

D4.1

Analysis of standards environment relevant for int:net



int:net

Interoperability Network for
the Energy Transition

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ABSTRACT

This deliverable contains the results of an analysis of the standards environment relevant to int:net. It examines current standardization projects and related activities and identifies and describes pertinent standardization expert groups. It provides easy-to-use tools for a structured overview and regular reports.

The document also explores how to facilitate networking with stakeholders and considers the dissemination of int:net developments related to standardization.

This analysis contributes to an overarching standardization strategy, identifying both project-specific and cross-project focal points. int:net partners are given easy access to standardization activities and the sustainable utilization of int:net project results in standardization is ensured.

KEYWORD LIST

Standardization, IEC, CENELEC, Technical Committee, Working Groups, Energy Transition, Interoperability, System Integration, Communication, IT Security, Cybersecurity

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EXECUTIVE SUMMARY

This report analyzes standardization information and activities relevant for int:net which can be referred to in the course of the project.

Relevant standardization expert groups of the International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC) have been identified and described.

A “Standardization Matrix” has been developed to illustrate the connections between int:net Work Packages (WP) and the pertinent Technical Committees (TC) of IEC and CENELEC at three levels of relevance. To facilitate usability and searchability, comprehensible key words have been included. The matrix is a sorted overview which has been copied in three variants: from the perspective of the int:net WPs, the int:net Interoperability Focus Groups (IFG) and the Energy Data Space Cluster Projects (EDSCP).

Since the matrix is a living document, a “Standardization Blog” has been launched. This blog serves as a platform for exchanging news about standardization, furthermore a regular newsletter provides updates on the progress of projects within the Working Groups (WG) of the committees, including links to current project documents.

The document also provides an in-depth analysis of the relevant standards applied across the work packages („Standardization Table“), alongside a review of the current state of the art. The standards are thoroughly described, listed, and categorized within the energy domain using the established Smart Grid Architecture Model (SGAM) framework. This categorization creates a comprehensive overview of the standards applicable to addressing interoperability challenges.

The Standardization Matrix, the Standardization Blog and the Standardization Table are accessible to all int:net partners and can be found in the annex. These tools create transparency, and each partner can get access to relevant WGs of IEC, CENELEC or other standardization groups via the partner VDE DKE.

int:net has been and will be involved in standardization, providing input and observing relevant standardization activities, e.g., in the areas Internet of Things (IoT), digital twin, reference architecture and data spaces, all with regard to interoperability efforts.

A connection has also been established with the Horizon Europe project InterSTORE, facilitating mutual benefits through the exchange of common topics.

Public relations efforts concerning standardization have been enhanced by presenting int:net at the fairs E-world 2023 in Essen, Germany and Hannover Messe 2024 in Hannover, Germany. Furthermore int:net is featured in both German and English language on the DKE website.

In conclusion, this document contributes to the development of an overarching standardization strategy, supporting the int:net partners in engaging with the relevant standardization groups to adapt existing standards, develop new standards, or adequately document their solutions, in order to ensure the sustainable utilization of the project results in standardization.

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1 Introduction

1.1 Objectives of the work reported

Objective of this report is an analysis of standardization information, projects, and activities relevant for int:net that can be referred to in the course of the project.

Pertinent standardization expert groups, e.g., of the International Electrotechnical Commission (IEC) or the European Committee for Electrotechnical Standardization (CENELEC), are to be identified and described to facilitate easy access for the int:net partners to the appropriate groups and activities. These activities must be updated regularly.

Another objective is to enhance public relations efforts with standardization-specific initiatives, including organizing events and conferences, maintaining online presences, and engaging in bilateral networking with selected countries and relevant stakeholders.

Finally, this document contributes to the objective of developing an overarching standardization strategy that supports the int:net partners in adapting existing standards, developing new standards, or adequately documenting their solutions, in order to ensure the sustainable utilization of the project results in standardization.

1.2 How to read this document

This report provides an analysis of the standards environment relevant for int:net. The main section offers an overview and description of the pertinent standardization expert groups.

This document is intended to assist interested stakeholders in identifying appropriate standardization groups and staying informed about current standardization activities. A look is taken at all int:net work packages and their relation to standardization, e.g., testing standards, maturity models, and the use of IEC 61850 Communication Protocols and IEC 61970 Common Information Model (CIM). A matrix is included as a useful structured overview.

Overall, this deliverable supports int:net partners in working on standards and appropriately documenting their solutions to ensure the sustainable integration of project results into standardization.

1.3 Structure of the document

The report begins with a basic explanation of the importance of standardization, followed by a listing of the most important (electrotechnical) standardization organizations.

In the main section, all standardization expert groups relevant to int:net are listed and described. For a better overview and improved usability, a Standardization Matrix has been created, which is explained in the subsequent section and appended in the annex.

Additional accompanying topics, such as the Standardization Blog, the enhancement of public relations efforts with standardization-specific activities, networking with stakeholders and the Standardization Table are addressed in the following sections. Contributions to standardization and the observation of relevant standardization activities are listed in the next part. A conclusion, which also explains how this report contributes to an overarching standardization strategy, completes this document.

2 Standardization

2.1 Introduction to standardization

Standardization is the process of developing and implementing standard rules, guidelines, and requirements that ensure products, services, and processes meet a set of established specifications or criteria.

Using and creating European and global (electrotechnical) standards offer numerous advantages for industries, businesses, and consumers: [1] [2]

- **Global and Regional Compatibility:** These standards are widely recognized, ensuring that products and systems are compatible across borders and within Europe, facilitating smoother trade and cooperation.
- **Quality and Safety:** Adherence to these standards ensures high levels of quality and safety for products, protecting consumers and minimizing risks associated with malfunctions and hazards.
- **Interoperability:** Standards enable different systems and devices to work together seamlessly, enhancing user experience and overall functionality.
- **Market Access:** Compliance with these standards is often necessary for market entry, particularly in regulated markets. This compliance opens doors to global and European markets, respectively.
- **Cost Efficiency:** Standardization streamlines production processes, reduces redundancy, and lowers costs related to custom designs and testing.
- **Innovation and Competitiveness:** Standards provide a clear foundation for innovation by establishing clear guidelines, allowing companies to focus on advancing technology rather than reinventing existing solutions.
- **Environmental and Social Responsibility:** Many of these standards address environmental impact and sustainability, helping companies meet regulatory and consumer demands for responsible practices.
- **Consumer Trust:** Adherence to recognized standards enhances consumer confidence in the safety, reliability, and performance of products.

Overall, these standards support economic growth, international trade, and technological progress while ensuring safety, quality, and sustainability (see Figure 1).

Why standards?



Figure 1: Why standards?

2.2 Relevant standardization organizations

The most important electrotechnical standardization organizations covered in this report are:

1. **CENELEC** (European Committee for Electrotechnical Standardization) [2]
2. **IEC** (International Electrotechnical Commission) [1]

As there are relevant joint committees and working groups with IEC, this report also describes

3. **ISO** (International Organization for Standardization) [3]

For the sake of completeness and due to occasional mentions, this document also explains

4. **IEEE SA** (Institute of Electrical and Electronics Engineers Standards Association) [4] [5]

2.2.1 CENELEC

CENELEC, the European Committee for Electrotechnical Standardization, is a non-profit organization that develops and publishes harmonized standards for electrical and electronic products and systems across Europe. CENELEC's responsibility extends to the European Union (EU), European Free Trade Association (EFTA), and other European countries.

Founded in 1973, CENELEC works closely with industry stakeholders and national standardization bodies to ensure that its standards are safe, reliable, and compatible with international standards. The organization's work covers a wide range of areas, including energy, telecommunications, transportation, and medical devices. Compliance with CENELEC standards is often required by EU legislation and is necessary for manufacturers to sell their products in the European market.

CENELEC has 34 member countries, the head office is located in Brussels, Belgium.

2.2.2 IEC

IEC, the International Electrotechnical Commission, is a global organization that develops and publishes international standards for electrical and electronic technologies.

Founded in 1906, IEC works with industry experts and stakeholders from around the world to establish standards that ensure safety, interoperability, and efficiency of electrical and electronic products and systems. IEC also provides conformity assessment services to ensure that products and systems meet these standards. Its work covers a wide range of areas, including energy, telecommunications, medical devices, and renewable energy.

IEC has 170 member countries, the head office is located in Geneva, Switzerland.

2.2.3 ISO

ISO, the International Organization for Standardization, is an independent, non-governmental organization that develops and publishes international standards.

Founded in 1947, ISO brings together experts to create consensus-based standards across various industries and sectors. These standards aim to enhance quality, safety, and efficiency while facilitating global trade and supporting innovation. ISO standards cover diverse fields including technology, healthcare, environmental management, and more, providing frameworks for best practices and regulatory compliance worldwide.

Joint committees of ISO, IEC and IEEE develop international standards for electrotechnical and IT sectors collaboratively.

ISO has 167 member countries, the head office is located in Geneva, Switzerland.

2.2.4 IEEE SA

IEEE is a professional association of electrical, electronics, and computer engineers, as well as other technology professionals.

Established in 1884, IEEE is one of the world's largest technical professional organizations, with over 460,000 individual members in more than 160 countries. IEEE fosters innovation in technology by developing and promoting technical standards, organizing events, and publishing technical content. The IEEE's standards (managed by IEEE SA) cover a wide range of areas, including power and energy, communications, aerospace, and computing.

IEEE is a non-governmental organization that holds a liaison status with IEC and ISO. This status allows IEEE to collaborate with IEC and/or ISO on technical matters and standards development, particularly in areas where their expertise overlaps.

The head office is located in Piscataway, New Jersey, USA.

2.3 Relevant standardization expert groups

The IEC and CENELEC Technical Committees (IEC/TC and CLC/TC) in the following subsections are evaluated as relevant for int:net.

Key factors for the transition to future energy grids are the interoperability of power systems, the integration of renewables, communication and IT security.

Criteria for identifying Technical Committees (TC) and projects in their Working Groups (WG) are relations to communication, systems integration, interoperable distributed energy resources (DER), cybersecurity, data spaces and electrical energy storage (EES) systems.

Tables with current projects of relevant WGs are appended in Annex A.

2.3.1 Power systems management and associated information exchange (IEC/TC 57)

IEC/TC 57 [1] is a technical committee within IEC, focused on developing standards for power systems management and associated information exchange. Established to address the growing complexity of power systems and the need for efficient information exchange, TC 57 (see Figure 2) plays a crucial role in ensuring the reliability, efficiency, and security of electrical grids.

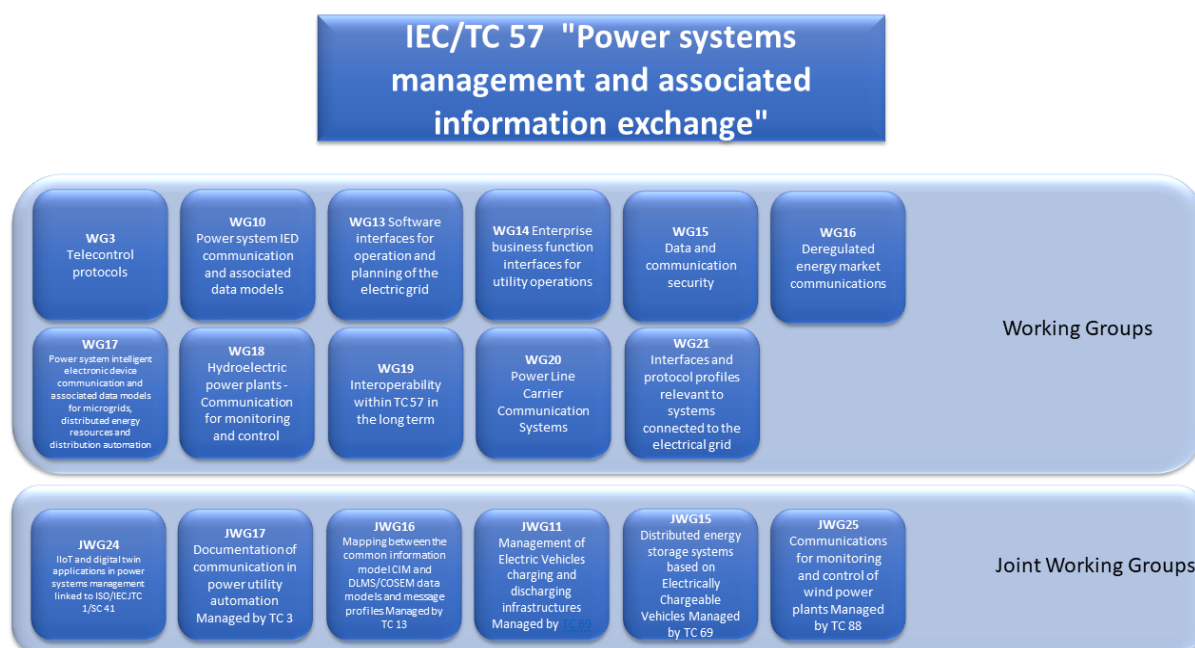


Figure 2: Working Groups IEC/TC 57 [1]

The scope of IEC/TC 57 includes a wide range of topics related to power system operations, such as real-time data exchange, system control, and protection. The committee's work encompasses the development of protocols, communication standards, and data models that facilitate the seamless exchange of information between various components of power systems. Key standards developed by TC 57 include the IEC 61850 series for substation automation, IEC 61970 (see Figure 3) for energy management system application programming interfaces (EMS-API), and IEC 61968 for distribution management system interfaces.

- IEC 61850: This standard focuses on communication networks and systems in substations. It defines the communication between intelligent electronic devices in substations and related system requirements. The standard is widely adopted for its role in enhancing interoperability and ensuring reliable data exchange in substation environments.
- IEC 61970: Known as the Common Information Model (CIM) for energy management, this standard provides a common framework for data exchange between different applications and systems within energy management systems. It supports interoperability by enabling seamless data integration and exchange.
- IEC 61968: This standard extends the CIM to distribution management systems, addressing the information exchange needs of utilities. It supports various functions such as outage management, asset management, and customer information systems, enhancing overall system interoperability and efficiency.

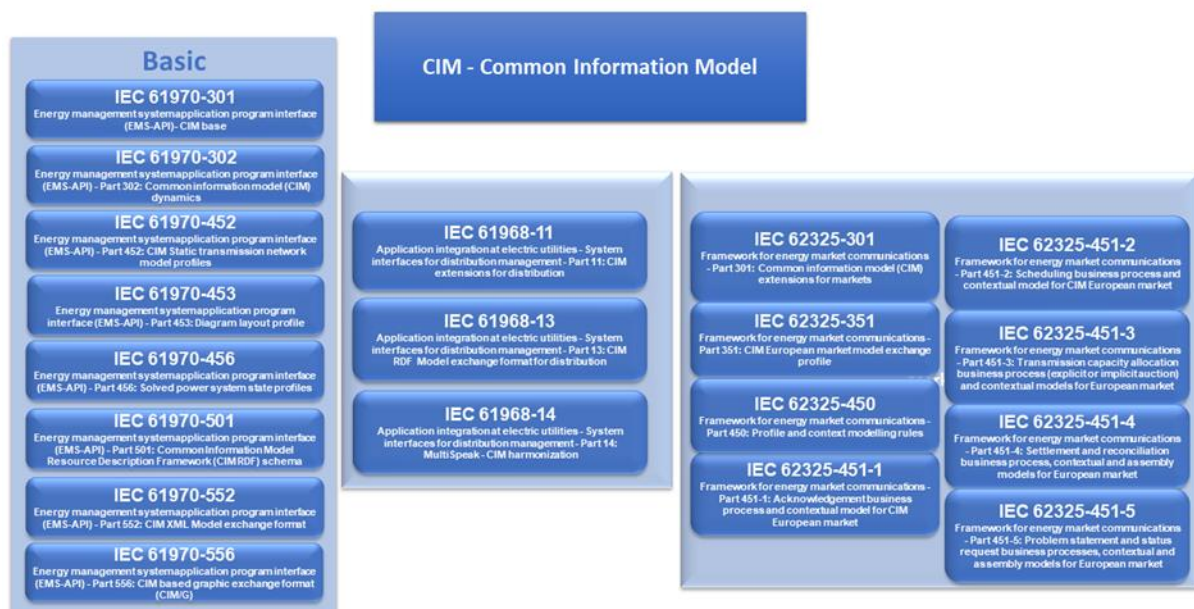


Figure 3: IEC 61970 CIM structure [1]

Interoperability is a key focus for IEC/TC 57 as it ensures that diverse systems and devices can work together harmoniously, regardless of the manufacturer. This is critical for the effective operation of smart grids, where numerous components must interact seamlessly to optimize performance, enhance resilience, and support the integration of renewable energy sources. The standards developed by IEC/TC 57 play a pivotal role in achieving this interoperability, thereby enabling utilities and other stakeholders to implement advanced power system solutions efficiently and cost-effectively.

In summary, IEC/TC 57 develops standards for efficient and secure communication in power systems, ensuring seamless data exchange and integration of advanced technologies. Its work facilitates interoperability and enhances grid management and sustainability through collaboration with stakeholders and alignment with technological advancements.

2.3.2 Information Technology (ISO/IEC JTC 1)

ISO/IEC JTC 1 (Joint Technical Committee 1) [1] [3] is a collaborative effort between ISO and IEC, established to address the rapidly evolving field of information technology (IT). The committee's primary mission is to develop, maintain, and promote a comprehensive portfolio of international standards that enable global interoperability and compatibility among IT systems. This collaboration is crucial in ensuring that IT products and services can function seamlessly across different markets and geographical regions.

JTC 1 covers a broad spectrum of IT topics, including but not limited to, Cloud Computing, Cybersecurity, Data Management, Software Engineering, Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain Technology. These standards provide a foundation for innovation, guiding the development of new technologies while ensuring they are secure, efficient, and interoperable. The committee's work helps to avoid technical trade barriers and facilitates the global exchange of information and technology.

The structure of JTC 1 includes multiple subcommittees (SC) and working groups (WG), each focused on specific aspects of IT (see Figure 4). These groups are composed of experts from various sectors, including industry, academia, and government, who bring diverse perspectives and expertise to the standardization process. The collaborative nature of JTC 1 ensures that the standards developed are comprehensive and widely accepted.

