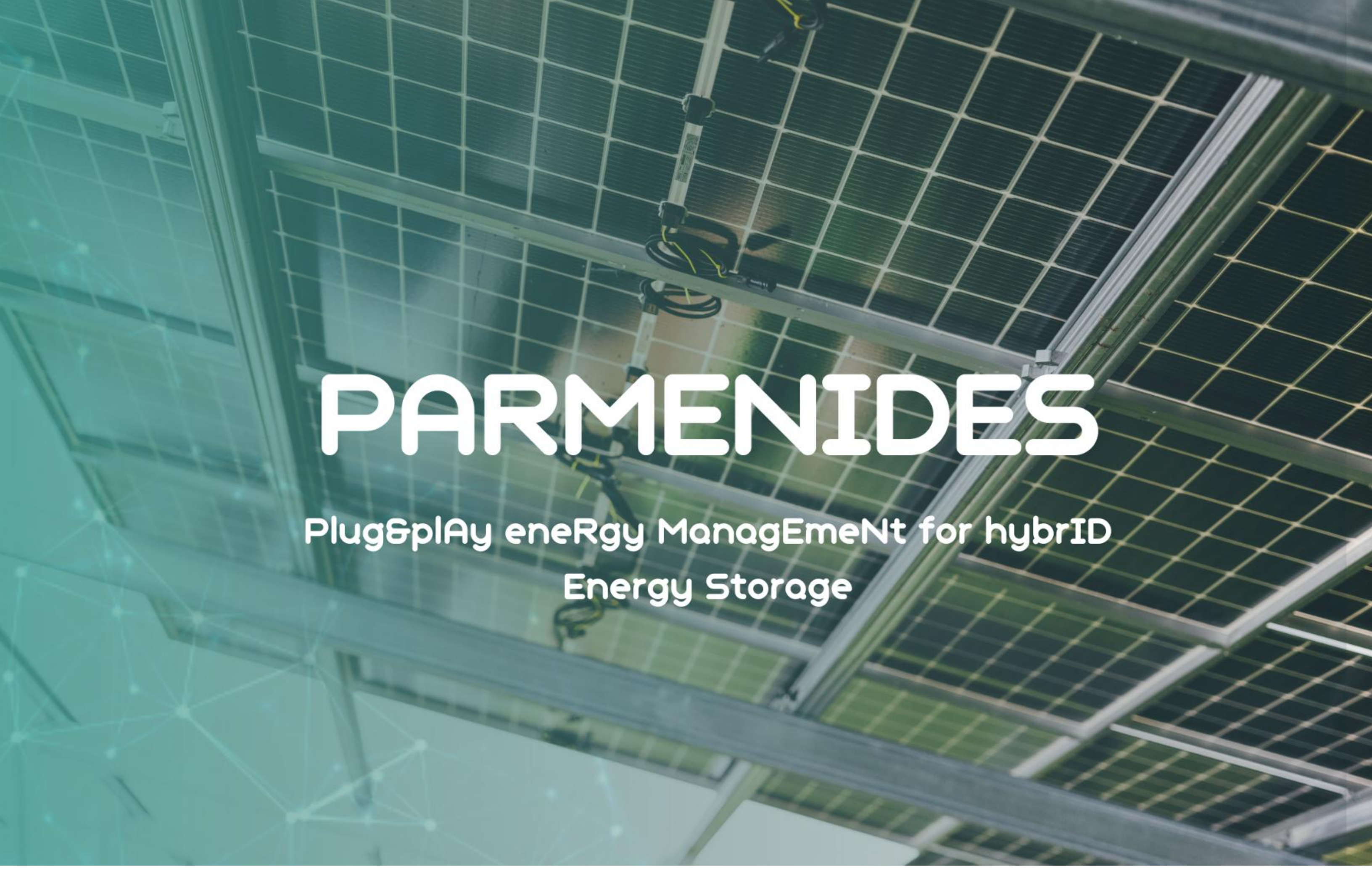

Deliverable D6.3

Standards and legislation for the market introduction of the PARMENIDES results

Work Package 6

Disclaimer

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Executive Summary

PARMENIDES project was conceived and designed to cover a fundamental problem in the energy sector, that is, the current fragmentation of existing *energy management systems* and *platforms*, *standards* and *protocols*. Among the project results, the following three were selected as KERs:

- KER#1: PARMENIDES Energy Management System EMS4HESS (developed by MAPS);
- KER#2: PARMENIDES flexibility and load management strategy (developed by KTH);
- KER#3: Grid Capacity Management Tool (developed by AIT).

This document aims to provide a comprehensive analysis of the regulatory, standardisation, and certification frameworks necessary for the successful market introduction of the PARMENIDES project's results.

Document structure:

- The document begins by examining the key regulations impacting the project, first addressing the energy sector and then focusing on data protection, cybersecurity, and AI governance frameworks.
- The second section details the standardisation landscape as well as relevant harmonised standards.
- The third section explores current certification approaches, detailing both voluntary and mandatory schemes, conformity assessment processes, and the role of notified bodies in ensuring market readiness.
- The final section highlights PARMENIDES' contributions to standardisation, including engagement with standardisation bodies and result-oriented contributions. This structured approach ensures a comprehensive understanding of pathways for compliance, market access, and industry impact.

Table 1: Overview of the Regulations covered by the PARMENIDES project

Category	Regulation/initiative
Energy	Clean Energy Package (EU) - 2019
	Renewable Energy Directive (RED II) - Directive (EU) 2018/2001
	Citizen Energy Communities (CEC) - Directive (EU) 2019/944
	Regulation (EU) 2019/943 on the internal market for electricity (recast)
	Regulation on demand response (based on Network code on demand response)
	Smart Readiness Indicator (SRI)
	JRC CoC energy smart appliance (ESA) and energy management system (EMS)
Data, Data privacy, cybersecurity, AI and trustworthiness	Cyber Resilience Act (CRA) - 2024
	Artificial Intelligence (AI) Act – 2024
	Ecodesign for Sustainable Products Regulation (ESPR) - 2024
	Data Act – 2024
	Data Governance Act – 2023
	Network and Information Security 2 (NIS 2) - 2022
	Digital Service Act (DSA) - 2023
	General Data Protection Regulation (GDPR) - 2018

Regulation influences standardisation, particularly in Europe, with the concept of *harmonised standards*, which are developed by a European Standardisation Organisation (CEN, CENELEC or ETSI), following a request from the European Commission concerning a union legislation. Manufacturers, other economic operators, or conformity assessment bodies use these harmonised standards to demonstrate that products, services or processes comply with this legislation.

Certification processes and their challenges around KERs play a key role in the PARMENIDES project and for the next steps of their market introduction. It ensures that both hardware and software components meet European regulatory requirements and international standards, covering performance, safety, interoperability, and cybersecurity. Given the PARMENIDES project's aim to develop advanced hybrid-storage and control systems, incorporating EMS certification in the deliverable demonstrates proactive alignment with regulatory and technical standards. This section especially focuses on EMS certification and grid connection/conformity requirements. Certified EMS ensures safety and reliability, but it also ensures that it is grid-compliant and market-ready.

The PARMENIDES contribution to the standardisation strategy was driven by partners with extensive experience in standardisation, actively contributing to and often leading initiatives in this area. PARMENIDES partners were already deeply involved in standardisation efforts before the project began and will remain engaged afterwards. In addition, targeted contributions to standardisation were made based on project outputs, specifically on the use cases, the architecture, and PARMENIDES Energy Community Ontology (PECO).

