of remote terminal units

Id	Competency Question/Statement
GRID-85	A remote terminal unit manages a set of line supervision cards
GRID-86	A remote terminal unit stores the identifier of the line supervision cards that it manages
GRID-87	A remote terminal unit collects information from the line supervision cards that it manages
GRID-88	A remote terminal unit stores manufacturer information
GRID-89	A remote terminal unit has a firmware
GRID-90	A remote terminal unit stores its task configuration
GRID-91	A remote terminal unit stores its data collection configuration

Table 17 shows the tasks related to the modification and retrieval of the configuration parameters of a remote terminal unit.

Table 17: Requirements for the tasks related to the configuration of remote terminal units

id	Competency Question/Statement
GRID-92	A remote terminal can stop managing a line supervision card
GRID-93	A remote terminal can modify its dynamic parameters
GRID-94	A remote terminal can send its dynamic and static parameters
GRID-95	A remote terminal unit can update its firmware
GRID-96	A remote terminal unit can send it task schedule
GRID-97	A remote terminal unit can send its event information
GRID-98	A remote terminal unit can send the identifier of the line supervision cards it manages

7.3 Management of OLTC transformers

Table 18 shows the measures performed by a line supervision card to select the smart meters from which to collect information to calculate the optimal output voltage. Moreover, the measures performed by those meters are also provided.

Table 18: Requirements for the management of OLTC transformers

id	Competency Question/Statement
GRID-99	A meter stores each second the voltage, current and power measured in each phase
GRID-100	A line supervision card stores each second the voltage, current and the active and reactive power measured in each phase
GRID-101	A meter stores each second the voltage amplitude measured in each phase
GRID-102	A remote terminal unit stores each second the voltage amplitude measured in each phase

Table 19 shows the tasks related to collecting the necessary information to calculate the optimal output voltage. This information is sent through communication messages with instant values or statistics about the measures.

Table 19: Requirements for the tasks related to the management of OLTC transformers

id	Competency Question/Statement
GRID-103	A meter can send an instantaneous values profile
GRID-104	An instantaneous values profile is represented by the instant data values that the meter measures
GRID-105	A meter can send a voltage and current profile
GRID-106	A voltage and current profile is represented by the average voltage/current/power measured in each phase over a period of time
GRID-107	A meter can send an extended voltage profile
GRID-108	An extended voltage profile is represented by the average voltage/current/power measured in each phase during a period of time and the maximum and minimum values registered in that period per phase
GRID-109	A meter can send an hourly instantaneous values profile
GRID-110	An hourly instantaneous values profile is represented by the instant data values measured in a meter each hour
GRID-111	A meter can send a voltage profile
GRID-112	A voltage profile is represented by the average, maximum, and minimum values of the voltage measured in each phase over a period of time
GRID-113	A line supervision card can send a real time values report
GRID-114	A real-time values report is represented by the voltage/current/active and reactive power magnitudes measured in each phase
GRID-115	A line supervision card can send an average voltage and current profile
GRID-116	An average voltage and current profile is represented by the average voltage/current/active and reactive power magnitudes measured in each phase over a period of time
GRID-117	A meter can send a voltage amplitude profile
GRID-118	A remote terminal unit can send a voltage amplitude profile
GRID-119	A voltage amplitude profile is represented by the average voltage amplitude measured in each phase during a period of time

7.4 Detection of meters connectivity

Table 20 shows the information that a meter stores in order to detect the connectivity of a meter.

Table 20: Requirements for the detection of meters connectivity

id	Competency Question/Statement
GRID-120	Clients are connected to the electrical network through meters
GRID-121	Meters store the actual connectivity data
GRID-122	Meters store a register of connectivity data

Table 21 shows the tasks related to obtaining the information to identify the phase, line, and secondary substation at which each meter is connected.

Table 21: Requirements for the tasks related to the detection of meters connectivity

Id	Competency Question/Statement
GRID-123	Meters can send its connectivity data
GRID-124	A line supervision card can send an instantaneous current profile
GRID-125	An instantaneous current profile is represented by the current measured in each phase at each second
GRID-126	Meters can send its register of connectivity data

8 Conclusions

The present document describes the use cases considered for the development of the SAREF4GRID extension as well as the first 126 requirements defined to be implemented in this extension. These requirements are split into the following categories: Remote management of meters (51), Management of tertiary sensor devices (47), Management of OLTC transformers (21), and Detection of meters connectivity (7).

Annex A: Bibliography

- ETSI TS 103 267 (V2.1.1) (2020): "SmartM2M; Smart Applications; Communication Framework".
- oneM2M TS-0001: "Functional Architecture".
- oneM2M TS-0002: "Requirements".

History

Document history		
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