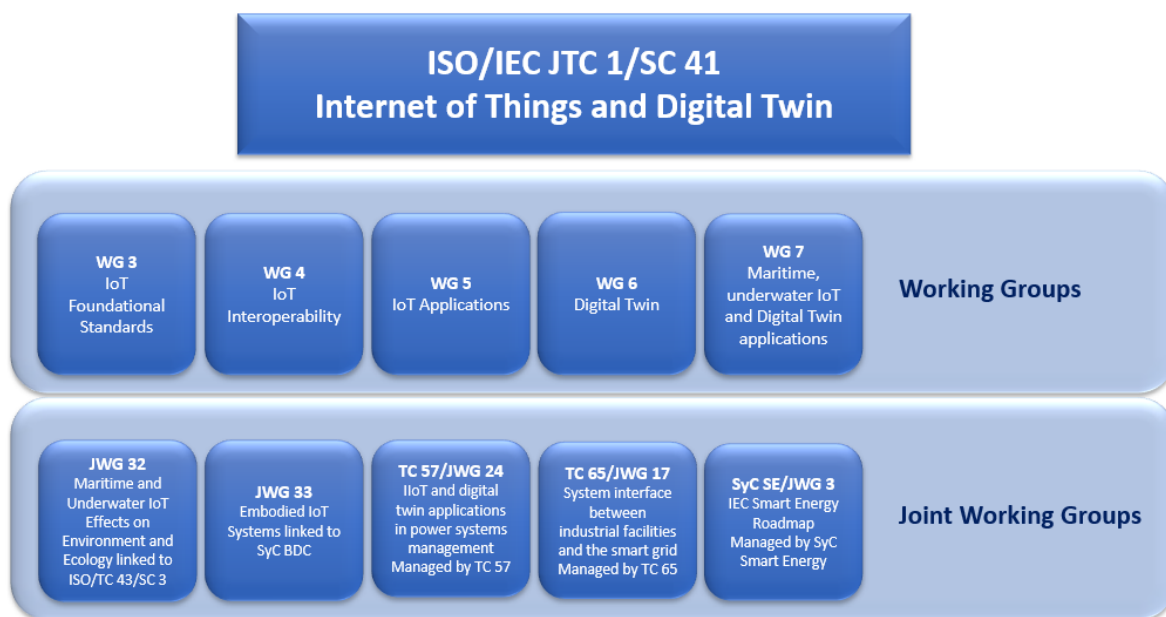


Figure 4: Working Groups ISO/IEC JTC 1/SC 41 [1]

One of the significant contributions of JTC 1 is its role in bridging the gap between emerging technologies and their practical implementation. By providing clear, consistent, and internationally recognized standards, JTC 1 helps stakeholders adopt new technologies with confidence, knowing that they meet global benchmarks for quality and interoperability. This support is vital for driving technological advancement, fostering innovation, and promoting economic growth on a global scale.

ISO/IEC JTC1 significantly enhances interoperability by creating standards that define common protocols, interfaces, and data formats. These standards ensure that IT systems and devices from different manufacturers can communicate and work together seamlessly, facilitating integration and interoperability across global IT infrastructures.

In summary, ISO/IEC JTC1 standardizes information technology, developing protocols and interfaces to ensure seamless communication and interoperability among IT systems and devices. The committee covers a broad range of technologies and regularly updates its standards to stay relevant with technological advancements, fostering innovation and global IT integration.

2.3.3 Industrial-process measurement, control and automation (IEC/TC 65)

IEC/TC 65 [1] is a TC within IEC, responsible for standardizing industrial-process measurement, control, and automation. Established to address the needs of the industrial automation sector, TC 65 develops international standards that ensure the interoperability, reliability, and safety of industrial systems and equipment.

The scope of TC 65 includes a wide range of topics related to industrial automation, such as sensors and instrumentation, control systems, and software used in the automation of manufacturing processes (see Figure 5). These standards cover the entire lifecycle of automation systems, from design and installation to operation and maintenance. By providing standardized guidelines, TC 65 helps manufacturers and end-users achieve consistency and quality in their automation processes, reducing downtime and improving productivity.

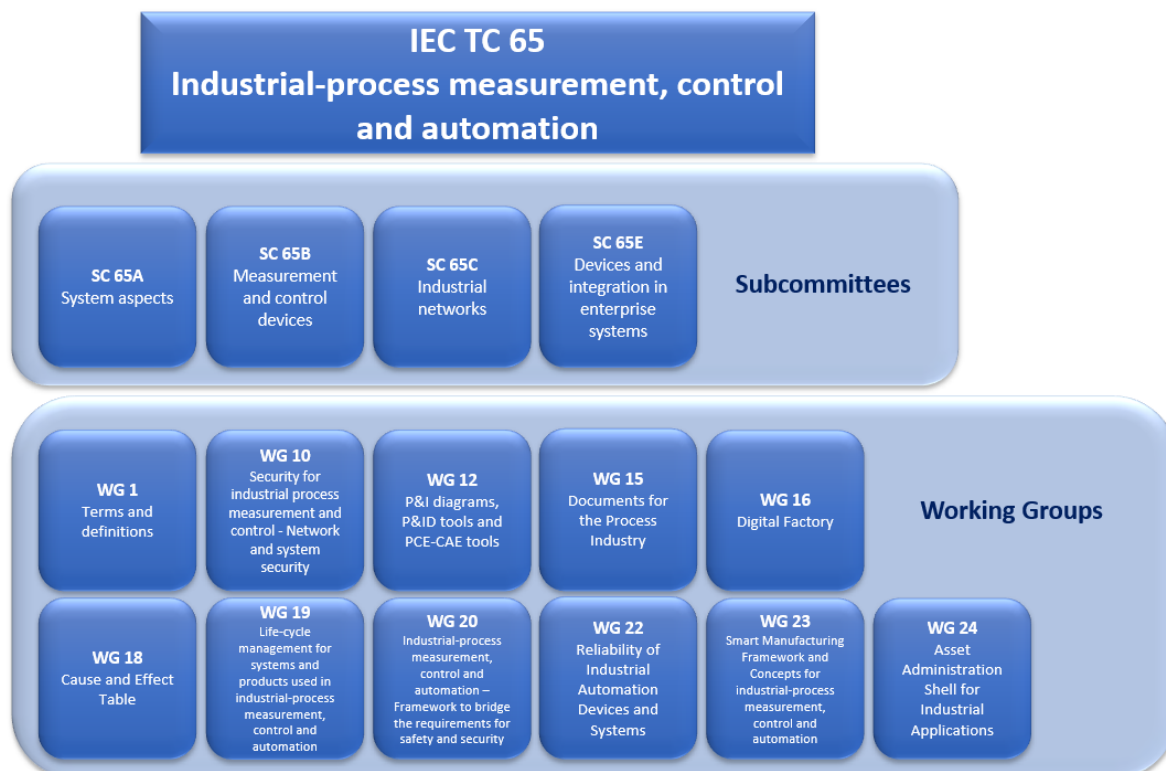


Figure 5: Subcommittees and Working Groups IEC TC 65 [1]

TC 65's work is crucial for industries that rely heavily on automation, such as manufacturing, chemical processing, and power generation. The committee addresses emerging technologies and trends, including Industry 4.0, the Industrial Internet of Things (IIoT), and smart manufacturing. By developing standards that incorporate these advancements, TC 65 ensures that industrial automation systems are equipped to meet the demands of modern production environments.

The committee consists of experts from various countries and industries, who collaborate to draft, review, and refine standards. This global participation ensures that the standards developed are comprehensive and applicable worldwide. TC 65 also works closely with other IEC committees and international organizations to align its standards with broader regulatory and technological frameworks.

One of the key benefits of TC 65's work is the enhancement of global trade in industrial automation equipment and systems. By adhering to internationally recognized standards, manufacturers can ensure that their products are compatible with those from other countries, facilitating smoother integration and reducing technical barriers to trade.

IEC/TC 65 enhances interoperability by developing standards that define common communication protocols, data models, and interfaces for industrial automation systems. This ensures that diverse devices and systems from different manufacturers can seamlessly communicate and operate together, improving efficiency and safety in industrial environments.

In summary, IEC/TC 65 focuses on standardizing industrial-process measurement, control, and automation to ensure efficiency, safety, and interoperability. The committee develops guidelines for sensors, control systems, and communication protocols, and collaborates with various stakeholders to align standards with technological advancements and regulatory requirements.

2.3.4 Smart Energy (IEC/SyC SE)

IEC/SyC Smart Energy [1] is a systems committee within IEC, focused on developing standards and frameworks to support the integration and management of smart energy systems (see Figure 6). These systems encompass various components of the energy sector, including generation, distribution, storage, and consumption, all interconnected through advanced communication and information technologies. The goal of IEC/SyC Smart Energy is to create a cohesive and efficient energy ecosystem that leverages smart technologies to enhance energy efficiency, reliability, and sustainability.

The committee's work involves addressing the complexities of integrating renewable energy sources, such as solar and wind, with traditional power grids. This integration requires sophisticated control systems, real-time data analytics, and robust cybersecurity measures to ensure the stable and secure operation of the energy network. IEC/SyC Smart Energy collaborates with various stakeholders, including industry experts, utilities, and technology providers, to develop comprehensive guidelines and best practices that facilitate the deployment of smart energy solutions.

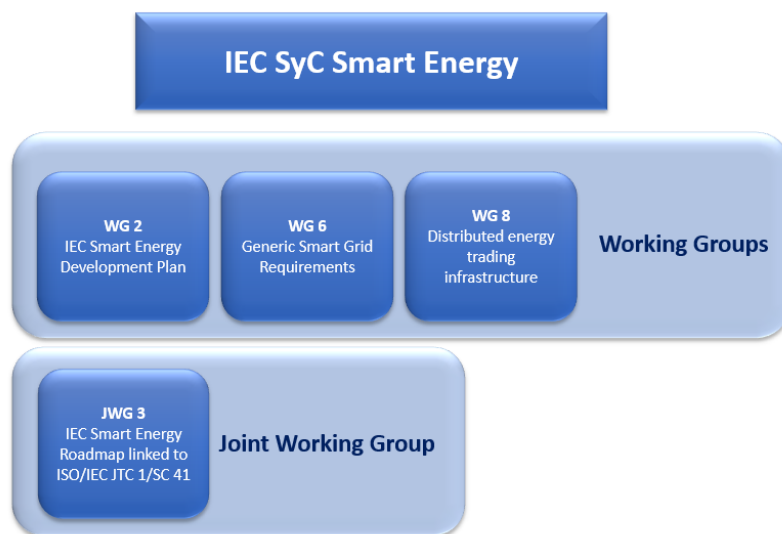


Figure 6: Working Groups IEC/SyC Smart Energy [1]

Examples of standardization work in which IEC/SyC Smart Energy has been involved include the Use Case methodology established in the energy sector according to IEC 62559 and the standardization of the SGAM framework via IEC 63200, which are used both for standardization work, but in particular also for requirements management for complex energy systems and to understand and address the interoperability challenges. The IEC TR 63097 standard also sets out a standardization roadmap for the development of the smart grid.

Interoperability is a key focus for IEC/SyC Smart Energy, as the success of smart energy systems relies on the seamless interaction of diverse technologies and components. The committee develops standards that ensure different devices, systems, and platforms can communicate and operate together efficiently. This interoperability enables the integration of new technologies without disrupting existing infrastructure, thereby optimizing performance and reducing costs.

Furthermore, IEC/SyC SEs emphasis on interoperability supports the creation of flexible and scalable energy systems. By ensuring that components from various manufacturers and different technological domains can work together, the committee promotes innovation and allows for the gradual evolution of energy systems in response to emerging needs and advancements.

In summary, IEC/SyC Smart Energy aims to develop standards that support the integration and management of smart energy systems, focusing on efficiency, reliability, and sustainability. The committee's emphasis on interoperability ensures seamless interaction among diverse technologies, fostering innovation and optimizing system performance. This interoperability is crucial for creating flexible, scalable, and sustainable energy ecosystems.

2.3.5 System aspects of electrical energy supply (IEC/TC 8 and CLC/TC 8x)

IEC/TC 8 and CLC/TC 8x are technical committees within IEC and CENELEC, focusing on system aspects of electrical energy supply.

While both committees aim to improve the efficiency, reliability, and integration of electrical energy systems, their primary difference lies in their geographic and regulatory focus areas.

2.3.5.1 IEC/TC 8

IEC/TC 8 [1] is the technical committee within IEC that focuses on standardizing system aspects of electrical energy supply. The committee's primary goal is to develop standards that ensure the reliable, efficient, and sustainable operation of electrical power systems. This includes addressing the needs of traditional power grids as well as modern smart grids, which incorporate advanced technologies for better management and distribution of electricity.

The work of IEC/TC 8 encompasses a broad range of areas including system design, operational practices, and integration of renewable energy sources. By establishing comprehensive guidelines and best practices, IEC/TC 8 helps utilities, manufacturers, and policymakers implement robust power systems that can meet the evolving demands of the energy sector. The committee collaborates with other IEC committees and external organizations to ensure that its standards are aligned with global needs and technological advancements.

Interoperability is a critical concern for IEC/TC 8, as it ensures that various components of the power grid, including generation, transmission, and distribution systems, can work together seamlessly. The standards developed by IEC/TC 8 facilitate the integration of different technologies and systems, enabling efficient communication and coordination across the entire power grid. This interoperability is essential for the effective operation of smart grids, which rely on the seamless interaction of diverse technologies to optimize performance and enhance grid stability.

IEC/TC 8 has established three subcommittees to cover grid integration of renewables, applications of renewables and grid stabilization (see Figure 7):

- **Grid Integration of Renewable Energy Generation (IEC/TC 8 SC 8A)**

This subcommittee is responsible for developing international standards and other deliverables for the grid integration of variable power generation from renewable sources such as photovoltaic (PV) and wind energy. The emphasis is on the overall system aspects of electricity supply systems, specifically the grids, as defined in the scope of TC 8. It's important to note that SC 8A does not cover issues typically regulated, such as renewable energy policies like infeed tariff schemes.

- **Decentralized electrical energy systems (IEC/TC 8 SC 8B)**

SC 8B's scope is to develop IEC publications enabling the development of secure, reliable and cost-effective systems with decentralized management for electrical energy supply, which are alternative, complement or precursor to traditional large interconnected and highly centralized systems. These new systems include but are not limited to AC, DC, AC/DC hybrid decentralized electrical energy systems and influence distributed generation, distributed energy storage, virtual power plants and electrical energy management systems.

A popular concept is currently the “microgrid” defined as a 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.

Decentralized electrical energy systems have applications for developing countries (focusing on access to electricity) as well as for developed countries (focusing on high reliability, black-out recovery and services). Interactions within decentralized multi-energy systems should also be considered.

- **Network management in Interconnected Electric Power Systems (IEC/TC 8 SC 8C)**

The focus of this expert group is on network management in interconnected electric power systems, including functions with different time horizons, such as design, planning, operation, control, and market integration. SC 8C plans to address issues contributing to the resilience, reliability, security, and stability of interconnected electric power systems. The current focus is on ensuring stable grid operation; however, the current projects are still in the preliminary phase.

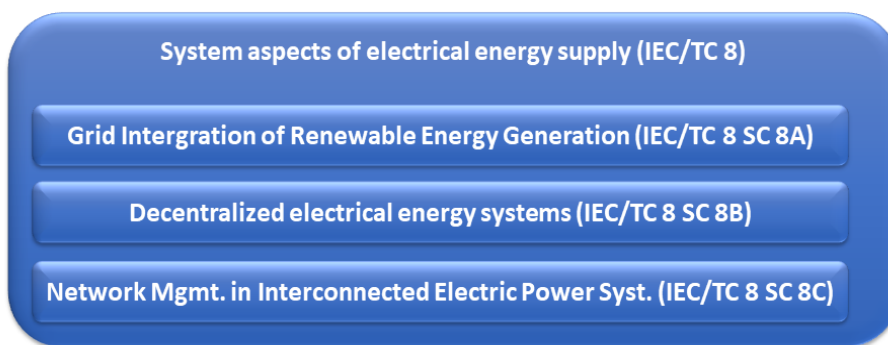


Figure 7: Structure of IEC/TC 8 [1]

In summary, IEC/TC 8 focuses on creating standards for the reliable, efficient, and sustainable operation of electrical power systems. By promoting interoperability among various components and technologies, these standards support the seamless integration and coordination necessary for modern and smart grids, enhancing overall grid performance and stability. This interoperability is vital for optimizing energy supply systems.

2.3.5.2 CLC/TC 8x

CLC/TC 8x [2] is the technical committee within CENELEC that focuses on standardizing system aspects of electrical energy supply. Several working groups, denoted by the "x" in the designation, address specific topics within the broader scope of TC 8's activities, such as renewable energy integration, smart grids, energy efficiency, or technical standards for electrical equipment and systems.

The committee plays a crucial role in developing standards that ensure the efficiency, safety, and reliability of these systems, which are fundamental to modern electrical infrastructure.

The committee's work includes establishing guidelines for the design, implementation, and management of electrical systems, covering aspects such as system performance, safety measures, and operational practices. By creating these standards, CLC/TC 8x supports the development of robust power systems

that can effectively integrate new technologies and adapt to evolving demands in the energy sector. The committee collaborates with various stakeholders, including industry experts and regulators, to ensure that its standards address current technological trends and industry needs.

Interoperability is a key aspect of CLC/TC 8x's mission. The standards developed by the committee are designed to facilitate the integration and seamless operation of diverse technologies within electrical power systems. This interoperability ensures that different components, such as generators, transformers, and control systems, can work together efficiently and reliably. By promoting interoperability, CLC/TC 8x helps enhance the overall performance and stability of power grids, enabling smoother communication and coordination among various system elements.

In summary, CLC/TC 8x, develops specialized European standards for efficient and sustainable electrical energy supply. Its focus on interoperability fosters seamless integration of diverse technologies, enhances grid performance, and aligns with European regulatory frameworks, ensuring reliable and adaptive energy management across Europe.

2.3.6 Electrical Energy Storage (EES) systems (IEC/TC 120)

IEC/TC 120 [1] is a technical committee within IEC dedicated to standardizing electrical energy storage (EES) systems. These systems are crucial for balancing supply and demand in power grids, integrating renewable energy sources, and enhancing the reliability and efficiency of electrical power systems. IEC/TC 120 focuses on various aspects of EES, including performance, safety, testing, and environmental impact, ensuring that these systems are reliable and can meet the demands of modern power grids.

The committee's work involves creating guidelines for different types of energy storage technologies such as batteries, supercapacitors, and flywheels. This includes establishing criteria for performance evaluation, safety protocols, and methods for lifecycle assessment. By providing a comprehensive framework, IEC/TC 120 helps manufacturers, utilities, and regulators implement and manage energy storage solutions effectively. This is vital for the transition to more sustainable and resilient energy systems, which increasingly rely on the ability to store and release energy as needed.

Interoperability is a key focus for IEC/TC 120, as energy storage systems must integrate seamlessly with various components of the power grid, including generation sources, transmission networks, and distribution systems. The standards developed by IEC/TC 120 ensure that different energy storage technologies can operate together and with other grid components, facilitating the smooth exchange of information and energy. This interoperability is essential for optimizing the performance of the entire power system, enhancing grid stability, and supporting the integration of renewable energy sources.

In summary, IEC/TC 120 develops standards for electrical energy storage systems, focusing on performance, safety, and environmental impact. These standards ensure interoperability among different energy storage technologies and other grid components, enhancing the reliability and efficiency of power systems and supporting the integration of renewable energy. This interoperability is crucial for optimizing grid performance and stability.

2.4 Standardization Matrix

Given the extensive number of technical expert groups within IEC and CENELEC, a structured approach was adopted to illustrate the requirements of the int:net Work Packages and the corresponding standardization expert groups within a matrix (see Figure 8).