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Abbreviations

Acronym	Description
ACER	EU Agency for the Cooperation of Energy Regulators
AI	Artificial Intelligence
AIOTI	Alliance for AI, IoT and Edge Continuum Innovation
AIT	Austrian Institute of Technology - Partner of the project
BACS	Building Automation and Control Systems
BDVA	Big Data Value Association
CASCO	Committee on Conformity Assessment
CEC	Citizen Energy Communities (CEC) - Directive (EU) 2019/944
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CEP	Clean Energy Package
CIM	Common Information Model
CINEA	European Climate, Infrastructure and Environment Executive Agency
CNIL	French national commission on informatics and freedom
CRA	Cyber Resilience Act
DCAT	Data Catalogue vocabulary
DER	Distributed Energy Resources
DG ENER	Directorate-General for Energy
DGA	Data Governance Act
DPA	Data Protection Authority
DPIA	Data Privacy Impact Assessment
DPO	Data Protection Officer
DPP	Digital Product Passport
DSA	Digital Service Act
DSO	Distribution System Operator
EAAV	*Energiewirtschaftliche Anschluss- und Anschlussverordnungen* (German Energy Connection and Grid Codes)
EC	Energy Community
EES	Electrical Energy Storage Systems
eIDAS	electronic Identification, Authentication and Trust Services
EMS	Energy Management System
EMS4HESS	Energy Management System for Hybrid Energy Storage System
EN	European Standard
ENISA	European Union Agency for Cybersecurity
ENS	Energienetze Steiermark - Partner of the project
EPBD	Energy Performance of Buildings Directive
ESO	European Standards Organisations

Acronym	Description
ESPR	Ecodesign for Sustainable Products Regulation
ETSI	European Telecommunications Standards Institute
EU	European Union
EUCC	EU Common Criteria
EUCS	EU Cybersecurity Certification Scheme for Cloud Services
EXP	Experientia - Partner of the project
GDPR	General Data Protection Regulation
GHG	Green House Gas
HESS	Hybrid Energy Storage System
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGD	Implementation Guidance Document
IoT	Internet Of Things
ISMS	Information Security Management System
ISO	International Organization for Standardization
JRC CoC ESA	Joint Research Centre Code of Conduct Energy Smart Appliance
JTC	Joint Technical Committee
KER	Key Exploitable Result
KTH	Swedish: "Kungliga Tekniska högskolan"; English: "KTH Royal Institute of Technology" - Partner of the project
MAPS	MAPS Group - Partner of the project
NC DR	Network Code on Demand Response
NELEV	*Niederspannungsanschlussverordnung* English: (German Low-Voltage Connection Ordinance)
NIS	Network and Information Security
NISG	Netz- und Informationssystemsicherheitsgesetz; English: (Network and Information Systems Security Act (Austria))
NIST	National Institute of Standards and Technology
OSD	Online Standards Developments
PARMENIDES	Plug&plAy eneRgy ManagEmeNt for hybrID Energy Storage
PECO	PARMENIDES Energy Community Ontology
PIA	Privacy Impact Assessment
PII	Personal Identifiable Information
RA	Reference Architecture
REC	Renewable Energy Community
RED II	Renewable Energy Directive (RED II) - Directive (EU) 2018/2001
SAREF	Smart Applications REFerence ontology
SGAM	Smart Grid Architecture Model

Acronym	Description
SG-CG	Smart Grid Coordination Group
SHBIRA	Smart Home/Building IoT Reference Architecture
SME	Small and Medium Enterprise
SRI	Smart Readiness Indicator
SyC	System Committee
TAR	German: Technische Anschlussregeln; English: Technical Connection Rules
TC	Technical Committee
TOR	German: Technische und Organisatorische Regeln für Betreiber und Benutzer von Netzen; English: Technical and Organisational Rules ....
TSO	Transmission network operator
Vlab	AIT Virtual Verification Laboratory - Partner of the project
W3C	World Wide Web Consortium

1 Introduction

1.1 PARMENIDES project introduction and summary

The ongoing transition of the energy system is accompanied by digitalisation activities, enabling new applications. This results in a fragmentation of existing platforms, protocols, and standards. Therefore, interoperability among various platforms as well as cross-domain interoperability must be ensured.

The usage of ontologies provides an opportunity to address cross-platform and cross-domain interoperability. PARMENIDES aims to develop a new ontology by extending existing ontologies to provide a knowledge base, with a focus on the electricity and heating domain for buildings, customers, and energy communities. It will support different use cases, focusing on the utilisation of Hybrid Energy Storage Systems (HESS). Besides the representation of storage technologies, information about energy community customers, their behaviours, and components, including their relations, will be part of the ontology, providing a standardised vocabulary of the domain of energy communities. This further includes technical, economic, regulatory, behavioural, and social constraints to be considered in operation.

To support use cases, a new generation of innovative Energy Management Systems (EMS) will be developed. These systems will be capable of using ontologies as a knowledge base. This will enable a very generic software design and ensure the scalability and replicability of the solution.

As a framework for the integration of the EMS, PARMENIDES have defined an information and communication architecture, enabling an interoperable, reliable, and secure exchange of data and instructions. The developed EMS was demonstrated in diverse pilots in Austria and Sweden. The Austrian pilot addressed two project energy communities with different storage technologies; the Swedish pilot will focus on flexibility from a very short time scale through innovative heat pump control to electrical and thermal batteries and seasonal storage through geothermal borehole heat exchangers.

1.2 Reminder of the PARMENIDES Key Exploitable Results (KER)

PARMENIDES project was conceived and designed to cover a fundamental problem in the energy sector, that is, the current fragmentation of existing *energy management systems* and *platforms*, *standards* and *protocols*. Among the project results, the following three were selected as KERs:

- KER#1: PARMENIDES Energy Management System EMS4HESS (developed by MAPS);
- KER#2: PARMENIDES flexibility and load management strategy (developed by KTH);
- KER#3: Grid Capacity Management Tool (developed by AIT).

Table 2: PARMENIDES Key Exploitable Results [1]

Result / Key Exploitable Result	Description
KER#1: **PARMENIDES Energy Management System EMS4HESS** (developed by MAPS)	**KER#1** is a technological solution based on the new generation of ontology-driven Energy Management Systems, which can handle different storage technologies, like batteries, hydrogen, electric vehicles, heat pumps, and capacity buildings, harmonising time resolution and aggregation levels. The KER owner and developer is MAPS.
KER#2: PARMENIDES flexibility and load management strategy (developed by KTH)	**KER#2** represents an innovative multi-objective software which operates as an optimiser for trade-offs between grid operators and the energy communities. The KER owner is the Royal Institute of Technology (KTH).
KER#3: Grid Capacity Management tool (developed by AIT)	**KER#3** is a Machine-learning based solution which is developed, on one hand, to be able to handle the grid management via a limited number of grid measurements and, on the other hand, to estimate the minimum and maximum power limits for the connected devices within a low-voltage grid, avoiding grid violations, *i.e.*, voltage, overloading, etc.

1.3 Document objectives and structure

This document aims to provide a comprehensive analysis of the regulatory, standardisation, and certification frameworks necessary for the successful market introduction of the PARMENIDES project's results. The document begins by examining the key regulations impacting the project, first addressing the energy sector (including the Clean Energy Package, Renewable Energy Directive, and related legislation) and then focusing on data protection, cybersecurity, and AI governance frameworks (including GDPR, NIS2, and the AI Act). The second section details the standardisation landscape as well as relevant harmonised standards. The third section explores current certification approaches, detailing both voluntary and mandatory schemes, conformity assessment processes, and the role of notified bodies in ensuring market readiness. The final section highlights PARMENIDES' contributions to standardisation, including engagement with standardisation bodies and result-oriented contributions. This structured approach ensures a comprehensive understanding of the pathways for compliance, market access, and industry impact.

2 Relevant regulations for the market introduction of PARMENIDES results

2.1 Introduction

This chapter aims to define the PARMENIDES results regulation framework to support the EU market introduction, with a specific focus on energy storage systems and EMS.

The regulations detailed in this chapter have been divided into two main categories: “Energy”, and “Data, Data privacy, cybersecurity, AI and trustworthiness”.

Table 3: Overview of the Regulations covered by the section

Category	Regulation/initiative
Energy	Clean Energy Package (EU) – 2019 [2]
	Renewable Energy Directive (RED II) - Directive (EU) 2018/2001 [3]
	Citizen Energy Communities (CEC) - Directive (EU) 2019/944 [4]
	Regulation (EU) 2019/943 on the internal market for electricity (recast) [5]
	Regulation on demand response (based on Network code on demand response) [6]
	Smart readiness Indicator (SRI) [7]
	JRC CoC energy smart appliance (ESA) and energy management system (EMS) [8]
Data, Data privacy, cybersecurity, AI and trustworthiness	Cyber Resilience Act (CRA) – 2024 [9]
	Artificial Intelligence (AI) Act – 2024 [10]
	Ecodesign for Sustainable Products Regulation (ESPR) - 2024
	Data Act – 2024 [11]
	Data Governance Act – 2023 [12]
	Network and Information Security 2 (NIS 2) - 2022 [13]
	Digital Service Act (DSA) - 2023
	General Data Protection Regulation (GDPR) – 2018 [14]

2.2 Energy regulation framework

2.2.1 Clean Energy Package (EU) 2019

Traditional energy systems operate with large, centralised power plants distributing electricity throughout one-way networks to passive consumers. However, climate goals and technological advances are transforming this model towards the decentralised paradigm, shifting to a participatory framework energy system where communities actively produce, share, and manage renewable energy.

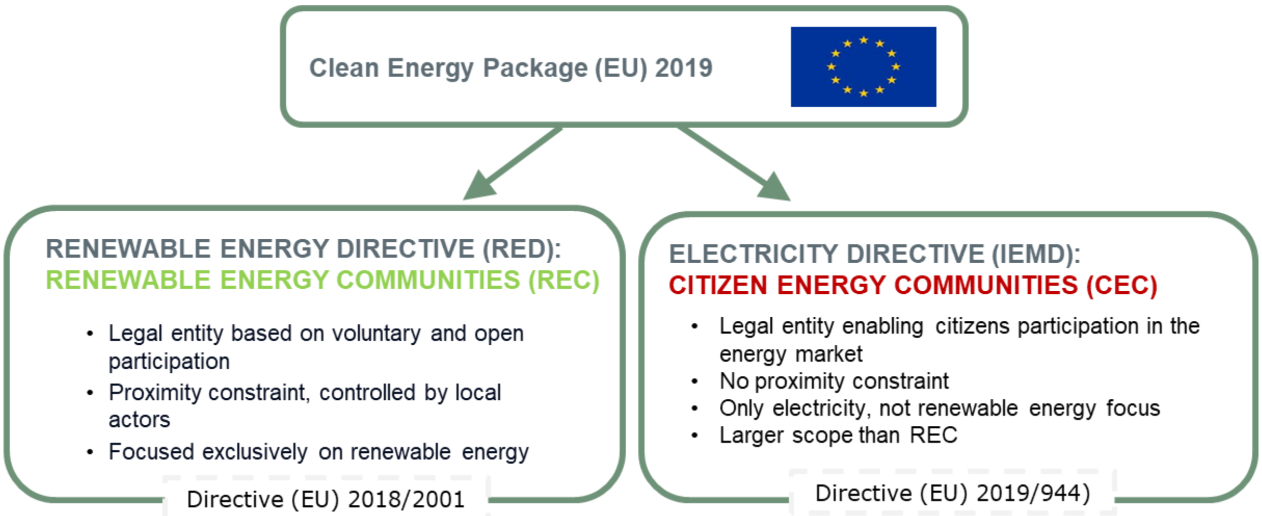

Figure 1: Clean Energy Package (EU) 2019 [2]

The Clean Energy Package (CEP)[2]represents the European Union comprehensive legislative response to this transformation, defining the legal framework that is necessary to citizens and communities to become active participants in the energy transition. This "package" does not simply regulate energy markets, but instead it fundamentally reimagines how the European society can collectively achieve carbon neutrality while ensuring energy security and democratic participation. It comprises eight legislative acts adopted between 2018 and 2019. Two directives are particularly relevant for the energy communities: Directive (EU) 2018/2001[1] and Directive (EU) 2019/944[2], see Figure 1. The directives work together to create complementary but distinct frameworks for energy community participation. Understanding why the EU created two separate types of energy communities requires recognising different community needs and energy sector complexities. Some communities primarily want to share locally produced renewable energy among neighbours, while others seek broader market participation, including storage services, demand response, and grid flexibility. The legislation accommodates both approaches throughout carefully crafted definitions and rights.

The Renewable Energy Communities (RECs), established under Article 22 of the RED II, is specifically focusing on renewable energy development within the defined geographic areas. The "proximity" concept is a requirement that refers to the fact that community members must be located near the renewable energy projects they collectively own and develop. This geographic limitation ensures communities maintain genuine local connections and shared interests in their energy infrastructure. RECs can include natural persons, including vulnerable and low-income households, small and medium enterprises (SMEs), and local authorities like municipalities. The legislation specifically mentions that vulnerable households should ensure that energy transition benefits reach all community members, not just those with economic resources to invest in the renewable technology domain. The activities of RECs can span the entire renewable energy value chain: generation, consumption, storage, distribution, and energy-related services. Very important to highlight that RECs operate across both the electricity and heating sectors, enabling

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[1] http://data.europa.eu/eli/dir/2018/2001/oj
[2] http://data.europa.eu/eli/dir/2019/944/oj

comprehensive local energy solutions. For instance, a rural community might develop solar panels for electricity generation while, at the same time, implementing biomass heating systems, managing both via their REC structure.

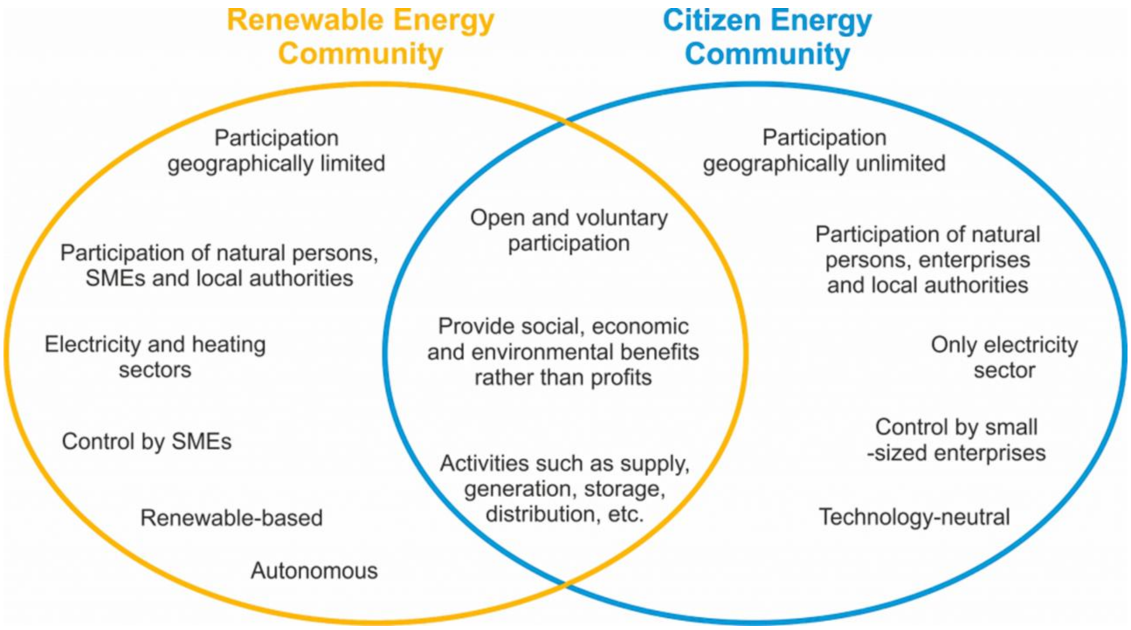

Figure 2: Overview of REC and CEC scopes [15]

On the other hand, the Citizen Energy Communities (CECs), defined in Article 16 of the Internal Electricity Market Directive (EU) 2019/944, operate without geographic restrictions and focus specifically on electricity markets. This broader scope enables CECs to aggregate distributed resources across wider areas and to participate in the wholesale electricity markets, balancing services, and grid flexibility mechanisms. The CECs maintain technology neutrality; in other words, they can utilise electricity generation technologies, but not exclusively renewable ones. This enhanced flexibility provides communities the possibility to optimise their energy portfolios based on local resources, grid constraints, and economic opportunities. A CEC might, for instance, combine solar generation, battery storage, demand response capabilities, and even participate in electric vehicle charging networks. The key restriction for CECs concerns large commercial actors: in fact, while any entity can participate as members, those engaged in large-scale commercial energy activity cannot exercise decision-making power, ensuring that CECs remain under the control of the community, rather than becoming vehicles for commercial energy companies to access community energy programs.

Both REC and CEC frameworks provide strong support to environmental, economic, and social community benefits over the financial profit generation. This principle distinguishes the energy communities from the traditional energy businesses and ensures that the community energy serves the public needs instead of supporting the commercial interests. Member States must establish the enabling frameworks to support the equal treatment for energy communities in dedicated markets, including:

- Removing unjustified regulatory barriers
- Ensuring non-discriminatory network access
- Providing the necessary institutional support for community development

The EU Commission reports that one of the critical factors affecting energy communities is, in fact, the lack of technical expertise and regulatory knowledge that is required for energy market participation, necessitating a tangible improvement in public support for capacity building and development assistance.

The PARMENIDES project is an example of innovation that is strongly supported by the Clean Energy Package directives, displaying how policy and technology development can complement each other to enable practical energy community solutions, potential implementations and management. The CEP defines the rights and obligations enabling energy communities to operate within Europe, but legislation alone cannot address the technical challenges that RECs and CECs might face when implementing practical actions and sophisticated energy management systems across different technology platforms and domains (PV, heating/cooling, geothermal, etc.). In these terms, PARMENIDES comes in hand and covers these issues, providing different technical solutions which, once extensively tested and implemented, which unlock the full potential of RECs and CECs, aligned with EU legislation. The energy communities can be thought as evolving organisms which have to dynamically adapt to increasingly complex environments, legislations, and competing technology solutions. In fact, the most advanced communities achieving a full integration with energy systems operate like complex organisms in ecological networks, providing essential services to the broader energy ecosystem while maintaining their community identity and democratic governance. The CEP legal framework provides the “genetic code” enabling this evolution, while projects like PARMENIDES develop the technical “organs” the communities need to function in a complex energy ecosystem.