Matrix IEC/CENELEC Technical Committees and int:net WPs			WP	int:net WP1	int:net WP2	int:net WP3	int:net WP4	int:net WP5
			Title	Interoperability best practices and knowledge base	Develop Interoperability Maturity Model and Reference Implementation	Community of Interoperability Testing Facilities	Standardization, coordination and regulation	Communication, Dissemination and Networking for a European Interoperability
			Key words (WP)	-catalogue initiatives -analysis use cases, value chain, business models -lifecycle process -energy data spaces	-reference framework -IMM -database/user interface maturity tracking -modeling, protocols	-testing concepts -procedures -involvement and community of testing facilities	-standards environment -regulatory framework -governmental, regulatory institutions	-approaching initiatives -network platform -roadmap, start network -capacity building -dissemination events
Technical Committee (TC) Subcommittee (SC) Working Group (WG) System Committee (SyC) Joint Technical Committee (JTC)	Title of TC/SC/WG/SyC/JTC	Key words (TC/SC/WG/SyC/JTC)						
IEC/TC 8	System aspects of electrical energy supply	power systems						
SC 8A	Grid integration of Renewable Energy Generation	connection requirements, grid integration, data spaces, interoperability, sector coupling	2	3	2	2	1	
-WG 2	Renewable energy power prediction	forecast, benchmarking, prognosis, renewables	2	3	2	2	1	
-WG 6	Connection of Renewable Energy with HVDC System	HVDC system, TSO	2	3	2	2	1	
-WG 7	Integrating distributed PV into DC systems and use cases	renewables, grid integration	2	3	2	2	1	
-WG 8	Modeling of renewable energy generation for power system dynamic analysis	modeling, simulation	2	3	2	2	1	
SC 8B	Decentralised electrical energy systems	renewables, grid integration, DSO, data spaces, interoperability, sector coupling	2	3	2	2	1	
-WG 3	Microgrid monitoring, control and energy management systems	islanding, generation, market, emergency, renewables, virtual power plants	2	3	2	2	1	
-WG 4	Virtual Power Plants	generation, market, emergency, renewables,	2	3	2	2	1	
-WG 5	Direct current and hybrid distribution systems	DSO, grid integration	2	3	2	2	1	
-WG 6	Demand side resources utilization	market, renewables, demand response, flexibility	2	3	2	3	1	
SC 8C	Network management in Interconnected Electric Power Systems	DSO, grid integration, renewables, data spaces, interoperability, sector coupling	2	3	2	2	1	
-WG 2	Electricity market integration	market, renewables, demand response, flexibility	2	3	2	2	1	
-WG 3	Power system stability control	grid integration, frequency, voltage	2	3	2	2	1	
WG 11	Power Quality	control, protection, grid integration, frequency	2	3	2	2	1	
CLC/TC 8x	System Aspects of Electrical Energy Supply	power systems, data spaces, interoperability, sector coupling						
WG 3	Requirements for connection of generators to distribution networks	connection requirements, protection, grid integration, frequency	2	3	2	2	1	
WG 4	Ah WG 38 – Endorsement of IEC 60038 as European Standard	control, protection, grid integration, frequency	2	3	2	2	1	
WG 6	Energy equipment	connection requirements, grid integration,	2	3	2	2	1	

Figure 8: Layout of Standardization Matrix

For improved readability see Annex B: Standardization Matrices.

The matrix shows IEC and CENELEC

- Technical Committees (TC)
- Subcommittees (SC)
- Working Groups (WG)
- System Committee (SyC)
- Joint Technical Committee (JTC)

and their relevance to the int:net work packages (WP)

- WP1: Interoperability best practices and knowledge base
- WP2: Develop Interoperability Maturity Model and Reference Implementation
- WP3: Community of Interoperability Testing Facilities
- WP4: Standardization, coordination and regulation
- WP5: Communication, Dissemination and Networking for a European Interoperability Ecosystem

The relevance is ranked in ascending importance:

- Level 1 - awareness: subject should be known, action is currently not necessary
- Level 2 - follow: activity which should be monitored (passive work)
- Level 3 - contribution: activity which requires action and submittance (active work)

Key words for the TC, SC, WG, SyC, JTC and key words for the int:net WP facilitate the search for int:net partners.

Illustration – the matrix can be utilized as follows:

For instance, WP2 focuses on the domain of “interoperability maturity model/reference implementation”, with key words including modelling and protocols. Similar key words are used in IEC/TC 57 WG 10. Consequently, WP2 is linked to IEC/TC 57 WG 10 at relevance level 3.

However, the matrix is a living document and may evolve as the project progresses.

Potential reasons for changes include:

- Modifications in int:net project activity or WP scope
 - Changes in project objectives
 - New technical developments
 - Regulatory changes
- Changes in standardization expert groups
 - New technical developments
 - New regulatory requirements

Extension to additional variants

Due to the popularity of the Standardization Matrix, two additional variants have been developed.

Variant 2: The int:net WPs in the matrix are replaced with int:net Interoperability Focus Groups (IFG). IFGs are moderated groups on specific activities within the int:net community.

The relevant TCs in the matrix remain the same, but the assignment of relevance levels and key words are revised according to the perspective of the IFGs.

IFGs included in variant 2:

- IFG-1: Interoperability profiles in data spaces
- IFG-2: Increasing maturity in interoperability
- IFG-3: The interoperability regulatory landscape
- IFG-4: Interoperability testing approaches, test cases, and test facilities
- IFG-5: Smart grid-related use cases and SGAM

Variant 3: Analog approach, the int:net WPs in the matrix are replaced with Energy Data Space Cluster Projects (EDSCP). The relevant TCs in the matrix remain the same, but the assignment of relevance levels and key words are revised according to the perspective of the EDSCPs.

EDSCPs included in variant 3:

- omega-x
- SYNERGIES
- Enershare
- DATA CELLAR
- EDDIE (European Distributed Data Infrastructure for Energy)

To avoid confusion, the matrices are distinguished by color-coded headers (see Figure 9):

- orange - variant 1 (int:net WG)
- yellow - variant 2 (int:net IFG)
- green - variant 3 (EDSCP)

For improved readability, see Annex B: Standardization Matrices.

Matrix IEC/CENELEC Technical Committees and int:net IFGs			IFG	IFG-1	IFG-2	IFG-3	IFG-4	IFG-5
			Title	Interoperability Profiles in Data Spaces	Increasing Maturity in Interoperability	The Interoperability Regulatory Landscape	Interoperability Testing Approaches, Test Cases, and Test Facilities	Smart Grid related Use Cases and SGAM
			Key words (IFG)	interoperability profiles data spaces trusted data sharing	organizational maturity collaboration in interoperability interoperable solutions	policy and regulatory initiatives promote development of interoperable energy services stakeholders	testing approaches, test cases, test facilities harmonisation of testing procedures integrated pan-European network of testing facilities	smart grid related use cases SGAM IEC 62559-2 interoperability
Technical Committee (TC) Subcommittee (SC) Working Group (WG) System Committee (SyC) Joint Technical Committee (JTC)	Title of TC/SC/WG/SyC/JTC	Key words (TC/SC/WG/SyC/JTC)						
IEC/TC 8	System aspects of electrical energy supply	power systems						
SC 8A	Grid Integration of Renewable Energy Generation	connection requirements, grid integration, data spaces, interoperability, sector coupling	3	2		2	3	3
-WG 2	Renewable energy power prediction	forecast, benchmarking, prognosis, renewables	3	2		1	3	3
-WG 6	Connection of Renewable Energy with HVDC System	HVDS, system, TSO	3	2		1	3	3
-WG 7	Integrating distributed PV into DC systems and use cases	renewables, grid integration	3	2		2	3	3
-WG 8	Modeling of renewable energy generation for power system dynamic analysis	modeling, simulation	3	2		1	3	3
SC 8B	Decentralized electrical energy systems	renewables, grid integration, DSO, data spaces, interoperability, sector coupling	3	2		2	3	3
-WG 3	Microgrid monitoring, control and energy management systems	islanding, generation, market, emergency, renewables, virtual power plants	3	2		1	3	3
-WG 4	Virtual Power Plants	generation, market, emergency, renewables	3	2		1	3	3
-WG 5	Direct current and hybrid distribution systems	DC, grid integration	3	2		1	3	3
-WG 6	Demand side resources utilization	market, renewables, demand response, flexibility	3	2		2	3	3
SC 8C	Network management in Interconnected Electric Power Systems	DSO, grid integration, renewables, data spaces, interoperability, sector coupling	3	2		2	3	3
-WG 2	Electricity market integration	market, renewables, demand response, flexibility	3	2		2	3	3
-WG 3	Power system stability control	grid integration, frequency, voltage	3	2		1	3	3
WG 11	Power Quality	control, protection, grid integration, frequency	3	2		1	3	3
CLC/TC 8x	System Aspects of Electrical Energy Supply	power systems, data spaces: interoperability, sector coupling						
WG 3	Requirements for connection of generators to distribution networks	connection requirements, protection, grid integration, frequency	3	2		1	3	3
WG 4	Ah WG 38 – Endorsement of IEC 60038 as European Standard	control, protection, grid integration, frequency	3	2		1	3	3
WG 6	Smart grid capabilities	connection requirements, grid integration,	3	2		1	3	3

Matrix IEC/CENELEC Technical Committees and EDSCP (Energy Data Space Cluster Projects)			Data Space Cluster Project	omega-x	SYNERGIES	EnerShare	DATA CELLAR	EDDIE (European Distributed Data Infrastructure for Energy)
			Key words (Data Space Cluster Project)	data spaces -text	-data management -smart grid -interoperability AI, analytics IoT, smart metering -energy/flexibility markets -mobility, storage -renewable energy	-data spaces -text	-data spaces -text	-data spaces -text
Technical Committee (TC) Subcommittee (SC) Working Group (WG) System Committee (SyC) Joint Technical Committee (JTC)	Title of TC/SC/WG/SyC/JTC	Key words (TC/SC/WG/SyC/JTC)						
IEC/TC 8	System aspects of electrical energy supply	power systems						
SC 8A	Grid Integration of Renewable Energy Generation	connection requirements, grid integration, data spaces, interoperability, sector coupling			2			1
-WG 2	Renewable energy power prediction	forecast, benchmarking, prognosis, renewables			2			1
-WG 6	Connection of Renewable Energy with HVDC System	HVDS, system, TSO			1			1
-WG 7	Integrating distributed PV into DC systems and use cases	renewables, grid integration			1			1
-WG 8	Modeling of renewable energy generation for power system dynamic analysis	modeling, simulation			2			1
SC 8B	Decentralized electrical energy systems	renewables, grid integration, DSO, data spaces: interoperability, sector coupling			2			2
-WG 3	Microgrid monitoring, control and energy management systems	islanding, generation, market, emergency, renewables, virtual power plants			2			1
-WG 4	Virtual Power Plants	generation, market, emergency, renewables			2			1
-WG 5	Direct current and hybrid distribution systems	DC, grid integration			1			1
-WG 6	Demand side resources utilization	market, renewables, demand response, flexibility			2			2
SC 8C	Network management in Interconnected Electric Power Systems	DSO, grid integration, renewables, data spaces: interoperability, sector coupling			2			1
-WG 2	Electricity market integration	market, renewables, demand response, flexibility			2			2
-WG 3	Power system stability control	grid integration, frequency, voltage			2			1
WG 11	Power Quality	control, protection, grid integration, frequency			2			1
CLC/TC 8x	System Aspects of Electrical Energy Supply	power systems, data spaces: interoperability, sector coupling						
WG 3	Requirements for connection of generators to distribution networks	connection requirements, protection, grid integration, frequency			1			1
WG 4	Ah WG 38 – Endorsement of IEC 60038 as European Standard	control, protection, grid integration, frequency			1			1
WG 6	Smart grid capabilities	connection requirements, grid integration,			1			1

Figure 9: Layout of variants 2 and 3

Note: Variant 3 requires input from the EDSCPs. Feedback has only been received from two EDSCPs so far, which is included in this report for completeness.

In summary, the Standardization Matrix is a strategic tool that links the int:net project with relevant Technical Committees and associated Working Groups of IEC and CENELEC. As it is a living document, it requires ongoing contributions from all int:net project partners.

2.5 Standardization Blog, networking and other actions

Since the Standardization Matrix is a living document, a Standardization Blog has been launched to keep everybody up to date. This blog serves as a platform for exchanging news about standardization, furthermore, a regular newsletter provides updates on the progress of projects within the relevant WGs of the relevant TCs. Links to project documents on the IEC website [1] are also posted.

Tables with details of the current projects of the relevant WGs can be found in Annex A.

Both the Standardization Matrix and the Standardization Blog are accessible to all int:net partners on the int:net project SharePoint [6]. These tools create transparency, and each partner can get access to the pertinent WGs of IEC, CENELEC or other standardization groups via the partner VDE DKE.

The INTEC initiative of VDE DKE facilitates networking with stakeholders in selected countries. The biennial “US-German Standards Panel” and the annual dialogue with South Korean standardization organizations are highlighted here. The next events are scheduled for 2025.

A connection to the Horizon Europe project InterSTORE (Interoperable open-source Tools to Enable hybridisation, utilisation, and monetisation of storage flexibility) [7] has been established, both projects benefit from the exchange of common topics.

Public relations work – regarding standardization – has been enhanced by the presentation of int:net at E-world 2023 [8] in Essen/Germany, Europe's top energy industry trade fair with 30,000 visitors, and Hannover Messe 2024 [9], one of the world's largest trade fairs with 130,000 visitors, which also included streaming of the VDE DKE conference stage.

Short presentations on the progress of int:net were also given at several smaller VDE DKE events. Additionally, int:net is featured in both German and English language on the DKE website [10].

Two internal workshops (int:net milestones M1 and M2) were conducted in Frankfurt, Germany: “General Introduction to Standardization” (Nov 30/Dec 1, 2022) and “Smart Energy Grid Data Modelling” (June 22, 2023). These workshops facilitated a common understanding of standards and contributed to the identification and discussion of new perspectives on specific int:net topics.

From an academic perspective, a tool named *Smart Grid Assistive Artificial Intelligence for Requirements Engineering (SGAIRE)* [11] was developed as part of the task. This AI tool aims to enhance the creation of IEC 62559 Use Case descriptions and SGAM models. In earlier years, these descriptions and models were primarily used in standardization efforts to identify gaps. Today, however, the focus has shifted more towards requirements management, to promote interoperability in system design and development.

In summary, a blog with a regular newsletter, cross-border networking with stakeholders and workshops with in-depth technical discussions support the dissemination and utilization of int:net results in standardization.

2.6 Standardization Table

Interoperability is closely linked to the topics of standardization. The int:net project actively engages with interoperability issues and works in alignment with relevant standards. The project structure is organized to categorize core topics into various work packages, which can be clustered around relevant standards:

- **WP1: “Interoperability Best Practices and Knowledge Base“** focuses on providing a knowledge base to enhance the understanding of interoperability within the energy sector. This includes considering standards that offer an overview of pertinent topics, outline standardization processes (e.g., IEC 63097 Smart Grid Roadmap), and support requirements management (e.g., IEC 62559 Use Case Methodology and IEC 63200 SGAM).
- **WP2: “Interoperability Maturity Model and Reference Implementation“** aims to develop a maturity model that tracks progress in interoperability and provides support in achieving higher maturity levels. By linking standardization and interoperability, the maturity model considers both the relevant processes and the contribution to or utilization of standardization efforts.
- **WP3: “Community of Interoperability Testing Facilities“** is dedicated to advancing testing procedures for energy systems, with a particular emphasis on interoperability testing.
- **WP4: “Standardization, Coordination, and Regulation“** addresses the themes of standardization, regulation, and the development of procedures to enhance interoperability efforts. Additionally, a concept for a Connectathon is being developed, with a broader focus on standards and standardization activities.

The objective of the Standardization Table is to document both past and current standardization activities relevant to the energy sector and to map these to the respective work packages, and vice versa. Additionally, the standards have been analyzed, adopting a technology-agnostic perspective on the Smart Grid as a system-of-systems. These standards have been categorized within the SGAM (Smart Grid Architecture Model) framework. The SGAM framework (see Figure 10) comprises three dimensions: interoperability layers, domains, and zones. This enables energy sector stakeholders to effectively utilize the relevant standards during system development to address specific interoperability challenges. The table can also be used to carry out more extensive contextual analyses.

The table was maintained and populated concurrently with other tasks. Members of the int:net project were able to contribute by adding relevant standards to the table. Additionally, all deliverables up to the date of this document were analyzed to extract and include additional standards.

The Standardization Table presented in Annex C provides a condensed overview.