2.2.2 Renewable Energy Directive (RED II) - Directive (EU) 2018/2001

The Renewable Energy Directive (RED II) - Directive (EU) 2018/2001[3], significantly amended by the RED III in 2023[4], the comprehensive legal and technical framework governing renewable energy deployment across the European Union. RED II mandates at least 42.5% renewable energy by 2030 (increases from 24.5% in 2023), creating substantial market opportunities for energy management technologies while imposing strict compliance requirements on energy communities, storage systems, and interoperability solutions. In this section, the RED II regulatory framework is analysed, referring to the most important supporting standards for the energy sector, particularly in the case of energy storage and energy management systems, in line with the goals of the PARMENIDES project.

Directive (EU) 2023/2413 (RED III) was adopted in October 2023, with the objective of strengthening the EU commitment to renewable energy. It amends Directive (EU) 2018/2001 (RED II), Regulation (EU) 2018/1999 and Directive 98/70/EC.

Regulation content and scope: The RED II establishes a binding Union target of 42.5% renewable energy in gross final consumption by 2030, with ideal goals of 45%, verbatim *Article 3* “*Members States shall collectively endeavour to increase the share of energy from renewable sources in the Union’s gross final consumption of energy in 2030 to 45%*”. The directive creates sector-specific obligations: 29% renewable energy in transport (or 14.5% in GHG reduction) - *Article 25*, 1.1% annual increase in heating/cooling - *Article 23*, 42% renewable hydrogen for industry by 2030 – *Article 22a*, and an indicative 49% target for buildings

[3] https://eur-lex.europa.eu/eli/dir/2018/2001/oj/eng

[4] https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

– *Article 15a*. The directive fundamentally transforms energy market participation through its renewable energy communities (RECs) framework. Article 22 legally defined RECs as entities based on “open and voluntary participation” that are “effectively controlled by shareholders or members located in proximity of renewable energy projects.” The primary purpose must be environmental, economic or social community benefits rather than financial profits[5]. This creates new market categories beyond traditional utility-scale development.

RED II scope encompasses all renewable energy sources: wind, solar, aerothermal, geothermal, hydrothermal, ocean energy, hydropower, biomass, and biogas[6]. The directive regulates all economic sectors, including electricity, heating/cooling, transport, industry, and buildings, affecting all market participants at all levels, from the individual self-consumers to large utilities and aggregators [3]. Critical legal definitions establish market boundaries. The renewable self-consumers are final customers who operate renewable generation for their own consumptions who may store or sell excess electricity; Energy Communities (EC) instead, must be constituted as legal entities under the national law with enabling frameworks including DSO cooperation for energy transfers and equal access to support schemes[7].

The cross-border cooperation mechanisms include statistical transfers, *i.e.*, virtual renewable energy trading between Member States, joint projects for shared renewable development, and joint support schemes enabling coordinated national policies[8]. These mechanisms provide cost-effective pathways for target achievement while maintaining strict accounting procedures[9].

Considering the administrative procedures and the grid access management, Article 16 establishes a maximum permitting timeframes of two years for onshore wind and solar installations of declared power > 1MW, one year in case of power < 1MW [1]. Renewable acceleration areas enable shortened procedures of six months for installations > 1MW in designated zones. The member states must establish single contact points and implement digital procedures [3]. Grid connection provisions require simple notification procedures for small installations, non-discriminatory access to electricity grids, and priority dispatch for renewable energy where technically feasible [5]. *Article 17* mandates DSO cooperation for energy transfers within communities without double charging [3].

Related harmonised standard: The European Standards frameworks can be though as a set of rules defining the operative boundaries of operability to comply with the obligations set by the EU Commission to reach pre-defined goals and objectives in the short-medium or long terms. In this respect, the CEN/CENELEC developed a comprehensive standard supporting RED II implementation across renewable

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[5] EU-Lex: Power Purchase Agreements

[6] https://eur-lex.europa.eu/eli/dir/2018/2001/2024-07-16/eng

[7] https://www.catf.us/resource/clean-energy-ground-up-energy-communities-european-union/

[8] Cooperation Mechanisms - https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/cooperation-mechanisms_en

[9] Anbumozhi, Venkatachalam, Bhupendra Kumar Singh, and Citra Endah Nur Setyawati. "Cross-Border Energy Cooperation and Trade: Impacts, Challenges and Policy Implications." In *Cross-Border Integration of Renewable Energy Systems*, pp. 1-26. Routledge India, 2023.

technologies[10]. CLC/TC 88 creates wind energy standards addressing site suitability and engineering integrity, while EN IEC 60400 series covers wind generation systems including floating offshore requirements. CLC/TC 82[11] develops photovoltaic standards from light conversion to grid interfaces, EN 61730 series establishing fundamental PV module safety requirements. Concerning the Energy Management Systems (EMS) and the Interoperability Standards, the ISO 50001:2018 provides the foundational framework for the EMS, requiring that the demonstrated energy performance improvement via a Plan-Do-Check-Act methodology[12]. The ISO 50002 governs energy audits, while the ISO 50006 addresses energy performance measurements using baselines and indicators[13]. Moving forward, the Smart Grid Interoperability centres on the IEC 61850 series for communication networks and power utility automation. In this context, the IEC 61850-7-420[14] specifically addresses distributed energy resources and distribution automation logical nodes. IEC 61970 and IEC 61968 provide Common Information Model (CIM) frameworks for transmission and distribution systems, respectively.

Instead, when referring to the cybersecurity standards, extremely important for establishing a robust operative framework highly reliable and aligned with EU expectations, the IEC 62351 series of standards for power systems communication security must be considered and implemented, where, specifically, the IEC 62351-12 standard provides specific resilience recommendations for the distributed energy resources. Another series of standards, the IEEE 1547, must be also considered since it governs the interconnection and interoperability of distributed energy resources[15].

Finally, when considering the *electrical energy storage systems* (EES) standards, it is important to mention the IEC 62933 standard series which define specific requirements for EES, covering several aspects that are safety, performance, planning, and installation regulations from grid-scale to distributed applications[16]. For instance, the IEC 61427-1 defines the general requirements and test methods for secondary cells and batteries used in renewable energy storage applications, while the IEC 61427-2 addresses the on-grid applications with the requirements for cycling performance and calendar life testing. The EN 50272 series mandates the safety requirements for secondary batteries and battery installations; the second part is covering stationary batteries and the third part of the series is covering the traction batteries. Finally, important to mention is the IEC 62619 which refers to the standards and regulations about safety for lithium-ion secondary cells and batteries used in industrial applications, including EES. These standards become particularly important under the RED II Article 20a provisions requiring battery management information sharing and smart charging capabilities, as they establish the technical foundation for interoperable energy storage integration within renewable energy communities and hybrid storage systems.

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[10] https://www.cencenelec.eu/areas-of-work/cen-sectors/energy-and-utilities-cen/renewable-energies/

[11] https://standards.cencenelec.eu/dyn/www/f?p=305:7:0:25:::FSP_ORG_ID,FSP_LANG_ID:1258463

[12] https://www.iso.org/standard/69426.html
[13] https://www.nqa.com/en-ca/certification/sectors/energy
[14] https://webstore.iec.ch/en/publication/34384
[15]https://smartgrid.ieee.org/bulletins/june-2016/interoperability-common-language-for-smart-grid-communication
[16] NREL – 2024 - https://www.nrel.gov/grid/standards-codes

Relevance for PARMENIDES results market introduction: RED II Article 22 entitled "*Renewable energy communities*[17]" provides a structured market potential for PARMENIDES technologies by mandating the Member State to enable the frameworks for renewable energy communities (REC). The RECs require complex energy management systems to coordinate the distributed generation of the energy produced by multiple sources, its concurrent storage, and the subsequent use and consumption across community members, while "coordinating" with DSO/TSOs entities. Over 140 EC across EU are currently seeking technical solutions for business plan developments[18].

The core solution developed within the PARMENIDES project, called PARMENIDES Energy Community Ontology (PECO), directly addresses the regulatory requirements for standardised vocabulary and interoperability among different community assets[19]. As mentioned in Article 22c, one of the requirements is that, *verbatim*, "*the relevant distribution system operator cooperates with renewable energy communities to facilitate energy transfers within the renewable energy communities*"[20], thus fostering the demand for the project's ICT architecture enabling secure data exchange between distributed energy systems. The directive about real-time information sharing requirements for renewable energy share and GHG emissions align with the PARMENIDES interoperability solution proposed. The *Article 20a*[21] mandates that battery management information systems sharing and smart recharging capabilities directly supporting commercialisation of hybrid energy storage systems (HESS) with integrated management capabilities. Finally, the SAREF[22] compliance represent one of the critical aspects to consider, from a technical point of view, to implement and aligned with when developing solutions, this being particularly relevant for PARMENIDES project. In fact, the solutions proposed must align with ETSI SAREF standards for the IoT interoperability, specifically the SAREF4ENER[23] extension for energy domain applications. EU guidance strongly supports the SAREF integration for demand-side flexibility, requiring PECO ontology extension of SAREF framework.

The implementation complexity is mainly due to the varying RED II (and its most recent form) transposition across member states. The analysis of nine countries[24] reveals considerable implementation variation, with even pioneer countries like Germany and the Netherlands experiencing slow transposition. The potential of PARMENIDES flexible architecture, and the solutions developed therein, enables adaptation to national implementations, maximising their potential adoption. The standardisation gap in energy communities' technologies creates both challenges and opportunities. The missing parameters for battery data sharing (addressed through EU ad hoc dialogue) position PARMENIDES for active contribution to standardisation via ontology development and the ETSI SAREF participation. In conclusion, the RED II regulation

[17] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001
[18] https://www.rescoop.eu/eu-projects
[19] https://publications.ait.ac.at/en/activities/parmenides-energy-community-ontology
[20] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001
[21] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L_202302413
[22] https://standict.eu/discussion-groups/interoperability/318/saref-compliant-knowledge-discovery-semantic-energy-and-grid
[23] https://saref.etsi.org/saref4ener/v2.1.1/
[24] Krug, Michael, Maria Rosaria Di Nucci, Lucas Schwarz, Irene Alonso, Isabel Azevedo, Massimo Bastiani, Anna Dyląg et al. "Implementing European Union provisions and enabling frameworks for renewable energy communities in nine countries: Progress, delays, and gaps." *Sustainability* 15, no. 11 (2023): 8861.

fosters the creation of a comprehensive regulatory framework driving substantial market opportunities for PARMENIDES project technologies, through energy communities' mandates, interoperability requirements, and energy storage integration obligations. The directive's enhanced targets and streamlined procedures provide stronger policy support for renewable energy investments while requiring complex technical solutions for compliance. The major hindering factor which might affect the adoption of PARMENIDES solution is the fragmentations of the RED II adoption across the EU countries, considerably slowing down the progress towards EU's goals.

2.2.3 Citizen Energy Communities (CEC) - Directive (EU) 2019/944)

Regulation content and scope: Directive (EU) 2019/944[25] deals with the common rules for the generation, transmission, distribution, storage and supply of electricity within the European Union. The overall goal aims to create a competitive, consumer-centred, flexible and transparent electricity market. Besides these, the integration of renewables should be promoted and the decarbonisation of the energy systems supported. In PARMENIDES, the optimised usage of flexibilities (storages etc.) plays an important role. In that case relevant articles in this directive are:

Article 32: Incentives for the use of flexibility in distribution networks

- Member States shall provide a regulatory framework for incentives to procure flexibility services, including congestion management, to improve the efficiency of the operation and development of the distribution network.
- Services are to be procured by the DSO from providers of distributed generation, demand response, or energy storage through a transparent, non-discriminatory, and market-based process.
- Promote energy efficiency when these services cost-effectively reduce the need for retrofitting or capacity replacement and support the efficient and safe operation of the distribution grid.
- Definition of specifications for flexibility services by the regulatory authority or the DSO (approval by the regulatory authority) should be done through a transparent and participatory process involving all relevant network users and TSOs, to ensure effective and non-discriminatory participation of all market participants.

Article 36: Ownership of energy storage facilities by distribution system operators

- Distribution system operators shall not own, develop, manage or operate energy storage facilities. Exception according to paragraph 2:
    - Approval by the regulatory authority if a fully integrated grid component or if the following conditions are met, *verbatim:*
        - *(a) other parties, following an open, transparent and non-discriminatory tendering procedure that is subject to review and approval by the regulatory authority, have not been awarded a right to own, develop, manage or operate such facilities, or could not deliver those services at a reasonable cost and in a timely manner;*

[25] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944

- *(b) such facilities are necessary for the distribution system operators to fulfil their obligations under this Directive for the efficient, reliable and secure operation of the distribution system and the facilities are not used to buy or sell electricity in the electricity markets*;
- *(c) the regulatory authority has assessed the necessity of such a derogation and has carried out an assessment of the tendering procedure, including the conditions of the tendering procedure, and has granted its approva*l.

- Storage system for ensuring an efficient, reliable, and secure grid operation. Storage system is not used to buy or sell electricity on electricity markets.
- Regulatory authority assesses if an exception is necessary, evaluates the bidding process including conditions and grants approval. The regulatory authority may develop guidelines/tender clauses.

The national transposition of the European Directive into Austria national law is currently pending. The next section provides an overview of the actual status.

Besides the above listed EU Directive and the concerned transposition into national law the ACER Recommendation DR NC – Annex 1 – Amended Demand Response Network Code must be considered (see section 3.2.6).

Relevance for PARMENIDES results market introduction: All the PARMENIDES systems with the aim to be used on the EU market will have to be compliant to the European harmonised standards. For the two pilots in Austria besides European harmonised standards, Austrian laws, etc. must be considered. Additionally, bilateral agreements were concluded.

2.2.4 REC and CEC - National transposition

Austria: Transposition done
Implements both RECs and CECs with clear legislative support, grid tariff reductions for RECs, proximity criterion of RECs by voltage levels, static or dynamic allocation of electricity, no P2P in the classical sense yet.

Sweden: Transposition has not yet formally transposed them
Only collective self-consumption allowed, no full REC or CEC implementation yet; first pilot areas exist for energy communities in a broader sense.

Italy: Transposition done
Both RECs and CECs implemented, subsidies for energy self-consumption within the EC, maximum generation capacity within REC of 1 MW, proximity criterion of RECs by voltage levels.

Germany: Transposition partially done
Citizen Energy Company in the EEG Act was changed to fit the REC definition (CECs not transposed yet), must be at least 50 natural persons and at least 75% of voting rights must be held by these, is new with voting rights restrictions, no energy sharing possible yet, electricity grid operation possible.

France: Transposition done

Both RECs and CECs implemented and allowed proximity criterion of RECs by location (department or neighbouring department), for associations at least 20 natural persons as members, energy sharing via contracts between EC and DSO, CECs financially responsible for imbalance costs.

Switzerland: Outside EU obligations but has local energy-sharing models
No EU obligations, ZEV model allows energy sharing across properties without using the public grid, but financial barriers exist for cross-property connections due to the need to establish direct lines, reduced tariffs for shared electricity, no grid operator involvement.

(Last update of the information above – December 2025)

2.2.5 Commission Recommendation on Energy Storage (C/2023/1729)

Content and scope: Recognising the pivotal role of energy storage in balancing supply and demand, integrating renewable energy sources, and enhancing grid stability, the European Commission issued recommendations (EU) C/2023/1729 on energy storage in 2023 [16]. The recommendations provide a strategic framework to accelerate the deployment of energy storage technologies across the EU, addressing both technical and regulatory barriers.

The main ideas of the recommendations for the member states are:

1. To consider the double role (generator-consumer) of energy storage when defining applicable regulatory framework and procedures.
2. To identify the flexibility needs of their energy systems in the short, medium and long term.
3. To ensure that energy system operators further assess the flexibility needs of their energy systems when planning transmission and distribution networks, including the potential of energy storage and whether energy storage can be a more cost-effective alternative to grid investments.
4. To identify potential financing gaps for energy storage, including behind-the-meter and other flexibility instruments, and if a need for additional flexible resources to achieve security of supply and environmental objectives is identified
5. To explore whether energy storage services are sufficiently remunerated, and whether operators can add up the remuneration of several services.
6. To consider competitive bidding processes to reach a sufficient level of flexibility source deployment.
7. To identify any specific actions, regulatory and non-regulatory, necessary to remove barriers to the deployment of demand response and behind-the-meter storage.
8. To accelerate the deployment of storage facilities and other flexibility tools in areas with insufficient grid capacity, unstable or long-distance connections to the main grid.
9. To publish more real-time and detailed data to facilitate investment decisions on energy storage facilities (e.g., network congestion, market prices, installed energy storage facilities).
10. To continue supporting research and innovation in energy storage, as well as guiding these technologies and product to the commercialisation stage.

Relevance for PARMENIDES results market introduction: The Commission's recommendations on energy storage helps by pushing for clearer rules and better support for energy storage, making it easier for

PARMENIDES to test and roll out its solutions in real-world energy markets. This means the project's innovations can have a bigger impact on Europe's energy transition.