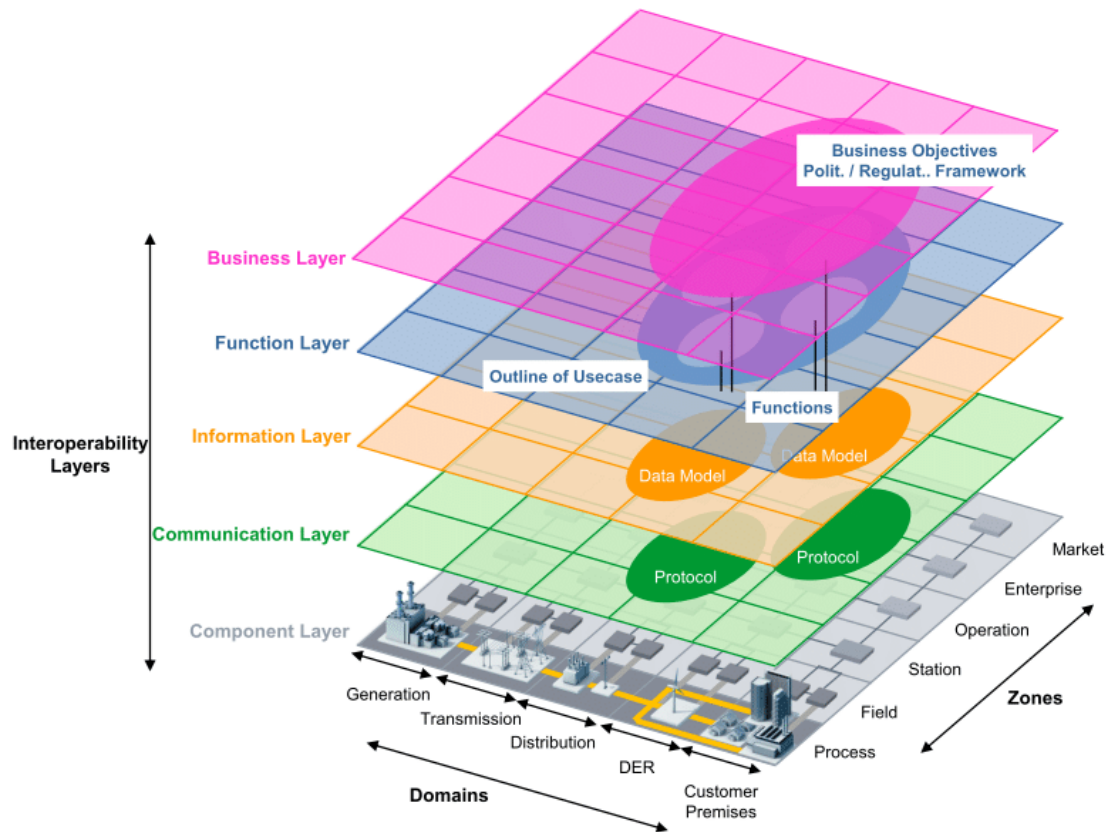


Figure 10: Smart Grid Architecture Model (SGAM) Framework [12]

2.7 Standardization Activities

Specific standardization activities were carried out or monitored by int:net:

- Contributions and interactions with associations (e.g., AIOTI [13], IDSA [14], ECLIPSE [15]) or other initiatives and projects (e.g., BRIDGE [16], DSSC [17], Common European Data Spaces [18], Enershare [19], Omega-X [20])
- Monitoring standardization committees (e.g., ISO/IEC JTC1 (SC7, SC27, SC32, SC38, SC41, SC42), IEC (SEG 15, SMB/SEG12, SyC Smart Energy), ETSI (SAREF), CEN-CENELEC JTC 13, JTC 21, JTC 25)

2.7.1 Contributions to standardization

This section covers work carried out in int:net that was subsequently used at standardization level (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

Table 1: Contributions to the development of standards

Topic	Work done in int:net	Standardization outcome
Interoperability maturity model	Work done in WP2 for a maturity model and its application	Preparation of a global paper in the evolution of interoperability standards. The paper will be completed in 2024, contributed to AIOTI, and submitted to ISO/IEC JTC1/SC41 in 2025 with a request to promote it as a global standardization paper. The content of the paper was presented during the IEC SyC Smart Energy workshop that took place on Sept 19 th and 20 th , 2024.
Interoperability testing	Work done in WP3 Description on constraint-based interoperability, reported in D3.1 Testing concepts and procedures harmonisation report	
Interoperability analysis	Work done in WP1 Survey done on data spaces analysis, reported in D1.2 Annex B (Report on identified interoperability use cases, requirements in the value chain and business models)	Input provided to ISO/IEC 21823-5 [21] IoT behavioural and policy interoperability, under development
Interoperability at energy domain level	Work done in WP5 and through liaison with BRIDGE and Enershare and IDSA (white paper on energy interoperability)	Discussion on an additional layer for SGAM and the concept of tube in the SGAM cube to take into account subdomains
Architecture and integration of digital twin and data spaces	Liaison with other projects, Enershare, Omega-X on digital twin and data spaces and within the CEEDS (Common European Energy Data Space)	Input provided to ISO/IEC 30188 [22] Digital twin reference architecture, under development Input provided to ISO/IEC 30151 [23] Extraction and transactions of data products Input provided to ISO/IEC 30152 [24] IoT and digital twins – Guidance on the connection to data spaces
Trustworthiness and privacy	Liaison with Enershare and liaison with ECLIPSE on the creation of the models4privacy [25] interest group	Input provided to ISO/IEC 27564 [26] Privacy protection - Guidance on the use of models for privacy engineering and ISO/IEC 27568 [27] Security and privacy of digital twins, under development

2.7.2 Monitoring standardization

This section covers committees that have been monitored within int:net (see Table 2).

Table 2: Relationship between standards under development and int:net

Committee	Standards under development	Relationship with int:net
ISO/IEC JTC 1/SC 7 [28] software and systems engineering	ISO/IEC/IEEE 42024 [29] Architecture fundamentals ISO/IEC/IEEE 42042 [30] Reference architecture	Monitoring work to ensure alignment of CEEDS blueprint
ISO/IEC JTC 1/SC 27 [31] Information security, cybersecurity and privacy protection	ISO/IEC 27115 [32] Cybersecurity evaluation of complex systems - Introduction and framework overview ISO/IEC 27564 [26] Privacy protection - Guidance on the use of models for privacy engineering ISO/IEC 27568 [27] Security and privacy of digital twins	Monitoring work to ensure alignment of cybersecurity of smart grid architecture, privacy standards, and digital twin security and privacy related to energy data spaces Monitoring ENISA SCCG [33] on cyber security certification
ISO/IEC JTC 1/SC 32 [34] Data management and interchange	Metadata and data usage standards	Monitoring work to ensure common concepts on data and on ontology and information model registries
ISO/IEC JTC 1/SC 38 [35] Cloud computing and distributed platforms	ISO/IEC 20151 [36] Cloud computing and distributed platforms - Dataspace concepts and characteristics	Monitoring work to ensure alignment on concept of data spaces
ISO/IEC JTC 1/SC 41 [37] Internet of Things and Digital Twin	ISO/IEC 30188 [22] Digital twin reference architecture ISO/IEC 40141 [38] IoT reference architecture guidance ISO/IEC 21823-5 [21] Interoperability for IoT systems - Part 5: Behavioural and policy interoperability ISO/IEC 30151 [23] Extraction and transactions of data products ISO/IEC 30152 [24] IoT and digital twins - Guidance on the connection to data spaces	Monitoring work to ensure alignment on architecture, interoperability and data space standards
IEC SyC Smart Energy [39]	IEC 63417 [40] Guidance and plan to develop smart energy ontologies	Monitoring work to ensure alignment on ontologies
IEC SEG 15 Joint SEG with ISO - Metaverse [41]	Explore needs for standardization on metaverse (virtual worlds)	Monitoring work to ensure alignment of energy standards needs on virtual worlds
IEC SMB/SG 12 [42] Digital Transformation and Systems Approach	IEC Guide 125 [43] Use case methodology guide	Monitoring work to ensure alignment in use case specifications

ETSI SAREF [44] The Smart applications reference ontology	Publication of multi domain ontologies, e.g., SAREF for Energy Flexibility [45]	Monitoring work to ensure alignment on ontology work and standardisation
CEN-CENELEC JTC 13 [46] Cybersecurity and data protection	CEN/CLC JTC 13 WG 9 [47] Special working group on cyber resilience act	Monitoring work to assess impact on energy data and service interoperability
CEN-CENELEC JTC 21 [48] Artificial intelligence	AI trustworthiness framework [49]	Monitoring work to ensure alignment on at energy data space level, energy data level and energy service level
CEN-CENELEC JTC 25 [50] Data management, Dataspaces, Cloud and Edge	Creation of this JTC in September 2024. This JTC will address standardization requests concerning data exchange, including on the use of ontologies.	Participation to the work of this JTC in order to provide the energy domain viewpoint

2.7.3 The way forward

The described activities are carried out within int:net:

- Alignment on architecture beyond the energy domain: coordination on data space in terms of architecture standards, in order to avoid fragmentations. For instance, defining an energy data space architecture that is not consistent with architectures in other domains and creating a silo needs to be avoided. Monitoring and coordination efforts consequently have the following objectives:
 - Agree on a common reference at standardization level, e.g., based on ISO/IEC 20151 [36] Cloud computing and distributed platforms - Data space concepts and characteristics
 - Agree on architecture patterns and associated implementations, e.g., based on IDSA [14] specifications
 - Ensure that proposed architecture blueprints, DSSC [51] and CEEDS [52] are aligned
- Alignment on interoperability beyond the energy domain: coordination in terms of information models, in order to enable integration of cross-cutting topics (e.g. integration of horizontal technologies such as AI, IoT, Digital twins) and cross-cutting characteristics (e.g., security, safety, resilience...), and cross-domain interoperability. Monitoring and coordination efforts consequently have the following objectives:
 - Agree on a consensus and governance practice for interoperability of concepts
 - Reusing common ontologies on cross-cutting topics and technologies
 - Reusing, adapting ontology subsets that need to be shared across domains
- Alignment on architecture and interoperability within the energy domain: coordination in terms of architecture and interoperability within sub-domains, e.g., based in the tube in the cube approach (see D4.3) defined by int:net. Monitoring and coordination efforts consequently have

the following objectives:

- Agree on a consensus and governance practice for interoperability of concepts at the tube level
- Reusing common ontologies on cross-cutting topics and technologies
- Reusing, adapting ontology subsets that need to be shared across subdomains and domains

int:net makes the recommendations for a continuation of these activities beyond the project.

3 Conclusion

This report analyzes standardization information and activities relevant for int:net which can be referred to throughout the project.

As a result, this document provides a listing and description of relevant standardization expert groups of IEC and CENELEC, and as an overview, a “Standardization Matrix” that links int:net work packages (WP) to the pertinent TCs of IEC and CENELEC. To facilitate usability and searchability, comprehensible key words have been included. The matrix has become very popular, so it has been copied in three variants: from the perspective of the int:net WPs, the int:net Interoperability Focus Groups (IFG), and the Energy Data Space Cluster Projects (EDSCP).

Since the matrix is a living document, a “Standardization Blog” with a regular newsletter has been established to keep all participants informed. It includes updates on the progress of projects within the working groups of the committees and provides links to current project documents on the IEC website [1].

The Standardization Table serves as a tool for a detailed analysis of individual standards considered within the project. This table provides an overview of the standards and maps them to the SGAM framework. This approach enhances the selection of standards to address interoperability challenges in the development of the system of interest.

int:net has been involved in standardization and will continue to contribute by providing input and observing pertinent standardization activities, e.g., in the domains of the IoT, digital twins, reference architecture, and data spaces, all concerning interoperability efforts.

The compilation of information at hand ensures that all int:net partners are aware of their appropriate standardization expert groups and can get access to relevant working groups of IEC, CENELEC, or other standardization groups via the partner VDE DKE. Networking with stakeholders is facilitated and supported by presentations of int:net at various events. A connection to the Horizon Europe project InterSTORE has been established, facilitating mutual benefits through the exchange of common topics.

In summary, this document contributes to the development of an overarching standardization strategy, supporting the int:net partners in engaging with the relevant standardization groups to update existing standards, develop new standards, or adequately document their solutions, to ensure the sustainable utilization of the project results in standardization.

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6 List of Abbreviations

AC	Alternating Current
AG	Advisory Group
CEEDS	Common European Energy Data Space
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CIM	Common Information Model
CLC	CENELEC
DC	Direct Current
DER	Distributed Energy Resources
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik
DSSC	Data Spaces Support Centre
EDSCP	Energy Data Space Cluster Project
EES	Electrical Energy Storage
EFTA	European Free Trade Association
EMS-API	Energy Management System - Application Programming Interface
ETSI	European Telecommunications Standards Institute
EU	European Union
IDSA	International Data Spaces Association
IEC	International Electrotechnical Commission
IEEE SA	Institute of Electrical and Electronics Engineers Standards Association
IFG	Interoperability Focus Group
IIoT	Industrial Internet of Things
int:net	Interoperability Network for the Energy Transition
IoT	Internet of Things
ISO	International Organization for Standardization
JTC	Joint Technical Committee
JWG	Joint Working Group
MT	Maintenance Team
PAS	Publicly Available Specification
PNW	New work item proposal
PR	Public Relations
PV	Photovoltaic
PWI	Preliminary work item
SAREF	Smart Applications REference Ontology
SC	Subcommittee
SEG	Standardization Evaluation Group
SGAAIRE	Smart Grid Assistive Artificial Intelligence for Requirements Engineering
SGAM	Smart Grid Architecture Model
SMB	Standardization Management Board

SRD	Systems Reference Deliverable
SyC	Systems Committee
TC	Technical Committee
TR	Technical Report
TS	Technical Specification
VDE	Verband der Elektrotechnik Elektronik Informationstechnik e.V.
WG	Working Group
WP	Work Package

A. Annex A: Projects in Working Groups (WG) of relevant Technical Committees (TC)

The tables below list projects which are related to communication, systems integration, interoperable distributed energy resources (DER), cybersecurity, data spaces and electrical energy storage (EES) systems.

In addition to the project no. (Project Reference) and title, the tables also list the current status of the project document (Document Reference) and the forecasted publication date.

(As of: July 2024)

1) IEC/TC 57 [1]

Table 3: Projects in WGs of IEC/TC 57 [1]

Project Reference	Title	Document Reference	Working Group	Fcst. Publ. Date
IEC TS 60870-5-7 ED2	Telecontrol equipment and systems - Part 5-7: Transmission protocols - Security extensions to IEC 60870-5-101 and IEC 60870-5-104 protocols (applying IEC 62351)	57/2652/CD	WG 3	2025-07
IEC TS 61334-5-6 ED1	Distribution automation using distribution line carrier systems - Part 5-6: Medium-voltage High Speed Power Line Communication systems	57/2589/NP	WG 3	2025-08
IEC 62488-1 ED2	Power line communication systems for power utility applications - Part 1: Planning of analogue and digital power line carrier systems operating over HV electricity grids	57/2631/CD	WG 3	2025-09
PNW 57-2668 ED1	Power systems management and associated information exchange - Communication networks and systems for power utility automation - Part 6-2: Configuration description languages for human-machine interfaces	57/2668/NP	WG 10	2027-04
IEC 61850-6/AMD2 ED2	Amendment 2 - Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in electrical substations related to IEDs	57/2602/CDV	WG 10	2024-10
IEC TS 61850-6-3 ED1	Format of machine-processable rules for validation of IEC 61850 XML-based files	57/2557/NP	WG 10	2025-07
IEC TR 61850-7-6 ED2	Communication networks and systems for power utility automation - Part 7-6: Guideline for definition of Basic Application Profiles (BAPs) using IEC 61850	57/2710/DTR	WG 10	2024-11
IEC 61850-10/AMD1 ED2	Amendment 1 - Communication networks and systems for power utility automation - Part 10: Conformance testing	57/2628/CDV	WG 10	2024-12
IEC TS 61850-80-6 ED1	Communication networks and systems for power utility automation - Part 80-6: Using IEC 61850 for communication between substations and control centres	57/2632/CD	WG 10	2025-07
IEC TS 61850-80-7 ED1	Communication networks and systems for power utility automation - Part 80-7: Communication services and data model to support IEC 61850 system management	57/2612/CD	WG 10	2025-12
IEC PAS 61850-90-19 ED1	Communication networks and systems for power utility automation - Part 90-19: Power system IED communication and associated data models for interoperability - Role Based Access Control (RBAC) with IEC 61850	57/2637/NP	WG 10	2025-05
IEC TR 61850-90-19 ED1	Communication networks and systems for power utility automation - Part 90-19: Using Role Based Access Control (RBAC) and IEC 61850		WG 10	
PWI TR 61850-90-20	Communication networks and systems for power utility automation - Part 90-20: Guideline to redundancy systems		WG 10	

IEC 61968-8 ED2	Application integration at electric utilities - System interfaces for distribution management - Part 8: Interfaces for customer operations	57/2318A/RR	WG 14	2025-08
PNW 57-2665 ED1	Power systems management and associated information exchange - Data and communications security - Part 16: Profiles for Ethernet security, MACsec (IEC 62351-16)	57/2665/NP	WG 15	2026-12
IEC 62351-7 ED2	Power systems management and associated information exchange - Data and communications security - Part 7: Network and System Management (NSM) data object models	57/2639/CDV	WG 15	2025-06
IEC 62351-8 ED2	Power systems management and associated information exchange - Data and communications security - Part 8: Role-based access control for power system management	57/2663/CD	WG 15	2025-08
IEC TS 62351-15 ED1	Power systems management and associated information exchange - Data and communications security - Part 15: Deep Packet Inspection (DPI) of encrypted communications	57/2586/NP	WG 15	2026-07
PWI 62325-452-1	Day Ahead Market		WG 16	
PWI 62325-452-4	Weather data to support market operations		WG 16	
PWI 62325-452-5	Communications with Demand Response Systems		WG 16	
PWI 62325-550-2	Common Dynamic Data Structures for DAM, RT, FTR		WG 16	
PWI 62325-552-1	Dynamic Data Structures for DAM		WG 16	
IEC TR 61850-90-23 ED1	Communication networks and systems for power utility automation - Part 90-23: Use of IEC 61850 for microgrid systems	57/2488/CD	WG 17	2025-04
IEC TS 63389 ED1	Developing a profile composed of a set of Basic Application Profiles (BAPs) of IEC 61850 for DER compliant to IEEE 1547	57/2264/NP	WG 17	2025-07
IEC 61850-7-410 ED3	Communication networks and systems for power utility automation - Part 7-410: Basic communication structure - Hydroelectric power plants - Communication for monitoring and control	57/2640/CD	WG 18	2025-09
IEC TS 61850-90-31 ED1	Communication networks and systems for power utility automation - Part 90-31: Use Cases for Dynamic Data model	57/2582/NP	WG 18	2025-11
IEC 62361-104 ED1	Power systems management and associated information exchange - Interoperability in the long term - Part 104: CIM Profiles to JSON Schema Mapping	57/2606/NP	WG 19	2026-01
PWI 62488-4	Broadband systems operating over EHV/HV/MV/LV electricity grids		WG 20	
IEC TR 62746-2 ED2	Systems interface between customer energy management system and the power management system - Part 2: Use cases and requirements	57/2643/CD	WG 21	2025-09
IEC 62746-4 ED1	Systems interface between customer energy management system and the power management system - Part 4: Demand Side Resource Interface	57/2625/CDV	WG 21	2025-02
IEC TR 63353 ED1	IIoT applications in power distribution systems management: Architecture and functional requirements	57/2616/CD	JWG 24	2025-04
PWI TR 57-1001	Development of IEC TR 61850-6-100, SCL Function Modelling for Substation Automation			
PWI TR 57-1002	IEC TR 61850-90-28: Specification for subscriber IED to validate GOOSE and SV messages			
IEC TR 61850-90-21 ED1	Communication networks and systems for power utility automation - Part 90-21: Travelling wave fault location	57/2559/DTR		2024-11
IEC TR 61850-90-22 ED1	Communication networks and systems for power utility automation - Part 90-22: SCD based substation network auto-routing with visualization and supervision support	57/2692/DTR		2024-11
IEC TR 61850-90-30 ED1	Communication networks and systems for power utility automation - Part 90-30: IEC 61850 Function Modelling in SCL	57/2693/DTR		2024-11
IEC TR 62351-90-4 ED1	Power systems management and associated information exchange - Data and communications security - Part 90-4: Migration of cryptographic algorithms	57/2672/CD		2025-04

2) ISO/IEC JTC 1 [1] [3]

2a) ISO/IEC JTC 1 SC 41 “Internet of Things and Digital Twin” [1] [3]

Table 4: Projects in WGs of ISO/IEC JTC 1 SC 41 [1]