2.2.6 Regulation (EU) 2019/943 on the internal market for electricity (recast)

Regulation content and scope: EU Regulation (EU) 2019/943[26] on the internal market for electricity (recast), adopted on 5 June 2019 and entering into force on 1 January 2020, establishes a comprehensive regulatory framework for the internal EU electricity market designed to achieve Energy Union and climate neutrality goals by 2050. The regulation's primary objectives centre on promoting efficiency, renewable energy integration, and decarbonization of the electricity sector while establishing principles for integrated electricity markets that provide non-discriminatory access to all resource providers and customers. The regulation comprises six main chapters:

- general provisions - Articles 1-3
- electricity trading - Articles 4-12
- capacity allocation and network access - Articles 13-19
- resource adequacy including capacity mechanisms - Articles 20-27
- transmission system operation - Articles 28-62
- final provisions - Articles 63-68

Key provisions demonstrate the regulation's comprehensive approach to market integration and renewable energy transition. Article 3 establishes core market principles including free price formation, non-discrimination, and market integration, while Articles 12-13 create market-based mechanisms for balancing services and re-dispatching that are open to all generation technologies, energy storage, and demand response. Article 20 introduces stringent capacity mechanism requirements with CO2 emission limits of 550g CO2/kWh for new plants and 350kg CO2/year/kW for existing plants, ensuring alignment with decarbonisation objectives. The regulation's scope extends across all EU Member States and EEA countries, covering wholesale electricity markets, transmission system operation, cross-border electricity trading, electricity balancing markets, and capacity mechanisms. The regulation specifically targets TSOs, DSOs, market operators, electricity producers, suppliers, and importantly, energy communities and aggregators as key market participants. Significant changes from the predecessor Regulation (EC) No 714/2009 include enhanced market integration mechanisms, modified priority dispatch rules for renewable energy (phased elimination for facilities > 200 kW from 1 January 2026), and a comprehensive framework for capacity mechanisms with mandatory cross-border participation. The regulation introduces Regional Coordination Centres as new institutional frameworks for enhanced regional cooperation, while establishing marginal pricing for balancing energy markets and improved access for demand response and storage technologies. Implementation follows a structured timeline with key deadlines including enhanced balancing market rules by 2025, modified priority dispatch rules by 2026, and maximum 6-month contract periods for balancing capacity by 2028. The regulation was recently amended by Regulation (EU) 2024/1747 of 13 June 2024, which further improved electricity market design and crisis management mechanisms.

[26] https://eur-lex.europa.eu/eli/reg/2019/943/oj/eng

Related harmonised standard: The harmonised standards framework supporting EU Regulation 2019/943 consists of legally binding network codes implemented as EU regulations and technical standards developed by European Standards Organisations (ESOs). The core regulatory framework includes five essential network codes: Commission Regulation (EU) 2016/631 establishing network code on requirements for grid connection of generators (OJ L 112, 27.4.2016), Commission Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management (OJ L 197, 25.7.2015), Commission Regulation (EU) 2017/1485 establishing a guideline on electricity transmission system operation (OJ L 220, 25.8.2017), Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (OJ L 312, 28.11.2017), and Commission Regulation (EU) 2017/2196 establishing a network code on electricity emergency and restoration (OJ L 312, 28.11.2017). These network codes provide the detailed technical and operational rules necessary for implementing the high-level principles established in Regulation 2019/943.

European harmonised standards further support the regulation's technical implementation through the EN 50549 series for grid connection requirements and the EN 61000 series for electromagnetic compatibility and power quality. The EN 50549 series, developed by CENELEC, includes EN 50549-1:2019 and EN 50549-2:2019 for generating plants connected to LV and MV distribution networks respectively, directly supporting compliance with Commission Regulation (EU) 2016/631. The EN 61000 series, harmonised under EMC Directive 2014/30/EU and published in Official Journal reference C/2020/7574, establishes critical power quality and electromagnetic compatibility requirements including EN 61000-3-2 for harmonic current emission limits, EN 61000-4-30 for power quality measurement methods, and EN 61000-6-1 through EN 61000-6-4 for immunity and emission standards across different environments. Additionally, the EN 62053 series for electricity metering equipment, with recent updates including EN IEC 62053-24:2021 published under Official Journal reference C/2022/2231, provides standardised metering requirements essential for market operations.

International standards adapted for EU implementation include IEC 61850 for communication networks and systems in power utility automation, and IEC 61970/61968 for Common Information Model (CIM) data exchange, though these are not directly harmonised as EN standards but are extensively referenced in network codes and grid connection requirements. The European Commission has issued standardisation requests to CEN/CENELEC for enhanced standards supporting the Clean Energy Package implementation, with ongoing coordination through CEN/CENELEC Joint Technical Committees including JTC 21 for AI applications in energy and JTC 13 for cybersecurity. ENTSO-E has published 18 Implementation Guidance Documents (IGDs) providing technical guidance for national implementation of network codes, ensuring consistent application across Member States while maintaining compatibility with the broader harmonised standards framework established under Regulation 2019/943.

Relevance for PARMENIDES results market introduction: The PARMENIDES project demonstrates strong alignment with EU Regulation 2019/943, directly addressing the regulation's core objectives for renewable energy integration, flexibility services, and market-based mechanisms through its innovative hybrid energy storage system (HESS) solutions. The project's technical innovations directly support Article 12 (balancing services) and Article 13 (re-dispatching and flexibility services) of Regulation 2019/943, which require market-based, non-discriminatory procurement of flexibility services open to energy storage and demand response technologies. PARMENIDES addresses critical market opportunities triggered by the regulation's framework, particularly the €40-43 billion[27] annual savings potential from flexibility services and the emerging ca. €45[28] billion European storage market by 2030. The project's PECO ontology provides the semantic interoperability framework necessary for energy communities to access the flexibility markets mandated by Article 16 of Directive 2019/944 (complementing Regulation 2019/943), which grants energy communities the right to participate in flexibility markets, while the EMS4HESS solution enables automated optimisation of hybrid storage systems for multiple revenue streams including balancing services, dispatching compensation, and capacity mechanism payments. The regulation's implementation timeline aligns with PARMENIDES commercialisation strategy, particularly the 2026 deadline for enhanced balancing responsibility requirements and the 2028 maximum contract periods for balancing capacity, creating immediate market opportunities for the project's plug-and-play energy management solutions upon completion in December 2025. The project's participation in the EU BRIDGE initiative further ensures alignment with regulatory evolution and positions PARMENIDES results as industry standards for energy community flexibility management within the regulatory framework established by Regulation 2019/943.

2.2.7 Regulation on demand response (based on the "Network code on demand response")

The EU Network Code on Demand Response represents a transformative regulatory framework that will fundamentally reshape the European electricity markets by enabling widespread participation of demand-side flexibility resources. On the 7th of March 2025, the ACER submitted the final proposal to the EU Commission[29], achieving a critical milestone toward harmonised demand response rules across all 27 EU Member States with expected implementation by March 2027.

Regulation content and scope: The Network code on Demand Response operates under Article 59 (9) of the Regulation (EU) 2019/943 of the EU Parliament and of the Council of 5 June 2019, on the internal market for electricity (recast), see Section 2.2.6. The Network code established 4 main regulatory objectives:

1. Facilitating market access for all electricity wholesale markets
2. Ensuring technology neutrality for load, storage, and distributed generation resources
3. Harmonising EU-wide common rules while respecting national specificities
4. Promoting cost-efficient market-based procurement of flexibility services

These goals support the EU energy transition vision, allowing the integration of renewable energy and distributed sources. Moreover, the regulation covers 4 main areas with specific provisions, which are:

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[27] https://ireland.representation.ec.europa.eu/news-and-events/news/commission-puts-forward-action-plan-affordable-energy-2025-02-26_en

[28] https://www.mordorintelligence.com/industry-reports/europe-battery-energy-storage-system-market

[29] ACER (2025). "New network code on demand response will further advance the energy transition." Agency for the Cooperation of Energy Regulators. Available at: https://www.acer.europa.eu/news/new-network-code-demand-response-will-further-advance-energy-transition

- *Market access provisions*: to establish harmonised rules for demand response participation in wholesale electricity markets
- *Standards*: to define an EU registry for standardised measurements and verification
- *Access*: to ensure non-discriminatory access to day-ahead, intraday, and balancing market
- *Resource participation*: to define minimum bid sizes of 500 kW, or less, enabling smaller resource participation

Finally, the regulation defined qualification settings for service providers, ensuring consistent product verification standards across all Member States while maintaining the national registration system in place, facilitating market entry. These qualifications/verification mechanisms adopt technology-agnostic principles, enabling the potential participation of all kinds of distributed energy resources without any discriminatory technical barrier. Moreover, the regulation mandates the system operators adopt dedicated market-driven procurement methodologies, supported by comprehensive transparency requirements governing service acquisition processes, performance-based selection criteria, and structure coordination protocols between transmission and distribution system operators.