Project Reference	Title	Document Reference	Working Group	Fcst. Publ. Date
ISO/IEC 30141 ED3	Internet of Things (IoT) - Reference architecture	JTC1-SC41/434/RR	WG 3	2025-10
ISO/IEC 30141 ED2	Internet of Things (IoT) - Reference architecture	JTC1-SC41/417/FDIS	WG 3	2024-07
ISO/IEC 21823-5 ED1	Internet of things – Interoperability for IoT systems – Part 5: Behavioural and policy interoperability	JTC1-SC41/397/NP	WG 4	2027-06
ISO/IEC 30178 ED1	Internet of Things (IoT) - Data format, value and coding	JTC1-SC41/447/CD	WG 4	2025-10
ISO/IEC 30181 ED1	Internet of Things (IoT) - Functional architecture for resource identifier interoperability	JTC1-SC41/393/CDV	WG 4	2025-01
ISO/IEC 30198 ED1	Internet of Things (IoT) - Edge computing gateway interoperability framework	JTC1-SC41/394/NP	WG 4	2027-06
PWI TR JTC1-SC41-18	(AWI) Internet of Things (IoT) - Guidance on IoT application to home healthcare		WG 5	
ISO/IEC 30180 ED1	Internet of Things (IoT) - Functional requirements to determine the status of self-quarantine through Internet of Things data interfaces	JTC1-SC41/366/CDV	WG 5	2025-09
ISO/IEC 30184 ED1	Internet of Things (IoT) - Autonomous IoT object identification in connected home - Requirements and framework	JTC1-SC41/384/CDV	WG 5	2024-11
ISO/IEC 30187 ED1	Internet of Things (IoT) - Evaluation indicators for IoT systems	JTC1-SC41/437/CD	WG 5	2025-12
ISO/IEC 30197 ED1	Internet of Things (IoT) - IoT for stress management, good health and well-being	JTC1-SC41/383/NP	WG 5	2027-06
PWI TR JTC1-SC41-20	(AWI) Digital Twin - Fidelity metric of digital twin system		WG 6	
PNW JTC1-SC41-440 ED1	IoT and digital twins – Guidance on the connection to data spaces	JTC1-SC41/440/NP	WG 6	2027-06
PNW JTC1-SC41-444 ED1	Digital Twin - Extraction and transactions of data products	JTC1-SC41/444/NP	WG 6	2027-11
ISO/IEC 30186 ED1	Digital twin – Maturity model and guidance for a maturity assessment	JTC1-SC41/400/CD	WG 6	2025-10
ISO/IEC 30188 ED1	Digital Twin - Reference architecture	JTC1-SC41/333/NP	WG 6	2026-06
ISO/IEC 30177 ED1	Internet of Things (IoT) - Underwater network management system (U-NMS) interworking	JTC1-SC41/411/CDV	WG 7	2025-04
ISO/IEC 63573-1 ED1	Internet of Things (IoT) — Multi-modal underwater wireless communication technologies — Part 1: Overview and requirements	JTC1-SC41/395/NP	WG 7	2027-06
ISO/IEC TR 30189-1 ED1	Internet of Things (IoT) - IoT-based management of tangible cultural heritage assets - Part 1: Framework	JTC1-SC41/429/DTR		2024-08
ISO/IEC TR 30194 ED1	Internet of Things (IoT) and digital twin – Best practices for use case projects	JTC1-SC41/416/DTR		2024-12
ISO/IEC TR 30195 ED1	Internet of Things (IoT) - IoT Applications for Long-distance Oil and Gas Pipeline	JTC1-SC41/428/CD		2025-04
ISO/IEC TR 30196 ED1	Internet of Things (IoT) – IoT applications for natural gas distribution system	JTC1-SC41/419/CD		2025-04
PWI TR JTC1-SC41-10	Internet of Things (IoT) – IoT-based cultural heritage management – Part 2: Use cases			
PWI TR JTC1-SC41-12	(AWI) Internet of Things (IoT) – Environmental and ecological effects, risks, and considerations of underwater acoustic signalling			
PWI JTC1-SC41-15	Internet of Things (IoT) – System requirements of IoT-based fixed asset seizure management			
PWI JTC1-SC41-19	(ISO/IEC 30153) Digital Twin- Guidelines for digital entity modeling			
PWI TR JTC1-SC41-21	(AWI) (ISO/IEC TR 40141) Internet of Things (IoT) – Reference architecture guidance			

PWI TR JTC1-SC41-22	Internet of Things (IoT) – Architecture considerations for IoT, edge and cloud			
PWI JTC1-SC41-23	Internet of Things (IoT) – General requirements of information publishing system based on IoT			
PWI JTC1-SC41-24	Internet of Things (IoT) – IoT systems using wireless power technology			

2b) ISO/IEC JTC 1 SC 42 “Artificial Intelligence” [1] [3]

Table 5: Projects in WGs of ISO/IEC JTC 1 SC 42 [1]

Description	Scope	Working Group	Creation Date
Foundational standards	Foundational standards	WG 1	2019-10-11
Data	Data	WG 2	2019-10-11
Trustworthiness	Trustworthiness	WG 3	2019-10-11
Use cases and applications	Use cases and applications	WG 4	2019-10-11
Computational approaches and computational characteristics of AI systems	Computational approaches and computational characteristics of AI systems	WG 5	2019-10-11
Joint Working Group ISO/IEC JTC1/SC 42 - ISO/IEC JTC1/SC 7 : Testing of AI-based systems	Joint Working Group ISO/IEC JTC1/SC 42 - ISO/IEC JTC1/SC 7 : Testing of AI-based systems	JWG 2	2023-07-20
Joint Working Group ISO/IEC JTC1/SC42 - ISO/TC 215 WG : AI enabled health informatics	Joint Working Group ISO/IEC JTC1/SC42 - ISO/TC 215 WG : AI enabled health informatics	JWG 3	2023-07-20
AI standardization roadmapping	AI standardization roadmapping	AG 3	2023-06-05

3) IEC/TC 65 [1]

Table 6: Projects in WGs of IEC/TC 65 [1]

Project Reference	Title	Document Reference	Working Group	Fcst. Publ. Date
IEC 62443-2-1 ED2	Security for industrial automation and control systems - Part 2-1: Security program requirements for IACS asset owners	65/1044/FDIS	WG 10	2024-08
IEC PAS 62443-2-2 ED1	Security for industrial automation and control systems – Part 2-2: IACS Security Protection	65/1051/DPAS	WG 10	2024-09
IEC TS 62443-6-2 ED1	Security evaluation methodology for IEC 62443 - Part 4-2: Technical security requirements for IACS components	65/932/CD	WG 10	2024-12
IEC 63131-1 ED1	Application function blocks and logic diagrams for Upstream Oil & Gas processes – System Control Diagrams – Part 1: General principles	65/919/NP	WG 12	2025-09
IEC TS 63069 ED1	Framework for safety and security	65/1018/CD	WG 20	2025-07
IEC TR 63283-2 ED2	Industrial-process measurement, control and automation - Smart manufacturing - Part 2: Use cases	65/1019/CD	WG 23	2025-04
PNW 65-1032 ED1	Asset Administration Shell for industrial applications – Part 5: Interfaces	65/1032/NP	WG 24	2026-12
IEC 63278-2 ED1	Asset Administration Shell for Industrial Applications – Part 2: Information meta model	65/992/CD	WG 24	2025-08
IEC 63278-3 ED1	Asset Administration Shell for Industrial Applications – Part 3: Security provisions for Asset Administration Shells	65/916/NP	WG 24	2025-08
IEC 63278-4 ED1	Asset administration shell for industrial applications - Part 4: Use cases and modelling examples	65/1024/CD	WG 24	2025-10
IEC 61010-2-201 ED3	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 2-201: Particular requirements for control equipment	65/1049/FDIS	JWG 13	2024-08
IEC 61010-2-203 ED1	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 2-203: Particular requirements for industrial communication circuits and communication port interconnection	65/1054/FDIS	JWG 13	2024-10
ISO 20140-5 ED2	Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 5: Environmental performance evaluation data	65/1046/FDIS	JWG 14	2024-08

IEC 63339 ED1	Unified reference model for smart manufacturing	65/1020/FDIS	JWG 21	2024-08
IEC 60050-351 ED5	International Electrotechnical Vocabulary (IEV) - Part 351: Control technology	65/869/RR		2025-09
IEC TR 63283-4 ED1	Industrial-process measurement, control and automation – Smart Manufacturing – Part 4: Recommendations for the usage of new technologies	65/1040/CD		2025-04
IEC TR 63283-5 ED1	Industrial-process measurement, control and automation – Smart manufacturing – Part 5: Market and innovation trends analysis	65/1008/DTR		2024-08
IEC TR 63319 ED1	A meta-modelling analysis approach to smart manufacturing reference models	65/812/DTR		2024-08

4) IEC/SyC Smart Energy [1]

Table 7: Projects in WGs of IEC/SyC Smart Energy [1]

Project Reference	Title	Document Reference	Working Group	Fcst. Publ. Date
IEC SRD 63443 ED1	Distributed Energy Resource Aggregation Business System: Architecture and Service scenario	SyCSmartEnergy/251/CD	WG 2	2025-07
IEC TS 63586 ED1	SRD: Reference Guidance for Energy Service Business Using Controllable Loads	SyCSmartEnergy/249/NP	WG 2	2025-10
IEC SRD 63417 ED1	Guide and plan to develop Smart energy Ontologies	SyCSmartEnergy/222/CD	WG 6	2024-11
IEC SRD 63460 ED1	Architecture and use-cases for EVs to provide grid support functions	SyCSmartEnergy/241/CD	JWG 3	2024-12
IEC TS 63443-2 ED1	Distributed Energy Resource Aggregation Business System - Part 2: Risk assessment and treatment	SyCSmartEnergy/256/NP		2026-06
PWI SyCSmartEnergy-2	Extension of the SGAM to include Distributed Ledger Technologies (DLT-SGAM-Reference Architecture Model)			
PWI SyCSmartEnergy-3	Archetypes of DLT-based business models for the energy sector			

5) IEC/TC 8 [1]

Table 8: Projects in WGs of IEC/TC 8 [1]

Project Reference	Title	Document Reference	Working Group	Fcst. Publ. Date
IEC TS 62749 ED3	Assessment of power quality - Characteristics of electricity supplied by public networks	8/1671/RR	WG 11	2025-07
IEC TS 63222-1 ED2	Power quality management - Part 1: General guidelines	8/1672/RR	WG 11	2026-01
IEC TS 63222-4 ED1	Power quality management - Part 4: Harmonic analysis over public supply network	8/1711/CD	WG 11	2025-07
IEC TR 63222-101 ED1	IEC TR 63222-101 Power quality management - Part 101: Power quality data application	8/1708/CD	WG 11	2025-04
IEC 60050-602/AMD1 ED1	Amendment 1 - International Electrotechnical Vocabulary (IEV) - Part 602: Generation, transmission and distribution of electricity - Generation	8/1568/RR	JWG 1	2025-10
IEC 60050-603/AMD2 ED1	Amendment 2 - International Electrotechnical Vocabulary (IEV) - Part 603: Generation, transmission and distribution of electricity - Power systems planning and management	8/1569/RR	JWG 1	2025-10
IEC 60050-605/AMD1 ED1	Amendment 1 - International Electrotechnical Vocabulary (IEV) - Part 605: Generation, transmission and distribution of electricity - Substations	8/1570/RR	JWG 1	2025-10
IEC 60050-614/AMD1 ED1	Amendment 1 - International Electrotechnical Vocabulary (IEV) - Part 614: Generation, transmission and distribution of electricity - Operation	8/1571/RR	JWG 1	2025-10
IEC 60050-617 ED2	International Electrotechnical Vocabulary (IEV) - Part 617: Organization/Market of electricity	8/1703/CD	JWG 1	2025-06

IEC 60050-691/AMD2 ED1	Amendment 2 - International Electrotechnical Vocabulary (IEV) - Part 691: Tariffs for electricity	8/1543/RR	JWG 1	2025-10
IEC TR 63282 ED2	LVDC systems - Assessment of standard voltages and power quality requirements	8/1695/DTR	JWG 9	2024-08
IEC TR 63282-101 ED1	IEC TR 63282-101 LVDC systems: DC power distribution system for typical scenarios	8/1707/CD	JWG 9	
IEC TR 63282-102 ED1	IEC TR 63282-102 LVDC systems: Technical report for low-voltage DC electric island power supply systems	8/1691/CD	JWG 9	2025-04
PWI TR 8-12	IEC TR 62786-100 Distributed energy resources connection with the grid - Part 100 Generating units grid connection standard mapping		JWG 10	
PWI TR 8-13	IEC TR 62786-101 Distributed energy resources connection with the grid – Part 101 Gravity storage connection to the grid		JWG 10	
PWI TR 8-14	IEC TR 62786-102 Distributed energy resources connection with the grid – Part 102 CAES connection to the grid		JWG 10	
PWI TR 8-15	IEC TR 62786-103 Distributed energy resources connection with the grid – Part 103 V2G application scenarios for the grid		JWG 10	
IEC TS 62786-2 ED1	Distributed energy resources connection with the grid - Part 2 Additional requirements for PV generation	8/1683/NP	JWG 10	2026-05
IEC TS 62786-42 ED1	Distributed energy resources connection with the grid – Part 42 Requirements for voltage measurement used to control DER and loads	8/1567/NP	JWG 12	2025-07
IEC 60038/AMD2/FRAG1 ED7	Amendment 2 (Fragment 1) - Standard voltages for LVDC supply and LVDC equipment (Proposed horizontal standard)	8/1627/RR	MT 1	2025-07
IEC 60038/AMD2/FRAG2 ED7	Amendment 2 (Fragment 2) - Standard voltages for HVDC supply and HVDC equipment (Proposed horizontal standard)	8/1627/RR	MT 1	2025-07
PWI TR 8-16	IEC TR 63282-103: LVDC systems – Part 103: Flexible interconnection systems with LVDC			

The project lists of IEC/TC 8 SC 8A, IEC/TC 8 SC 8B and IEC/TC 8 SC 8C can be found on the IEC website [1].

6) CLC/TC 8x [2]

Table 9: Projects in CLC/TC 8x [2]

Project reference	Title	Forecasted voting date
EN 50160:2022/prA1:2024 (pr=78493)	Voltage characteristics of electricity supplied by public electricity networks	02.04.2025
prEN 50549-10 (pr=78903)	Requirements for generating plants to be connected in parallel with distribution networks – Part 10: Tests for conformity assessment of generating units	25.06.2025
CLC/prTS 50744-1 (pr=77890)	Electrical characteristics of grid-forming generating and storage units to be connected in parallel with electrical networks - definitions and tests	
EN 60038:2011/prA2 (Fragment 2) (pr=75674)	Standard voltages for HVDC supply and HVDC equipment (Proposed horizontal standard)	22.04.2024
EN 60038:2011/prA2 (Fragment 1) (pr=63051)	Standard voltages for LVDC supply and LVDC equipment (Proposed horizontal standard)	01.10.2018

7) IEC/TC 120 [1]

Table 10: Projects of WGs in IEC/TC 120 [1]

Project Reference	Title	Document Reference	Working Group	Fcst. Publ. Date
IEC TS 62933-2-3 ED1	Electric Energy Storage (EES) Systems - Part 2-3: Unit parameters and testing methods - Performance assessment test after site operation	120/342/CD	WG 2	2025-07
IEC TR 62933-2-201 ED1	Review of testing for BESS in consideration of implementing repurpose and reuse batteries	120/366/DTR	WG 2	2024-08
IEC 62933-3-1 ED1	Electrical energy storage (EES) systems - Part 3-1: Planning and performance assessment of electrical energy storage systems - General specification	120/328/CD	WG 3	2025-09

IEC TR 62933-3-200 ED1	Electrical Energy Storage (EES) Systems - Part 3-200: Design principles of electrochemical based EES systems	120/341/CD	WG 3	2024-11
IEC 62933-4-2 ED1	Electric Energy Storage Systems - Part 4-2- Assessment of the environmental impact of battery failure in an electrochemical based storage system	120/316/CDV	WG 4	2024-12
IEC 62933-4-3 ED1	Electrical energy storage(EES) systems - Part 4-3: The protection requirements of BESS according to the environmental conditions and location types	120/370/CD	WG 4	2025-08
IEC 62933-5-4 ED1	Electrical energy storage (ESS) systems Part 5-4 - Safety test methods and procedures for grid integrated EES systems - Lithium-ion battery-based systems	120/332/CD	WG 5	2025-09
IEC 62933-5-2 ED2	Electrical energy storage (EES) systems - Part 5-2: Safety requirements for grid-integrated EES systems - Electrochemical-based systems	120/353/CDV	MT 7	2025-05
IEC 62933-5-1 ED1	Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid-integrated EES systems - General specification	120/368/FDIS	MT 8	2024-08

B. Annex B: Standardization Matrices

On the following pages, each Standardization Matrix variant has been divided into three extracts for better readability.

1) Matrix variant 1: IEC/CENELEC TC and int:net WP

Orange: IEC/CENELEC Technical Committees (TC) and int:net Work Packages (WP)

2) Matrix variant 2: IEC/CENELEC TC and int:net IFG

Yellow: IEC/CENELEC Technical Committees (TC) and int:net Interoperability Focus Groups (IFG)

3) Matrix variant 3: IEC/CENELEC TC and EDSCP

Green: IEC/CENELEC Technical Committees (TC) and Energy Data Space Cluster Projects (EDSCP)

The original matrices used in the int:net project [6] are Excel sheets.

Table 11: Standardization Matrix in three variants (Annex B)

Matrix IEC/CENELEC Technical Committees and int:net WPs

1 = awareness
2 = follow
3 = contribution

WP	int:net WP1 Interoperability best practices and knowledge base	int:net WP2 Develop Interoperability Maturity Model and Reference Implementation	int:net WP3 Community of Interoperability Testing Facilities	int:net WP4 Standardization, coordination and regulation	int:net WP5 Communication, Dissemination and Networking for a European Interoperability
Key words (WP)	-catalogue initiatives -analysis use cases, value chain, business models -lifecycle process -energy data spaces	-reference framework -MIM -database/user interface maturity tracking -modelling, protocols	-testing concepts -procedures -involvement and community of testing facilities	-standards environment -regulatory framework (governmental, regulatory institutions)	-approaching initiatives -network platform -roadmap, start network -capacity building, dissemination events
<p>Technical Committee (TC)</p> <p>Subcommittee (SC)</p> <p>Working Group (WG)</p> <p>System Committee (SYC)</p> <p>Joint Technical Committee (JTC)</p>					
IEC/TC 8	System aspects of electrical energy supply	Grid integration of Renewable Energy Generation	power systems	2	2
SC 8A	Renewable energy power prediction	Connection of Renewable Energy with HVDC System	connection requirements, grid integration, data spaces, interoperability, sector coupling	2	1
-WG 2	Forecast, benchmarking, prognosis, renewables	Integrating distributed PV into DC systems and use cases	HVDS, system, TSO	2	1
-WG 7	Modeling of renewable energy generation for power system dynamic analysis	Decentralized electrical energy systems	modelling, simulation	2	1
SC 8B	Microgrid monitoring, control and energy management systems	Virtual Power Plants	renewables, grid integration, DSO, data spaces, interoperability, sector coupling	2	1
-WG 3	generation, market, emergency, renewables, renewables, virtual power plants	Direct current and hybrid distribution systems	islanding, generation, market, emergency, renewables, virtual power plants	2	1
-WG 4	DSO, grid integration	Demand side resources utilization	generation, market, emergency, renewables, renewables, virtual power plants	2	1
-WG 5	market, renewables, demand response, flexibility	Network management in Interconnected Electric Power Systems	DSO, grid integration	2	1
SC 8C	DSO, grid integration, renewables, data spaces, interoperability, sector coupling	Electricity market integration	market, renewables, demand response, flexibility	2	1
-WG 2	market, renewables, demand response, flexibility	Power system stability control	interoperability, sector coupling	2	1
-WG 3	grid integration, frequency, voltage	Power Quality	grid integration, frequency, voltage	2	1
WG 11	control, protection, grid integration, frequency	System Aspects of Electrical Energy Supply	control, protection, grid integration, frequency	2	1
CLC/TC 8x	power systems, data spaces, interoperability, sector coupling	Requirements for connection of generators to distribution networks	power systems, data spaces, interoperability, sector coupling	2	1
WG 3	connection requirements, protection, grid integration, frequency	Smart grid requirements	connection requirements, protection, grid integration, frequency	2	1
WG 4	control, protection, grid integration, frequency	System aspects for HVDC grid	control, protection, grid integration, frequency	2	1
WG 5	connection requirements, grid integration	Power frequency measurement for DER management	HVDS, system, TSO	2	1
WG 6	control, protection, grid integration, frequency	Assessment of Standards for Network Code Compliance	grid integration, frequency, voltage	2	1
WG 7	grid integration, frequency, voltage			2	1
WG AHG				2	1

Extract 1 of 3
Standardization Matrix - variant 1
IEC/CENELEC Technical Committees (TC) and int:net Work Packages (WP)

CONTINUATION

	Key words (TC/SC/WG/SG/JTC)	internet WP1	internet WP2	internet WP3	internet WP4	internet WP5
IEC/TC 57	Information exchange, data spaces: interoperability, sector coupling					
WG 3	Power systems management and associated information exchange					
WG 10	Telecontrol protocols	2	3	3	3	1
WG 13	Power system ED communication and associated data models	2	3	3	3	1
WG 14	Software interfaces for operation and planning of the electric substation, grid integration	2	3	3	3	1
WG 15	Enterprise business function interfaces for utility operations	2	3	3	3	1
WG 16	Data and communication security	2	3	3	3	1
WG 17	cybersecurity, end2end, access control, grid integration, trust management, data transactions communication, market, grid integration	2	3	3	3	1
WG 18	Deregulated energy market communications	2	3	3	3	1
WG 20	Power system intelligent electronic device communication and associated data models for microgrids, distributed energy resources and distribution automation	2	3	3	3	1
WG 21	Hydroelectric power plants – Communication for monitoring and control	2	3	3	3	1
WG 22	Interoperability within TC57 in the long term	2	3	3	3	1
WG 23	Power Line Carrier Communication Systems	2	3	3	3	1
WG 24	Interfaces and protocol profiles relevant to systems connected to the electrical grid	2	3	3	3	1
IEC/TC 65	Industrial-process measurement, control and automation					
WG 10, 12, 20, 23, 24		2	2	3	2	1
JWG 13, 14, 21		2	2	3	2	1
SC 65A	System aspects	2	3	3	2	1
-WG 4, 19		2	3	3	2	1
-JWG 21		2	3	3	2	1
SC 65B	Measurement and control devices	3	2	3	2	1
-WG 30, 37, 51		3	2	3	2	1
-JWG 1		3	2	3	2	1
SC 65C	Industrial networks	2	3	3	2	1
-WG 12, 17, 18		2	3	3	2	1
-JWG 10		2	3	3	2	1
SC 65E	Devices and integration in enterprise systems	3	2	3	2	1
-WG 2, 3, 4, 8, 9, 10, 12, 13, 14		3	2	3	2	1
-JWG 5		3	2	3	2	1
IEC/TC 120	Electrical Energy Storage (EES) systems					
WG 1	Terminology	2	2	1	2	1
WG 2	Unit parameters and testing methods	2	2	1	2	1
WG 3	Planning and installation	2	2	1	2	1
WG 4	Environmental issues	2	2	1	2	1
WG 5	Safety considerations	2	2	1	2	1

Extract 2 of 3
Standardization Matrix - variant 1
IEC/CENELEC Technical Committees (TC) and int:net Work Packages (WP)

CONTINUATION		int:net WP1	int:net WP2	int:net WP3	int:net WP4	int:net WP5
IEC/SYC	Smart Energy	2	3	2	3	1
WG 2	IEC Smart Energy Development Plan	2	3	2	3	1
JWG3	Smart Energy Roadmap (joint with ISO/IEC/JTC1/SC41 IoT and digital twin)	2	3	2	3	1
WG 5	Methodology and Tools	2	3	2	3	1
WG 6	Generic Smart Grid Requirements	2	3	2	3	1
WG 8	Distributed energy trading infrastructure	2	3	2	3	1
ISO/IEC/JTC 1	Information Technology					
SC 7	Software and systems engineering	2	3	3	2	1
SC 27	Information security, cybersecurity and privacy protection	2	3	3	2	1
SC 32	Data management and interchange	3	3	3	2	1
SC 38	Cloud computing and distributed platforms	2	3	3	2	1
SC 41	Internet of things and digital twin	2	3	3	3	1
SC 42	Artificial intelligence	2	3	3	2	1

Key words IEC/SC/WG/SYC/JTC
 smart grid, smart energy, systems level standardization, data spaces: interoperability, sector smart grid, development plan smart grid, roadmap, IoT, digital twin
 use cases, actors, use case repository, interoperability, requirement engineering smart grid, functionality, requirement engineering reference architecture, distributed grid management
 IT
 systems engineering, software engineering, requirements engineering, architecture, security, cybersecurity, digital twin
 data, ontologies, metadata, registries, data usage
 cloud, data spaces
 IoT, digital twin, data spaces: interoperability, sector coupling, data transactions
 AI, data spaces: interoperability, sector coupling, trust

Extract 3 of 3
Standardization Matrix - variant 1
 IEC/CENELEC Technical Committees (TC) and int:net Work Packages (WP)

Matrix IEC/GENELEC Technical Committees and int:net IFGs						
IFG	IFG-1 Interoperability Profiles in Data Spaces	IFG-2 Increasing Maturity in Interoperability	IFG-3 The Interoperability Regulatory Landscape	IFG-4 Interoperability Testing Approaches, Test Cases, and Test Facilities	IFG-5 Smart Grid related Use Cases and SGAM	
IFG Title	Interoperability Profiles in Data Spaces	Increasing Maturity in Interoperability	The Interoperability Regulatory Landscape	Interoperability Testing Approaches, Test Cases, and Test Facilities	Smart Grid related Use Cases and SGAM	
Key words (IFG)	interoperability profiles -data spaces -trusted data sharing	-organizational maturity -collaboration in interoperability -interoperable solutions	-policy and regulatory initiatives -promote development of interoperable energy services -stakeholders	-testing approaches, test cases, test facilities -harmonisation of testing procedures -integrated pan-European network of testing facilities	-smart grid related use cases -SGAM -IEC 62559-2 -interoperability	
Technical Committee (TC) Subcommittee (SC) Working Group (WG) System Committee (Syc) Joint Technical Committee (JTC)	Title of TC/SC/WG/Syc/JTC					
IEC/TC 8	System aspects of electrical energy supply					
SC 8A	Grid integration of Renewable Energy Generation					
-WG 2	Renewable energy power prediction					
-WG 6	Connection of Renewable Energy with HVDC System					
-WG 7	Integrating distributed PV into DC systems and use cases					
-WG 8	Modeling of renewable energy generation for power system dynamic analysis					
SC 8B	Decentralized electrical energy systems					
-WG 3	Microgrid monitoring, control and energy management systems					
-WG 4	Virtual Power Plants					
-WG 5	Direct current and hybrid distribution systems					
-WG 6	Demand side resources utilization					
SC 8C	Network management in Interconnected Electric Power Systems					
-WG 2	Electricity market integration					
-WG 3	Power system stability control					
WG 11	Power Quality					
CLC/TC 8x	System Aspects of Electrical Energy Supply					
WG 3	Requirements for connection of generators to distribution networks					
WG 4	An WG 38 – Endorsement of IEC 60038 as European Standard					
WG 5	Smart grid requirements					
WG 6	System aspects for HVDC grid					
WG 7	Power frequency measurement for DER management					
WG AHG	Assessment of Standards for Network Code Compliance					
	Key words (TC/SC/WG/Syc/JTC)					
	power systems connection requirements, grid integration, data spaces: interoperability, sector coupling forecast, benchmarking, prognosis, renewables HVDS, system, TSO renewables, grid integration modeling, simulation renewables, grid integration, DSO, data spaces: interoperability, sector coupling islanding, generation, market, emergency, renewables, virtual power plants generation, market, emergency, renewables, DSO, grid integration market, renewables, demand response, flexibility DSO, grid integration, renewables, data spaces: interoperability, sector coupling market, renewables, demand response, flexibility grid integration, frequency, voltage control, protection, grid integration, frequency power systems, data spaces: interoperability, sector coupling connection requirements, protection, grid integration, frequency control, protection, grid integration, frequency connection requirements, grid integration HVDS, system, TSO control, protection, grid integration, frequency grid integration, frequency, voltage					

Extract 1 of 3
Standardization Matrix - variant 2
IEC/GENELEC Technical Committees (TC) and int:net Interoperability Focus Groups (IFG)

CONTINUATION		IFG-1	IFG-2	IFG-3	IFG-4	IFG-5
IEC/TC 57	Title of TC/SC/WG/SyC/JTC Power systems management and associated information exchange	Key words TC/SC/WG/SyC/JTC Information exchange, data spaces: interoperability, sector coupling				
WG 3	Telecontrol protocols	3	2	1	3	3
WG 10	Power system IED communication and associated data models	3	2	1	3	3
WG 13	Software interfaces for operation and planning of the electric substation, grid integration	3	2	1	3	3
WG 14	Enterprise business function interfaces for utility operations	3	2	2	3	3
WG 15	Data and communication security	3	2	2	3	3
WG 16	Deregulated energy market communications	3	2	2	3	3
WG 17	Power system intelligent electronic device communication and associated data models for microgrids, distributed energy resources and distribution automation	3	2	2	3	3
WG 18	Hydroelectric power plants – Communication for monitoring and control	3	2	1	3	3
WG 19	Interoperability within TC 57 in the long term	3	2	2	3	3
WG 20	Power Line Carrier Communication Systems	3	2	2	3	3
WG 21	Interfaces and protocol profiles relevant to systems connected to the electrical grid	3	2	2	3	3
IEC/TC 65	Industrial-process measurement, control and automation	Integration of components into systems, safety,				
WG 10, 12, 20, 23, 24		3	2	1	3	3
WG 13, 14, 21		3	2	1	3	3
SC 65A	System aspects	3	2	1	3	3
-WG 4, 19		3	2	1	3	3
-JWG 21		3	2	1	3	3
SC 65B	Measurement and control devices	3	2	1	3	3
-WG 30, 37, 51		3	2	1	3	3
-JWG 1		3	2	1	3	3
SC 65C	Industrial networks	3	2	1	3	3
-WG 12, 17, 18		3	2	1	3	3
-JWG 10		3	2	1	3	3
SC 65E	Devices and integration in enterprise systems	3	2	1	3	3
-WG 2, 3, 4, 8, 9, 10, 12, 13, 14		3	2	1	3	3
-JWG 5		3	2	1	3	3
IEC/TC 120	Electrical Energy Storage (EES) systems	EES, data spaces: interoperability, sector coupling				
WG 1	Terminology	3	2	1	3	3
WG 2	Unit parameters and testing methods	3	2	1	3	3
WG 3	Planning and installation	3	2	1	3	3
WG 4	Environmental issues	3	2	1	3	3
WG 5	Safety considerations	3	2	1	3	3

Extract 2 of 3
Standardization Matrix - variant 2
IEC/CENELEC Technical Committees (TC) and int.net Interoperability Focus Groups (IFG)

CONTINUATION

	IFG-1	IFG-2	IFG-3	IFG-4	IFG-5
IEC/SYC Smart Energy	3	3	2	3	3
WG 2 IEC Smart Energy Development Plan	2	3	3	2	2
JWG3 Smart Energy Roadmap (joint with ISO/IEC/JTC1/SC41 IoT and digital twin)	2	3	3	2	2
WG 5 Methodology and Tools	2	3	3	2	2
WG 6 Generic Smart Grid Requirements	2	3	3	2	2
WG 8 Distributed energy trading infrastructure	2	3	3	2	2
ISO/IEC/JTC 1 Information Technology					
SC 7 Software and systems engineering	2	1	3	2	1
SC 27 Information security, cybersecurity and privacy protection	2	1	3	2	1
SC 32 Data management and interchange	3	1	3	2	1
SC 38 Cloud computing and distributed platforms	3	1	3	2	1
SC 41 Internet of things and digital twin	3	2	2	3	3
SC 42 Artificial intelligence	3	2	2	3	3

Key words ITC/SC/WG/SYC/JTC
 smart grid, smart energy, systems level standardization, data spaces, interoperability, sector smart grid, development plan, smart grid, roadmap, IoT, digital twin
 use cases, actors, use case repository, interoperability, requirement engineering, smart grid, functionality, requirement engineering, reference architecture, distributed grid management
 IT
 systems engineering, software engineering, requirements engineering, architecture, security, cybersecurity, digital twin
 data, ontologies, metadata, registries, data usage
 cloud computing
 IoT, digital twin, data spaces: interoperability, sector coupling, data transactions
 AI, data spaces: interoperability, sector coupling, trust

Extract 3 of 3
Standardization Matrix - variant 2
 IEC/CENELEC Technical Committees (TC) and int:net Interoperability Focus Groups (IFG)

Matrix IEC/GENELEC Technical Committees and EDSCP (Energy Data Space Cluster Projects)

1= awareness
2= follow
3= contribution

Technical Committee (TC) Subcommittee (SC) Working Group (WG) System Committee (Syc) Joint Technical Committee (JTC)	Title of TC/SC/WG/Syc/JTC	Key words (TC/SC/WG/Syc/JTC)	Data Space Cluster Project	omega-x	SYNERGIES	Energshare	DATA CELLAR	EDDIE (European Distributed Data Infrastructure for Energy)
IEC/TC-8	System aspects of electrical energy supply	power systems	Key words (Data Space Cluster Project)	-data spaces -text	-data management -smart grid -interoperability -AI, analytics -IoT, smart metering -energy/flexibility markets -mobility, storage -renewable energy	-data spaces -text	-data spaces -text	-data spaces -text
SC 8A	Grid integration of Renewable Energy Generation	connection requirements, grid integration, data spaces, interoperability, sector coupling, forecast, benchmarking, prognosis, renewables			2			1
-WG 2	Renewable energy power prediction	HVDS, system, TSO			2			1
-WG 6	Connection of Renewable Energy with HVDC System	renewables, grid integration			1			1
-WG 7	Integrating distributed PV into DC systems and use cases	modelling, simulation			2			1
-WG 8	Modeling of renewable energy generation for power system dynamic analysis	renewables, grid integration, DSO, data spaces; interoperability, sector coupling			2			2
SC 8B	Decentralized electrical energy systems	islanding, generation, market, emergency, renewables, virtual power plants			2			1
-WG 3	Microgrid monitoring, control and energy management systems	DSO, grid integration			2			1
-WG 4	Virtual Power Plants	market, renewables, demand response, flexibility			1			1
-WG 5	Direct current and hybrid distribution systems	interoperability, sector coupling			2			2
-WG 6	Demand side resources utilization	market, renewables, demand response, flexibility			2			2
SC 8C	Network management in Interconnected Electric Power Systems	DSO, grid integration, renewables, data spaces; interoperability, sector coupling			2			1
-WG 2	Electricity market integration	market, renewables, demand response, flexibility			2			2
-WG 3	Power system stability control	grid integration, frequency, voltage			2			2
-WG 4	Power Quality	control, protection, grid integration, frequency			2			1
WG 11	Power Quality	power systems, data spaces; interoperability, sector coupling			2			1
CLC/TC 8x	System Aspects of Electrical Energy Supply	connection requirements, protection, grid integration, frequency			1			1
WG 3	Requirements for connection of generators to distribution networks	control, protection, grid integration, frequency			1			1
WG 4	An-WG 3B – Endorsement of IEC 60038 as European Standard	connection requirements, grid integration			1			1
WG 5	Smart Grid requirements	HVDS, system, TSO			1			1
WG 6	System aspects for HVDC grid	control, protection, grid integration, frequency			1			1
WG 7	Power frequency measurement for DER management	grid integration, frequency, voltage			1			1
WG 4HG	Assessment of Standards for Network Code Compliance	grid integration, frequency, voltage			1			1
Partial completion								

Extract 1 of 3
Standardization Matrix - variant 3
IEC/GENELEC Technical Committees (TC) and Energy Data Space Cluster Projects (EDSCP)

CONTINUATION

IEC/TC 57	Title of TC/SC/WG/SYC/JTC	Key words (TC/SC/WG/SYC/JTC)	omega-x	SYNERGIES	Enershare	DATA CELAR	EDDIE
	Power systems management and associated information exchange	Information exchange, data spaces: interoperability, sector coupling					
WG 3	Telecontrol protocols	telecontrol protocols		1			1
WG 10	Power system IED communication and associated data models	communication, protocol, application, interface		2			1
WG 13	Software interfaces for operation and planning of the electric substation, grid integration	substation, grid integration		3			1
WG 14	Enterprise business function interfaces for utility operations	CI/MI, market, data model		3			1
WG 15	Data and communication security	cybersecurity, end2end, access control, grid integration, trust management, data transactions		3			1
WG 16	Deregulated energy market communications	communication, market, grid integration		2			3
WG 17	Power system intelligent electronic device communication and associated data models for microgrids, distributed energy resources and distribution automation	data exchange, renewables		3			1
WG 18	Hydroelectric power plants – Communication for monitoring and control	monitoring, control, hydro storage		1			1
WG 19	Interoperability within TC 57 in the long term	SGAM, grid integration, CIM, mapping		3			2
WG 20	Power Line Carrier Communication Systems	PLC, communication		1			1
WG 21	Interfaces and protocol profiles relevant to systems connected to the electrical grid	SGAM, grid integration		1			3
IEC/TC 65	Industrial-process measurement, control and automation	integration of components into systems, safety,					
WG 10, 12, 20, 23, 24				1			1
WG 13, 14, 21				1			1
SC 65A	System aspects	operational conditions, methodology for assessment of systems, functional safety		1			1
-WG 4, 19				1			1
-WG 21				1			1
SC 65B	Measurement and control devices	measurement devices, analysing equipment, actuators, programmable logic controllers, interchangeability, performance evaluation		1			1
-WG 30, 37, 51				1			1
-JWG 1				1			1
SC 65C	Industrial networks	interoperability, co-existence, performance		1			1
-WG 12, 17, 18				1			1
-JWG 10				1			1
SC 65E	Devices and integration in enterprise systems	device properties, classification, selection, configuration, commissioning, monitoring, diagnostics		1			1
-WG 2, 3, 4, 8, 9, 10, 12, 13, 14				1			1
-JWG 5				1			1
IEC/TC 120	Electrical Energy Storage (EES) systems	EES, data spaces: interoperability, sector coupling					
WG 1	Terminology	terms, definitions		2			2
WG 2	Unit parameters and testing methods	testing		1			1
WG 3	Planning and installation	set-up, connection requirements, maintenance		1			1
WG 4	Environmental issues	environmental protection, recycling		1			1
WG 5	Safety considerations	safety, handling, emergency		2			1

Extract 2 of 3
Standardization Matrix - variant 3
IEC/CENELEC Technical Committees (TC) and Energy Data Space Cluster Projects (EDSCP)

CONTINUATION

IEC/SyC	Title of TC/SC/WG/SyC/JTC	Key words (TC/SC/WG/SyC/JTC)	omega-x	SYNERGIES	Enershare	DATA CELLAR	EDDIE
	Smart Energy	Smart grid, smart energy, systems level standardization, data spaces: interoperability, sector					
WG 2	IEC Smart Energy Development Plan	smart grid, development plan		2			1
JWG3	Smart Energy Roadmap (Joint with ISO/JEC/JTC1/SC41 IoT and digital twin	smart grid, roadmap, IoT, digital twin		2			1
WG5	Methodology and Tools	use cases, actors, use case repository, interoperability, requirement engineering		2			2
WG 6	Generic Smart Grid Requirements	smart grid, functionality, requirement engineering		2			1
WG 8	Distributed energy trading infrastructure	reference architecture, distributed grid management		2			1
ISO/JEC/JTC.1	Information Technology	IT					
SC 7	Software and systems engineering	systems engineering, software engineering, requirements engineering, architecture, security, cybersecurity, digital twin		2			2
SC 27	Information security, cybersecurity and privacy protection	requirements engineering, architecture, security, cybersecurity, digital twin		2			1
SC 32	Data management and interchange	data, ontologies, metadata, registries, data usage					
SC 38	Cloud computing and distributed platforms	cloud, data spaces		2			2
SC-41	Internet of things and digital twin	IoT, digital twin, data spaces: interoperability, sector coupling, data organizations		2			1
SC-42	Artificial intelligence	AI, data spaces: interoperability, sector coupling, trust		2			1

Extract 3 of 3
Standardization Matrix - variant 3
IEC/CENELEC Technical Committees (TC) and Energy Data Space Cluster Projects (EDSCP)

C. Annex C: Standardization Table

This part of the appendix contains the Standardization Table, which was motivated and described in section 2.6.