National implementations of the Network Code on Demand Response are expected, from every member state, by March 2027, following the common two-years standard implementation period. The member states must adapt national regulatory frameworks to properly align with the directive code requirements, define or update the national registration systems for demand response providers, ensure that the national market rules comply with harmonised provisions, and to establish the TSO-DSO coordination procedures, and implement monitoring systems for demand response participation. The economic benefits expected by the regulation implementation are estimated to be in the range of €1.5-2 billion by 2030[30] through reduced systems costs, lower consumer bills, enhanced investment incentives, and improved market integration.

Related harmonised standard: The regulatory framework for demand response is anchored by Commission Regulation (EU) 2016/1388 on Demand Connection[31] and Commission Regulation (EU) 2016/631 on Requirements for Generators[32], which entered into force on 7 September 2016 and 17 May 2016 respectively, establishing binding harmonised requirements across all EU Member States for transmission and distribution-connected facilities participating in demand response services. These foundational network codes are complemented by the EN 50549 series[33] representing core harmonised standards for grid

[30] EPEX SPOT (2025). "More flex, less copper: Proposal for new Network Code demand-response ushers in the era of Local Flexibility markets in Europe." Press Release, 17 March 2025. Available at: https://www.epex-spot.com/en/news/more-flex-less-copper-proposal-new-network-code-demand-response-ushers-era-local-flexibility

[31] https://eur-lex.europa.eu/eli/reg/2016/1388/oj/eng

[32] https://eur-lex.europa.eu/eli/reg/2016/631/oj/eng

[33] CENELEC (2019). "EN 50549-1:2019 - Requirements for generating plants to be connected in parallel with distribution networks - Part 1: Connection to a LV distribution network - Generating plants up to and including Type B." European Committee for Electrotechnical Standardization; CENELEC (2022). "EN 50549-10:2022 - Requirements for generating plants to be connected in parallel with distribution networks - Part 10: Tests for conformity assessment of generating units." European Committee for Electrotechnical Standardization.

connection of distributed energy resources, encompassing low-voltage connections (EN 50549-1:2019), medium-voltage networks at 1kV-35kV levels (EN 50549-2:2019), and conformity assessment testing procedures (EN 50549-10:2022), supported by EN 61000 series standards for electromagnetic compatibility and power quality requirements. Semantic interoperability is facilitated through the ETSI SAREF ecosystem, including the core SAREF standard (ETSI TS 103 264 V3.2.1)[34], energy-specific extensions (SAREF4ENER)[35], and grid domain ontology (SAREF4GRID)[36] based on IEC 62056 DLMS/COSEM standards[37], while communication protocols are governed by IEC 61850 (adopted as EN 61850)[38] for power utility automation and demand response signalling. The conformity assessment framework ensures harmonised standards provide presumption of conformity with EU regulations when cited in the Official Journal, with EN 50549-10:2022 establishing specific testing procedures for reactive power control, low-voltage ride-through, and frequency response capabilities, while CE marking requirements apply to compliant products through accredited laboratories covering inverters, energy storage systems, generators, and grid-connected devices.

Relevance for PARMENIDES results market introduction: The PARMENIDES project directly addresses the four main regulatory areas of the Network Code on Demand Response. For market access enhancement, the project’s ontology-based approach and interoperable architecture support new EU-wide rules for easier participation of smaller energy players in electricity markets, with PECO ontology providing standardised frameworks for consistent measurements and management of demand response resources across EU Member States. The EMS4HESS system addresses service provider qualification requirements through simplified prequalification processes and product verification for flexibility service providers. The project’s focus on addressing fragmentation of existing IoT platforms, protocols, and standards aligns with the Network Code’s emphasis on technological neutrality and interoperability, supporting cross-platform integration essential for demand response market development.

The project incorporates comprehensive regulatory compliance mechanisms through four key technical implementations: first, standardised data exchange protocols that align with the EU Data Strategy and the proposed Data Act requirements for interoperability between IoT devices and energy services; second, a robust cybersecurity architecture compliant with the EU Cybersecurity Act and NIS2 Directive, implementing ISO 27001/27002 security controls and NIST Cybersecurity Framework guidelines specifically adapted for smart grid environments; third, privacy-by-design principles embedded throughout the system architecture to ensure full compliance with the General Data Protection Regulation (GDPR), including explicit

[34] ETSI (2024). "ETSI TS 103 264 V3.2.1 (2024) - SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping (SAREF)." European Telecommunications Standards Institute.
[35] ETSI (2020). "ETSI TS 103 410-1 - SmartM2M; Extension to SAREF; Part 1: Energy Domain (SAREF4ENER)." European Telecommunications Standards Institute
[36] ETSI (2021). "ETSI TS 103 410-12 - SmartM2M; Extension to SAREF; Part 12: Grid Domain (SAREF4GRID)." European Telecommunications Standards Institute.
[37] IEC (2017). "IEC 62056 series - Electricity metering data exchange (DLMS/COSEM)." International Electrotechnical Commission.
[38] IEC (2020). "IEC 61850 series - Communication networks and systems for power utility automation." International Electrotechnical Commission. Adopted as EN 61850.

consent mechanisms, data minimization protocols, and user acceptance criteria that respect individual privacy rights while enabling energy flexibility services; and fourth, cross-border data portability and semantic interoperability features that support the EU's vision for liquid, integrated electricity markets by enabling seamless information exchange between national energy systems, market operators, and flexibility service providers across Member State boundaries.

2.2.8 Smart Readiness Indicator (SRI)

Content and scope: The Smart Readiness Indicator[39] represents Europe's most comprehensive standardised framework for assessing building intelligence, creating substantial market opportunities for smart building technologies including energy management systems like those developed in the PARMENIDES project. The SRI measures a building's ability to use smart technologies to optimise energy efficiency, adapt to occupant needs, and interact with energy grids[40] - capabilities that directly align with the energy community management and hybrid storage systems being developed under PARMENIDES. As an optional EU-wide scheme introduced through the 2018 Energy Performance of Buildings Directive (EPBD 2018/844/EU)[41], SRI establishes standardised criteria for evaluating building "*smartness*" across all EU member states[42]. The framework is transitioning from test phases to broader implementation, with 16 countries currently conducting official pilots and mandatory requirements expected for certain building types by 2026[43]. This regulatory momentum creates a compliance-driven market projected to grow from €5.27 billion in 2023 to €18.59 billion by 2030 in Europe alone[44].

The Smart Readiness Indicator defines building "smartness" as a building's ability to sense, interpret, communicate and actively respond in an efficient manner to changing conditions in its operation, external environment, and occupant demands[26-SRI]. This comprehensive definition encompasses three fundamental functionalities that buildings must demonstrate: optimising energy efficiency and overall performance, adapting operations to meet occupant needs, and responding to signals from energy grids for flexible energy management. SRI employs a structured assessment methodology spanning nine technical domains:

- Heating systems
- Cooling systems
- Domestic hot water

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[39] Smart readiness indicator - European Commission
[40] https://energy.ec.europa.eu/index_en
[41] https://eur-lex.europa.eu/eli/dir/2018/844/oj/eng
[42] Kourgiozou, Vasiliki, Daniel Godoy Shimizu, Mark Dowson, Andrew Commin, Rui Tang, Dimitrios Rovas, and Dejan Mumovic. "A new method for estimating the smart readiness of building stock data using display energy Certificate data." *Energy and Buildings* 301 (2023): 113673.
[43] https://www.rehva.eu/rehva-journal/chapter/the-smart-readiness-indicator-for-buildings-current-status-and-next-steps
[44] https://www.globenewswire.com/en/news-release/2023/07/10/2701605/0/en/Europe-Smart-Building-Market-Size-to-Surpass-USD-18-59-Billion-by-2030-Exhibiting-a-CAGR-of-19-7.html; https://www.fortunebusinessinsights.com/europe-smart-building-market-105128

- Ventilation
- Lighting
- Dynamic building envelope
- Electricity management
- Electric vehicle charging
- Monitoring and control systems

Each domain is evaluated against seven impact criteria, which are:

- energy efficiency
- maintenance and fault prediction
- comfort
- convenience
- health and well-being
- information to occupants
- energy flexibility and storage

This creates a comprehensive 63-point evaluation matrix that captures the full spectrum to classify an intelligent building. The methodology offers three assessment approaches tailored to different use cases and expertise levels. *Method A* provides a simplified checklist approach with 27 core services suitable for basic self-assessments, while *Method B* enables comprehensive expert-led evaluations using over 52 smart-ready services with on-site assessments and formal certification capabilities[45]. A performance-based *Method C* is under development to enable automated assessment using actual building operational data. SRI scores are expressed as percentages (0-100%), indicating closeness to maximum smart readiness, with buildings classified from G (0-20%) to A (80-100%), like Energy Performance Certificates [26-SRI]. The scoring incorporates weighting factors that can be adapted by member states to reflect local building types, climate conditions, and national priorities while maintaining EU-wide comparability.