It includes a total of 81 entries, comprising both standards and de facto standards, which are compared based on the following properties:

- **ID:** A sequential number for the unique identification of the entry.
- **Name:** The name of the standard or relevant activity.
- **Responsible Organization(s):** The organizations or committees involved and responsible for the entry.
- **Link / Reference:** A link or reference to the respective entry.
- **Start Date:** The date when the entry was first made available.
- **Last Update Date:** The date when the entry was last updated, serving as an indicator of its currency.
- **Country:** The country where the entry was primarily developed.
- **Short Description:** A brief description of the entry.
- **Keywords:** Key terms for identifying the standard.
- **Relevant SGAM Domains & Zones:** The assignment of the element to the corresponding SGAM domains and zones, allowing for an agnostic view.
- **Component Layer, Communication Layer, Information Layer, Function Layer, Business Layer, and Framework Layer (Governance):** A boolean classification of the elements within the interoperability layers according to the SGAM framework.
- **Added value for int:net:** Describes how the respective entry can impact the int:net project, particularly by providing guidance on its utilization.

The comprehensive table includes various properties that facilitate a detailed analysis and application of standardization activities within the int:net project. These properties include:

- **Priority:** Assesses the relevance of the entry for its use within the project.
- **Author:** Identifies the responsible person for the entry, serving as the point of contact for any inquiries.
- **Status of the Standardization Blog:** Supports the planning and management of blog posts related to standardization topics.
- **Source of the Entry:** Facilitates the assignment of the entry to specific work packages and references the original source.

Table 12: Standardization Table

ID	Name	Responsible Organization(s)	Links / Reference	Start Date	Last Update Date	Country	Short Description	Keywords	Domains of Relevance (acc. SGAM Domains)	Zones of Relevance (acc. SGAM Zones)	Added-value for int:net (Relevance; name also examples and possible WP/Tasks/Subtasks)	Component Layer	Communication Layer	Information Layer	Function Layer	Business Layer	Framework Layer (Governance)
1	IEC 62559 Series - Use Case-Methodology	IEC SYC	https://syce.iec.ch/deliveries/iec-62559-use-cases/	NA	NA	EU	Standardized documentation of use cases	Use Case, Interoperability	All	All	WP1, 2, 4	X	X	X	X	X	(X)
2	IEC SRD 63200:2021 - Definition of extended SGAM smart energy grid reference architecture model	IEC SYC	https://website.iec.ch/publication/62757	NA	NA	EU	Standardized documentation of use cases: Smart Grid Architecture Modelling-Framework as a Reference Designation System	SGAM, Interoperability	All	All	WP 2.1	X	X	X	X	X	(X)
3	IEC TR 62357-1:2016 - Power systems management and associated information exchange - Part 1: Reference architecture	IEC TC 57	https://website.iec.ch/publication/26251	2012	2016	EU	Reference Designation for relevant standards in accordance to their respective domains and zones within SGAM.	SGAM, SIA, Interoperability	All	All	(WP 2.1)				X		

4	IEC 61970 Series - Energy management system application program interface (EMS-API)	IEC TC 57	https://websites.iec.ch/publication/61167#additionalinfo	NA	NA	EU	Information Model for Power Systems Communication	CIM, Semantic Interoperability	All	Operation, Enterprise			X	X	X	(X)	
5	IEC 61968 Series - Application integration at electric utilities - System interfaces for distribution management	IEC TC 57	https://websites.iec.ch/publication/32542	NA	NA	EU	Information Model for Power Systems Communication	CIM, Semantic Interoperability	All	Operation, Enterprise			X	X	X		
6	IEC 62325 Series - Framework for energy market communications	IEC TC 57	https://www.entsoe.eu/digital/common-information-model/cim-for-energy-markets/	NA	NA	EU	Information Model for Market Communication	CIM, Semantic Interoperability	All	Enterprise, Market			X	X	X	X	
7	IEC 61850 Series - Communication networks and systems for power utility automation	IEC TC 57	https://websites.iec.ch/publication/6028	NA	NA	EU	It defines a common language for intelligent devices in electrical substations, function profiles and methods of exchanging data through any kind of network, including public networks.	Technical Interoperability, Semantic Interoperability	All	Process, Field, Station, (Operation)			X	X	X		(X)
8	ISO/IEC 15504: SPICE	ISO/IEC JTC 1	https://www.iso.org/standard/60555.html	2004	NA	Global	Software Process Improvement and Capability Determination for the assessment of maturity levels of processes	Assessment, Maturity Model	N/A	N/A	(REFERENCE WORK) WP 2.1				X	(X)	

9	NISTIR 7628 - Guidelines for Smart Grid Cybersecurity	NIST	https://nvlpubs.nist.gov/nistpubs/jr/2014/nist.jr.7628r1.pdf	NA	NA	USA	MEMO: Maybe change to "CEN-CENELEC-ETSI Smart Grid Coordination Group Smart Grid Information Security", or add both	Cybersecurity	All	All			(X)	(X)	(X)	(X)	(X)
10	IEC SRD 63417 ED1 - Guide and plan to develop Smart energy Ontologies	IEC SyC/WG 6	https://www.iec.ch/dyn/www/f?p=103:38:10848152305681:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:11825,23,105467	2021	2023	EU	This publication provides a Guide and Plan to develop a Smart Energy Ontology and other domain-based ontologies within smart energy through semantic interoperability. This includes but is not limited to: <ul style="list-style-type: none"> Inventory and assessment of existing ontologies for the purpose of Smart energy applications: Reuse of existing ontologies in the smart energy domain Evaluation of developed smart energy ontologies Cross domain semantic interoperability support and mapping to other ontologies Guide and Development plan for smart energy ontology development and usage including Definition of smart energy ontology lifecycle process Guidance for smart energy ontology use cases Definition of a governance process 	Energy, Ontology	All	All				X			
11	SAREF4ENER	ETSI	https://saref.etsi.org/extensions.html#SAREF4ENER:~:text=SAREF4ENER%3A%20extension%20for%20the%20Energy%20domain	2020	2020	EU	The present document is a technical specification of SAREF4ENER, an extension of SAREF that was created in collaboration with Energy@Home (http://www.energy-home.it) and EEBus (http://www.eebus.org/en), the major Italy and Germany-based industry associations, to enable the interconnection of their (different) data models. The Energy@Home association, abbreviated in the rest of the document as E@H. E@H aims at developing and promoting technologies and services for energy efficiency in smart homes, based upon the interaction between user devices and the energy infrastructure. The E@H data model. EEBus is an important initiative in the area of the Internet of Things, which has its roots in the sector of smart and renewable energy. EEBus developed a standardized and consensus-oriented smart grid and smart home networking concept. The EEBus data model. SAREF4ENER is meant to enable the (currently missing) interoperability among various proprietary solutions developed by different consortia in the smart home domain. By using SAREF4ENER, smart appliances from manufacturers that support the EEBus or E@H data models will easily communicate with each other using any energy management system at home or in the cloud	Energy, Ontology	All	All				X			
12	Data Catalog Vocabulary (DCAT)	W3C	https://www.w3.org/TR/vocab-dcat-3/	NA	2023	Global	standard for data catalog information	ontology, data management, data catalog	information layer	All	WP3, WP4			(X)			

13	SAREF4GRID	ETSI	https://saref.etsi.org/saref4grid/v1.1.1/	2023	2023	EU	SAREF4GRID is an extension to the Smart Appliance REFERENCE (SAREF) standard, specifically designed for the Smart Grid domain. It defines a set of standardized vocabulary and concepts for representing smart grid devices, their properties, and interactions. This allows different devices and systems from various manufacturers to communicate and exchange information seamlessly within a smart grid network. Essentially, it acts like a common language for smart grid devices, enabling them to understand each other and work together efficiently, ultimately contributing to a more intelligent and optimized energy system.	Energy, Ontology, Grid	All	All					X			
14	Data Quality Vocabulary	W3C	https://www.w3.org/TR/vocab-dqv/	NA	2016	Global	data standard for expressing data quality metrics of data (sets)	ontology, data management, data quality, data spaces	information layer	All	WP3, WP4				(X)			
15	PROV-O - The PROV Ontology	W3C	https://www.w3.org/TR/prov-o/	NA	2013	Global	data standard for expressing data lineage/provenance	ontology, data management, data lineage, data integrity, data spaces	NA	NA	WP3, WP4		(X)	X				
16	Open Digital Rights Language (ODRL)	W3C	https://www.w3.org/TR/odrl-model/	NA	2018	Global	data standard for specifying data policies, rights and responsibilities of data users and producers	ontology, data governance, data spaces	information layer, function layer, business layer		WP4		(X)	X				
17	IEC SRD 62913 Series – Use case approach in the Smart Energy domain	IEC SyC	https://www.se.iec.ch/deliveries/use-case-approach/	NA	NA	EU	How to elicit generic smart grid requirements by applying the IEC 62559 use case methodology	Use Case, Interoperability, Requirements	All	All	WP4			X	X	X		

18	Semantic Sensor Network Ontology	W3C	https://www.w3.org/TR/vocab-ssn/	2017	2017	Global	Semantic Sensor Network (SSN) ontology is a way to describe sensors and their observations. It includes classes for sensors, observations, samples, and actuators, and it is modular, meaning it can be broken down into smaller parts for easier use and understanding	ontology	All	All				X			
19	ISO/IEC 21823 Series - Interoperability for IoT systems	ISO/IEC JTC 1/SC 41	https://www.iso.org/standard/71885.html	NA	NA	Global	Internet of things (IoT) — Interoperability for IoT systems	Internet of Things	All	All	(X)	(X)	X				
20	Common Grid Model Exchange Specification (CGMES)	ENTSO-E	https://eepublicdownloads.entsoe.eu/lean-documents/CIM_documents/IOP/CGMES_2_5_TechnicalSpecification_61970-600_Part%201_Ed2.pdf	2014	2023	EU	The Common Grid Model Exchange Specification (CGMES) facilitates the exchange of power system models among European Transmission System Operators, supporting key analyses and operational processes. It serves as a baseline exchange standard for implementing Common Grid Model (CGM) methodologies, supporting analyses like load flow, contingency analyses, short circuit calculations, market information, capacity calculation for allocation and congestion management, and dynamic security assessment.	CGMES	All	All			X	X	X		
21	IEC 60255-24:2013 - Measuring relays and protection equipment - Part 24: Common format for transient data exchange (COMTRADE) for power systems	IEC TC 95	https://webstore.iec.ch/publication/1170	NA	2013	EU	The IEC 60255-24:2013 standard specifies a universal format for exchanging data related to power system events and simulations. This format allows easy sharing of fault, test, and simulation data between different systems by defining a common structure for files stored on standard media like USB drives and CDs. It simplifies data exchange and analysis in the power system industry.	Data exchange	All	All			X				
22	OCCP 2.0 - Open Charge Point Protocol	Open Charge Alliance	https://openchargealliance.org/protocols/	2018	2020	Global (5 Continents)	An application protocol for communication between Electric vehicle, charging stations and a central management system	Communication/application protocol	Customer Premise	Operation, Enterprise, Station			X				

23	Modbus RTU (Remote Terminal Unit)	Modbus Organization, Inc	https://modbus.org/	1970	NA	Global	Data communications protocol for using with programmable logic controllers (PLCs), where devices are connected to the same cable or Ethernet network.	Communication protocol	Distribution	Operation, Enterprise, Station, Field			X				
24	NATS (New Atomic Messaging System)	Synadia Communication	https://nats.io/	NA	NA	Global	Protocol of messaging that enables the exchange of messages among computer applications and services, not depending on the network location.	Messaging protocol	Customer Premise	Enterprise			X	X	(X)		
25	HTTPS (Hypertext Transfer Protocol Secure)	Internet Engineering	NA	1994	2023	Global	It is an extension of the Hypertext Transfer Protocol (HTTP), used for secure communication over a computer network. In HTTPS, the communication protocol is encrypted using Transport Layer Security (TLS) or, formerly, Secure Sockets Layer (SSL).	Communication protocol	All	All			X				
26	IEEE 802.3 - ETHERNET	Institute of Electrical and	https://www.ieee802.org/3/	1983	2023	Global	Protocol that defines the physical layer and data link layer's media access control (MAC) of wired Ethernet.	Ethernet Network Standards	Customer Premise	Station, Field	X	X	X	X			
27	ZigBee/RF	Zigbee Alliance	https://csa-iot.org/all-solutions/zigbee/	2004	2010	Global	ZigBee/RF is a communication standard built on top of Radio Frequency (RF) technology, specifically targeting low-power devices for wireless mesh networks.	Wireless communication protocol	DER, Customer Premise	Station, Field			X		(X)		
28	API RESTful	NA	NA	NA	NA	Global	Application Programming Interface for REpresentational State Transfer. API is a software intermediary that allows two applications to talk to each other, whilst REST is an architectural style for distributed hypermedia systems, working stateless. Both define a set of distributed resources accessible and manipulable through a set of public functions.	API	All	All			X				
29	JSON (JavaScript Object Notation)	Internet Engineering	https://www.json.org/	NA	NA	Global	It is a human-friendly data format built on key-value pairs. It is a simple and versatile way to store and exchange data across different systems and applications. Widely used for its lightweight nature, clear structure, and ease of integration with web services and APIs.	Data exchange	All	All			X				

30	MQTT (Message Queuing Telemetry Transport)	OASIS (Organization)	https://mqtt.org/	1999	2023	Global	It is an open OASIS standard and an ISO recommendation (ISO/IEC 20922) over TCP/IP, being a lightweight, publish-subscribe network protocol that transports messages between devices.	Network protocol	DER, Customer Premise	Station, Field				X			
31	TCP/IP - Transmission Control Protocol/Internet Protocol	Internet Engineering	NA	NA	NA	Global	A set of communication protocols used to interconnect network devices on the internet. It specifies how data is exchanged over the internet by providing end-to-end communications that identify how it should be broken into packets, addressed, transmitted, routed, and received at the destination.	Network protocol	All	All				X			
32	IEEE 1901 - Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications	IEEE	https://standards.ieee.org/ieee/1901/7598/	2000	2012	Global	IEEE 1901 standard enables high-speed data transfer directly through your electrical wiring, useful for smart homes, buildings, grids, and even industrial settings. It is used in connecting devices, automating systems, and monitoring energy usage all through your existing outlets, potentially reaching areas Wi-Fi can't.	Broadband over power lines (BPL)	All	All				X			
33	EN 50090 Series - Home and Building Electronic Systems (HBES)	CENELEC	https://www.din.de/de/mitwirken/normenausschuesse/dke/veroeffentlichungen/wdc-beuth.din21:145117927	NA	NA	EU	It establishes a common language (communication protocol) for devices in smart homes and buildings. This "openness" enables diverse equipment, from lighting and heating to security and energy systems, to seamlessly work together.	Home automation	DER, Customer Premise	All				X			(X)

34	EN 13321-1:2021 - Open data communication in building automation, controls and building management - Home and building electronic system - Part 1: Product and system requirements	CENELEC	https://www.din.de/de/mitwirken/normenausschuesse/nhrs/veroeffentlichungen/wdc-beuth:din21:329767212	2021	2022	EU	It defines common rules for a class of multi-application bus systems used in building automation and management. It specifies basic requirements for products, systems, and their interoperability, ensuring they function together seamlessly within a decentralized communication network.	Home automation	DER, Customer Premise	All		X			X		
35	EN 14908 Series - Open Data Communication in Building Automation, Controls and Building Management - Building Network Protocol	CENELEC	https://www.din.de/de/wdc-beuth:din21:203805763	NA	NA	EU	It defines the "Control Network Protocol" (CNP) for building automation, employing LonWorks technology. Encompassing both hardware and software specifications, it lays out a communication system based on the OSI model's "Protocol Stack."	Home automation	DER, Customer Premise	All		X	X	X	X		
36	EN 13757 Series - Communication systems for meters	CENELEC	https://www.din.de/de/mitwirken/normenausschuesse/nhrs/veroeffentlichungen/wdc-beuth:din21:339279330	NA	NA	EU	It defines communication protocols for remote reading of meters in various applications, including water, gas, and electricity. It acts as a common language for meters and data collection systems, enabling seamless communication regardless of manufacturer. Key parts of the standard address physical and link layer (e.g., wired, wireless), application layer (data format, commands), and specific functionalities like wireless M-Bus communication.	Data exchange	Distribution, DER, Customer Premise	All		X	X	X	(X)		

37	IEC 62056 Series - Electricity metering data exchange	IEC TC 13	https://websites.tore.iec.ch/publication/6397	NA	NA	Global	It is a standardized framework for electricity metering data exchange, encompassing communication protocols, data models, security mechanisms, and interoperability with other standards.	Smart metering	Distribution, DER, Customer Premise	All		X	X	X	X		
38	KNX	KNX Association	https://www.knx.org/knx-en/for-your-home/	1996	2013 (KNX Specification)	Global	KNX is an OSI layer based communication standard for building automation that enhances energy efficiency through the intelligent control of heating, cooling, and lighting.	Communication protocol	DER, Customer Premise	Operation, Field			X	X			
39	Matter (as standard)	Connectivity Standards	https://csa-iot.org/all-solutions/matter/	NA	2019	Global	Matter is a standard designed around Internet Protocol (IP) to facilitate communication among smart home devices, mobile apps, and cloud services.	Communication protocol, Internet of Things	DER, Customer Premise	Operation, Field			X				
40	IEC 62196 Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles Part 2: Dimensional compatibility requirements for AC pin and contact-tube accessories	IEC SC23H	https://websites.tore.iec.ch/publication/64364	2011	2022	EU	IEC 62196 Type 2, known as the Mennekes plug, is a European standard for electric vehicle charging connectors, defining the physical characteristics, communication protocols, and electrical specifications for the Type 2 plug and socket, ensuring compatibility and safety across different EV models and charging infrastructure across Europe's EV infrastructure.	EV Charging, Electrical Standard	Distribution, DER, Customer Premise	Operation, Station, Field		X			X		

41	P2030 - Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads	IEEE SA	https://standards.ieee.org/ieee/2030/10261/	2009	2023	Global	This guide provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end use applications and loads. It includes the Smart Grid Interoperability Reference Model (SGIRM), defining interfaces in power systems, communication, and IT.	Interoperability	All	All					X			
42	IEEE 2030.5:2023 - IEEE Approved Draft Standard for Smart Energy Profile Application Protocol	IEEE SA	https://standards.ieee.org/ieee/2030.5/11216/	2013	2023	Global	This standard focuses on the interoperability of energy management systems, smart meters, and other devices in the smart grid. It supports advanced energy management and demand response capabilities.	Profile Application Protocol	All	Operation, Station, Field			X	X	X			
43	ISO/IEC 9646 Series - Conformance testing methodology	ISO/IEC JTC 1	https://www.iso.org/standard/17473.html	1991	2000	Global	ISO/IEC 9646 provides a framework for developing and conducting conformity tests based on the requirements of a wide range of standards, protocols, and specifications. It defines a set of generic test levels and procedures to ensure the interoperability, reliability, and security of smart grid devices and systems.	Conformance	All	All								(X)
44	ISO/IEC/IEEE 15288:2023 - Systems and software engineering - System life cycle processes	ISO/IEC JTC 1/SC 7	https://ieeexplore.ieee.org/document/10123367 , https://www.iso.org/standard/81702.html	2008	2023	Global	Specifies testing and testing as part of the life cycle process.	Life Cycle	All	All					X			

45	IEC TR 63097 Smart Grid Roadmap	IEC SyC	https://www.se.iec.ch/deliveries/iec-tr-63097-smart-grid-roadmap/	2017	2017	EU	The IEC TR 63097 Smart Grid Roadmap is a guideline document for selecting standards and specifications for Smart Energy use cases. It focuses on interoperability in the energy sector, addressing developments like smart metering, e-mobility, and microgrids.	Interoperability	All	All		(X)	(X)	(X)	(X)	(X)	(X)
46	IEC Smart Grid standardization map	IEC	https://mapp.ing.iec.ch/#/maps/1	2015	2022	EU	Map of standards according to their domain (Generation, Distribution, DER, Consumption, Communication, Crosscutting) and their application area (e.g., power plant, generic substation, electromobility infra or home and building automation)	Interoperability	All	All		(X)	(X)	(X)	(X)	(X)	(X)
47	IEC SRD 63199:2020 - Top priority standards development status in the domain of smart energy	IEC SyC	https://www.ics.iec.ch/publication/62688	2020	2022	EU	It presents the current status of the IEC systems committee Smart Energy (SyC SE) development plan for readers. It identifies items that require standardization, their current status and work required, possibly by multiple technical committees or working groups, to address any issues.	Interoperability	All	All		(X)	(X)	(X)	(X)	(X)	(X)
48	NIST's interoperability framework	National Institute of Standards and Technology	https://www.nist.gov/publications/nist-framework-and-roadmap-smart-grid-interoperability-standards-release-40	2007	2021	USA	It facilitates smart grid understanding and communication among stakeholders. It includes a Smart Grid Conceptual Model and Communication Pathways Scenarios to explore varying system architectures and control strategies. This framework also covers Testing and Certification for Smart Grid Standards and Interoperability Profiles, crucial for smart grid technology development and integration.	Interoperability	All	All		(X)	(X)	(X)	(X)	(X)	(X)
49	CGMES Conformity Assessment Framework	ENTSO-E	https://www.entsoe.eu/data/cim/cim-conformity-and-interoperability/	~2014/2015	2017	EU	It focuses on ensuring interoperability of applications used by TSOs for operational and system development exchanges through compliance with the Common Grid Model Exchange Standard (CGMES) requirements. It involves facilitating the elaboration of relevant IEC specifications, supporting the implementation of European network codes, and aiding in system development studies. The framework includes a set of documentation such as test configurations and procedures for guiding conformity tests. This plays a crucial role in smooth data exchanges between TSOs and in maintaining operational efficiency.	Interoperability	TSO	All		(X)	(X)	(X)	(X)	(X)	(X)
50	IES Method	Smartgrids Austria	https://www.smartgrids.at/integrating-the-energy-system-ies.html	2016	2019	EU	The "Initiative IES - Integrating the Energy System" focuses on creating a common framework and understanding to develop interoperability profiles for data exchange, moving away from proprietary solutions. It involves a three-pillar approach: developing technical frameworks containing integration profiles, providing software tools for interoperability testing, and publishing the developed frameworks and test results online.	Interoperability	All	All							

51	OpenADR	openADR alliance	https://www.openadr.org/	2009	2023	Global	OpenADR (Open Automated Demand Response) is a non-proprietary, open standardized demand response (DR) interface that enables electricity providers to communicate DR signals directly to their customers using a common language and existing communication methods such as the internet.	demand response communication	All	Operation, Station, Field			X	(X)	X		
52	IEC 62351 series – Power systems management and associated information exchange - Data and communications security	IEC SYC	https://websites.iec.ch/publication/6912	NA	NA	Global	This standard addresses the security requirements and measures for protecting communication networks and systems in the smart grid. It provides guidelines for authentication, encryption, access control, and other security mechanisms.	Security	All	All		X	X	X	X		(X)
53	IEC 60870-5:2024 series (IEC 104) - Telecontrol equipment and systems - Part 5: Transmission protocols	IEC TC 57	https://websites.iec.ch/publication/3755	NA	NA	Global	It is a set of international standards defining communication protocols for telecontrol equipment used in monitoring and controlling geographically dispersed processes, like power grids. It ensures interoperability between different devices by specifying data formats, transmission methods, and communication procedures.	Communication, Interoperability	All	Operation, Station, Field			X	X	X		
54	IEEE P3158 - Standard for Trusted Data Matrix System Architecture	IEEE SA	https://standards.ieee.org/ieee/3158/10881/	2022	2022	Global	The standard specifies the system architecture for a trusted data matrix which includes business, functional, process, and technology requirements. Based on consensus-made requirements, agreements and management tools, the trusted data matrix is a data and resource sharing digital infrastructure to facilitate trusted, secure, transparent and accountable data sharing, exchanging, circulation and trading among different stakeholders.	Security	All	All			X				
55	IEC 62541 Series - OPC Unified Architecture	IEC SC 65E	https://websites.iec.ch/publication/68039	NA	NA	Global	This standard for OPC Unified Architecture is a platform-independent service-oriented architecture that integrates all the functionality of the individual OPC Classic specifications into one extensible framework. It provides a secure and scalable framework for interoperability between various devices, systems, and platforms in industrial environments.	Communication mechanism	All	All			X	X	X		

56	ISO/IEC/IEE E 42010:2022 - Software, systems and enterprise - Architecture description	ISO/IEC JTC 1/SC 7	https://websites.iec.ch/publication/80194	2007	2022	Global	This standard provides a framework for the architecture description of systems, designed to guide the development of architectures for various systems, emphasizing the importance of defining the environment, entities of interest, stakeholder concerns, as well as viewpoints and views.	Architectural Description Framework	All	All								(X)
57	IEC TR 61334 Series - Distribution automation using distribution line carrier systems	IEC TC 57	https://websites.iec.ch/publication/5294	NA	NA	Global	This series of technical reports provides a set of guidelines for the design, implementation, and operation of power line communication for distribution automation systems. These standards cover a wide range of topics, including the physical, data link, network, and application layers of the communication system, as well as performance characteristics and application guidelines.	Interoperability	All	Operation, Field		X	X	X				
58	IEC 62361 Series - Power systems management and associated information exchange - Interoperability in the long term	IEC TC 57	https://websites.iec.ch/publication/6923	NA	NA	Global	This series of standards is a comprehensive set of standards that standardizes communication, data exchange, and security for power systems management. The standards provide a common information model (CIM), a standardized communication protocol (IEC 61850), and guidelines for developing standardized profiles and security measures.	Information exchange	All	Operation, Field				X				
59	IEC 62488 Series- Power line communication systems for power utility applications	IEC TC 57	https://websites.iec.ch/publication/7095	NA	NA	Global	This series is a set of standards developed to standardize the planning, design, operation, and performance of power line communication (PLC) systems used to transmit information over power networks.	Powerline communication	All	Operation, Field			X					

60	IEC TR 62746 Series-Systems interface between customer energy management system and the power management system	IEC TC 57	https://websites.iec.ch/publication/22279	NA	NA	Global	This series of technical reports provides guidance on architecture, use cases, communication interfaces, and data models for enabling seamless communication and data sharing between various stakeholders involved in energy management systems in smart grids. It defines a layered architecture model, identifies and describes use cases, specifies communication interfaces, defines data models, and provides guidelines for developing interoperable energy management systems.	Interoperability	All	Operation, Field			X	X			
61	IEC 62933 Series-Electrical energy storage (EES) systems	IEC TC 120	https://websites.iec.ch/publication/92274	NA	NA	Global	These standards establish the terminology, unit parameters, testing methods, safety requirements, and performance assessment guidelines for electrical energy storage (EES) systems.	Energy Storage	All	Operation, Field		X			X		
62	IEC TR 63401 Series - Dynamic characteristics of inverter-based resources in bulk power systems	IEC SC 8A	https://websites.iec.ch/publication/64424	NA	NA	Global	It is a comprehensive guide to the dynamic characteristics of inverter-based resources (IBRs) in bulk power systems. It addresses various aspects of IBR integration, including interconnecting IBRs to low SCR networks, mitigating sub-synchronous control interactions (SSCIs), implementing fast frequency response (FFR) and frequency ride-through (FRT), and managing bus voltage variations.	RES Grid integration	All	Operation					X		
63	IEC TS 63102:2021 - Grid code compliance assessment methods for grid connection of wind and PV power plants	IEC SC 8A	https://websites.iec.ch/publication/31475	2017	2021	Global	It is a technical specification that outlines recommended methods for assessing the grid code compliance of wind and PV power plants. It provides a comprehensive framework for evaluating the electrical behavior of these power plants, ensuring they operate within the specified frequency and voltage range, provide or absorb reactive power as needed, employ effective control strategies, maintain grid connectivity during faults, and minimize power quality disturbances.	RES Grid integration	All	Operation					X		

64	IEC 62934:2021 - Grid integration of renewable energy generation - Terms and definitions	IEC SC 8A	https://websites.tore.iec.ch/publication/27340	2012	2023	Global	This standard provides a comprehensive set of terms and definitions, grid connection requirements, and grid interaction issues related to the grid integration of renewable energy generation.	RES Grid integration	NA	NA				(X)			
65	IEC TR 63410:2023 - Decentralized electrical energy systems roadmap	IEC SC 8B	https://websites.tore.iec.ch/publication/65975	2022	2023	Global	This technical report provides a road map for categorizing and understanding decentralized electrical energy systems (DEIS). It outlines DEIS characteristics and classification as well as the challenges and opportunities associated with their integration into the grid.	Standardization Roadmap	All	All		(X)	(X)	(X)	(X)	(X)	(X)
66	IEC TS 62898 Series - Microgrids	IEC SC 8B	https://websites.tore.iec.ch/publication/88234	NA	NA	Global	This technical report provides a set of use cases and Technical requirements related to the operations and management of microgrids, which are decentralized energy systems.	Microgrids	All	Field, Station, Operation					X		
67	IEC TS 63189 Series - Virtual Power Plants	IEC SC 8B	https://websites.tore.iec.ch/publication/61957	NA	NA	Global	It is a comprehensive technical specification that defines the architecture, functional requirements, and use cases for virtual power plants (VPPs).	Virtual power plant	All	All					X	(X)	
68	IEC SRD 63268:2020 - Energy and data interfaces of users connected to the smart grid with other smart grid stakeholders - Standardization landscape	IEC 5YC	https://websites.tore.iec.ch/publication/65148	2020	2023	Global	It is a Technical Specification on the standardization landscape for interfaces between grid users and grid stakeholders, which can be either physical or logical (i.e. power or communication).	Grid user interfaces, Standardization landscape	All	All		(X)	(X)	(X)	(X)	(X)	(X)

69	IEC 62056 Series - Electricity metering data exchange	IEC TC 13	https://webstore.iec.ch/publication/6397	NA	NA	Global	It is a standardized framework for electricity metering data exchange, encompassing communication protocols, data models, security mechanisms, and interoperability with other standards.	Smart metering	Distribution, DER, Customer Premise	All			X	X	X	X		
70	IEC 62439 Series - Industrial communication networks - High availability automation networks	IEC 65C	https://webstore.iec.ch/publication/24248	NA	NA	Global	It is a comprehensive set of international standards for high-availability automation networks, establishing a framework of redundancy protocols, classification schemes, and availability calculation methodologies to safeguard industrial control systems against network failures.	Process automation	All	All						X		
71	ISO/IEC 12139-1:2009 - Telecommunications and information exchange between systems - Powerline communication (PLC) - High speed PLC medium access control (MAC) and physical layer (PHY) - Part 1: General requirements	IEC TC 13	https://webstore.iec.ch/publication/9704	2009	2009	Global	It is a standard for high-speed powerline communication (PLC), defining the physical and medium access control (MAC) layer specifications for in-home and access networks.	Powerline communication	NA	NA						(X)		
72	ISO/IEC 14543 Series - Home electronic systems (HES) architecture	ISO/IEC JTC1/SC 25	https://webstore.iec.ch/publication/10111	NA	NA	Global	These are standards for home electronic system (HES) architecture, establishing a layered framework for communication, data formats, and management functions to facilitate seamless integration of different devices and enable effective control and management of home environments.	Home automation	Distribution, DER, Customer Premise	All					(X)	X		

73	ISO/IEC 14908 Series - Control network protocol	IEC TC 13	https://websites.tore.iec.ch/publication/10210	NA	NA	Global	These are standards for a communication protocol used in control networks. It defines how devices can exchange data over different types of physical connections, including twisted pair cables, power lines, and IP networks.	Communication Protocols	All	All			X		X		
74	ISO/IEC 27001:2022 - Information security, cybersecurity and privacy protection	ISO/IEC JTC 1/SC 27	https://websites.tore.iec.ch/publication/79694	2005	2022	Global	It is a standard for information security management systems (ISMS). It is a risk-based approach that helps organizations to identify, assess, and mitigate their information security risks. The standard is structured around a process approach that breaks down information security management into a series of processes, each with inputs, outputs, and controls.	Information security management system	All	All					(X)		
75	IEC TS 63531 ED1 - Specification for evaluation of renewable energy power forecasting results	IEC/TC 8/SC 8A- WG2	https://www.iec.ch/dyn/www/f?p=103:38:61208096:9525840:::FS:P_ORG_ID,FS_P_APEX_PAG_E,FSP_PROJECT_ID:10072,23,119156	2023	Ongoing	Global		Interoperability	All	All							
76	IEC TS 63487 ED1 - Joint commissioning for grid-connection of offshore wind farms via VSC-HVDC transmission	IEC/TC 8/SC 8A- WG6	https://www.iec.ch/dyn/www/f?p=103:38:61208096:9525840:::FS:P_ORG_ID,FS_P_APEX_PAG_E,FSP_PROJECT_ID:10072,23,113212	2022	Ongoing	Global		Interoperability	NA	NA							
77	IEC TR 63534 ED1 - Integrating distributed PV into LVDC systems and use cases	IEC/TC 8/SC 8A- WG7	https://www.iec.ch/dyn/www/f?p=103:38:61208096:9525840:::FS:P_ORG_ID,FS_P_APEX_PAG_E,FSP_PROJECT_ID:10072,23,103987	2020	Ongoing	Global		Interoperability	NA	NA							

78	IEC TS 62898-3-5 ED1 - Microgrids - Technical requiremen ts - Testing for Microgrid Monitoring, Control, and Energy Managemen t Systems	IEC/TC 8/SC 8B- WG3	https://www. iec.ch/dyn/w ww/f?p=103: 38:61208096 9525840:::FS P_ORG_ID,FS P_APEX_PAG E,FSP_PROJE CT_ID:20639, 23,116874	2023	Ongoing	Global		Interope rability	NA	NA							
79	IEC TS 63354 ED1 - Guideline for the Planning and Design of Decentraliz ed DC Distribution Systems	IEC/TC 8/SC 8B- WG5	https://www. iec.ch/dyn/w ww/f?p=103: 38:61208096 9525840:::FS P_ORG_ID,FS P_APEX_PAG E,FSP_PROJE CT_ID:20639, 23,103711	2019	Ongoing	Global		Interope rability	NA	NA							
80	IEC TS 63427 ED1 - Guideline for the adjustment potential evaluation of demand side resources	IEC/TC 8/SC 8C- WG3	https://www. iec.ch/dyn/w ww/f?p=103: 38:61208096 9525840:::FS P_ORG_ID,FS P_APEX_PAG E,FSP_PROJE CT_ID:20639, 23,106832	2021	Ongoing	Global		Interope rability	NA	NA							
81	IEC TR 63530 ED1 - Market Catalogue for Stable Grid Operation	IEC/TC 8/SC 8C- WG2	https://www. iec.ch/dyn/w ww/f?p=103: 38:60295395 8023699:::FS P_ORG_ID,FS P_APEX_PAG E,FSP_PROJE CT_ID:25987, 23,104882	2020	Ongoing	Global		Interope rability	NA	NA							

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The sources mentioned have been used and analyzed, but not quoted.

These sources are particularly valuable if the reader wants to find out more about standardization.