The SRI regulatory framework operates through a carefully structured hierarchy that balances EU-wide standardisation with national implementation flexibility. Commission Delegated Regulation (EU) 2020/2155 establishes the binding legal framework and calculation principles, while Commission Implementing Regulation (EU) 2020/2156 details technical implementation modalities [26-SRI]. This creates a "two-tier" system where the core methodology remains consistent across the EU, but member states can adapt technical catalogues, weighting factors, and assessment criteria to national contexts.

SRI applies to all building types without restrictions, from residential to commercial, passing through the public, industrial, and mixed-use buildings. They can all be assessed using the framework. However, member states retain significant implementation autonomy, choosing whether to make SRI mandatory or

[45] https://sri-faq.eu/methodology/

voluntary, which building categories to prioritise, and how to integrate assessments with existing energy performance certification schemes. This flexibility has enabled diverse adoption of approaches across Europe. Currently, 16 EU countries are conducting official test phases: Austria, Belgium (Flanders), Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Poland, Portugal, Slovenia, and Spain[46]. These pilots are validating the methodology and building implementation capacity before broader deployment. Countries must report test phase outcomes within six months of completion and decide whether to proceed with full implementation based on evidence gathered[47]. The regulatory framework establishes rigorous quality assurance requirements. Assessments must be conducted by qualified or accredited experts, with member states responsible for establishing independent control systems for certificate validation. SRI certificates remain valid for a maximum of 10 years and must include overall SRI class scores for the three key functionalities and domain-specific ratings. Integration with broader EU energy policy creates additional regulatory drivers. All non-residential buildings >290kW must implement building automation and control systems (BACS) by 2025 under EPBD requirements[48]. The EU's Nearly Zero Energy Buildings mandate for all new construction by 2030 and the Renovation Wave Strategy targeting improved renovation rates create sustained demand for smart building technologies that enable SRI compliance.

Relevance for PARMENIDES results market introduction: The PARMENIDES project demonstrates remarkable strategic alignment with SRI requirements and market drivers. The project's hybrid energy storage focus directly targets SRI's "energy flexibility and storage" impact category - one of the seven criteria used to evaluate smart building performance. PARMENIDES technologies enable buildings to "adapt to signals from the grid", a core SRI functionality, while optimising energy efficiency through intelligent storage management. The system's ability to coordinate electricity and heating domains addresses multiple SRI technical domains through a single integrated platform. Market opportunities emerge through multiple channels. SRI compliance creates immediate demand for technologies that PARMENIDES addresses: energy management systems, building automation platforms, and grid-interactive storage systems. The project's pilot demonstrations in Austria and Sweden provide real-world validation of SRI compliance benefits in the markets where mandatory implementation is anticipated by 2026.

The regulatory timeline creates urgent commercial opportunities. As SRI transitions from voluntary to mandatory implementation across EU member states, building owners require technologies that enable compliance while delivering operational benefits. PARMENIDES' plug-and-play approach reduces integration complexity, a critical barrier to smart technology adoption identified in SRI market research. Strategic positioning for PARMENIDES should emphasise regulatory compliance enablement alongside technical innovation. The project's technologies can be marketed as "SRI-ready" solutions that address multiple

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[46]https://energy.ec.europa.eu/topics/energy-efficiency/energy-performance-buildings/smart-readiness-indicator/sri-eu-countries_en
[47]https://energy.ec.europa.eu/topics/energy-efficiency/energy-performance-buildings/smart-readiness-indicator/your-questions-about-sri_en
[48]https://build-up.ec.europa.eu/en/news-and-events/news/building-conversations-eubac-experts-developments-building-automation-and

assessment domains through standardised ontology integration. Partnership opportunities exist with SRI assessment tool providers, building automation companies, and energy service providers seeking comprehensive platforms for regulatory compliance.

In conclusions, the SRI represent and transformative shift in the EU building policy, providing clear pathways for market entry and technology adoption for intelligent building techs. The SRI spans nine technical domains and seven impact criteria, establishing a strong and robust mapping procedure that extend far beyond the basic energy efficiency to encompass the occupant well-being, grid interaction, and system intelligence. In this context, the PARMENIDES project is perfectly aligned with the SRI expectations being the technologies and solutions developed therein can be considered SRI enablers.

2.2.9 JRC CoC ESA (Joint Research Centre Code of Conduct for Energy Smart Appliances)

Content and scope: The JRC CoC ESA is a collaborative and voluntary initiative led by the European Commission's Directorate-General for Energy (DG ENER) and the Joint Research Centre (JRC). Its primary objective is to establish a voluntary Code of Conduct (CoC) for manufacturers of Energy Smart Appliances (ESA), aiming to ensure interoperability and seamless data sharing among appliances, home automation systems, electric vehicle chargers, aggregators, and DSOs. Unlike traditional energy efficiency regulations, this initiative focuses on certifying the "energy-smart" behavior of products, fostering a cohesive and open ecosystem that prevents market fragmentation and proprietary incompatibilities.

The scope of the CoC ESA encompasses defining principles for data exchange and developing interoperability requirements, with a strong emphasis on leveraging open standards such as the Smart Appliances REFerence (SAREF) ontology. The initiative involves a wide range of stakeholders, including industry representatives, NGOs, academia, and Member State authorities, through workshops, surveys, and collaborative working groups.

Relevance for PARMENIDES results market introduction: The JRC CoC ESA initiative is highly relevant to the PARMENIDES project because both focus on interoperability, secure data exchange, and ontology-driven energy management. PARMENIDES develops innovative Energy Management Systems (EMS) and ontologies for hybrid energy storage and community energy sharing concepts. The CoC ESA provides a standardised framework for interoperability and data sharing among smart appliances, aligning with PARMENIDES' goals of creating a reliable, interoperable, and secure energy ecosystem. Following JRC CoC ESA and adopting CoC ESA principles would ensure PARMENIDES' solutions are compatible with broader EU standards, enhancing scalability and market integration.

2.3 Data, Data privacy, cybersecurity, AI and trustworthiness regulation framework

2.3.1 Cyber Resilience Act (CRA) - 2024

Regulation content and scope: Cyber Resilience Act (CRA) came into force in December 2024. CRA aims to ensure the cybersecurity of products with digital elements, i.e., digital systems and software, throughout their lifecycle. It continues the regulation Cybersecurity Act started in 2019, intending to achieve a high-level cybersecurity, cyber resilience and trust within the EU. Organisations in the scope of this regulation have until December 2027 to comply.

It requires products with digital elements to guarantee:

- cybersecurity by design,
- to maintain security updates throughout the product's lifetime,
- to be able to prove the robustness against cyber-attacks and
- to report security vulnerabilities and incidents to the European Cyber Agency (ENISA).

Related harmonised standards: A series of harmonised standards are in development to support CRA compliance by CEN-CENELEC JTC 13 WG9 & 6. This series of standards is divided into horizontal and vertical ones. More information about CEN-CENELEC JTC 13 could be found in section 3.4.1.

Relevance for PARMENIDES results market introduction: The CRA is highly relevant for PARMENIDES as some PARMENIDES developments result in products with digital elements and thus will have to comply with this regulation. CRA mandates cybersecurity-by-design for digital products, including smart energy systems and IoT devices. PARMENIDES focuses on interoperable energy management systems and secure data exchange for hybrid energy storage. The CRA will ensure that PARMENIDES solutions comply with EU-wide cybersecurity standards, protecting against vulnerabilities and fostering trust in decentralised energy networks, which are critical for community-based energy resilience and innovation.

2.3.2 AI Act – 2024

Regulation content and scope: Artificial Intelligence Act (AI Act) came into force on August 1st of 2024. This regulation is the first comprehensive legal structure of its kind in the world. This regulation aims to ensure trustworthiness, transparency, accountability and ethical AI, as well as promoting confidence in the European market.

This regulation applies to all AI systems developed in and out of the EU for the EU market. The concerned stakeholders are AI systems providers, deployers, importers, distributors and all affected persons located in the EU.

It classifies the AI system based on the level of risk and implements strict requirements on high-risk applications.

Table 4: AI Act "Minimal risk" category

Minimal risk	
Category description	Category requirements
AI systems that do not raise risks to safety or fundamental rights. Examples: AI in video games, spam filters, recommendations based on AI for entertainment (e.g., movies)	No requirements, but still recommended to follow general principles such as human oversight, non-discrimination and fairness.

Table 6: AI Act "Limited risk" category

Limited risk	
Category description	Category requirements
AI systems that do not raise risks to safety or fundamental rights but still require some transparency obligations to ensure that users are well informed about the nature and the function of an AI system. Examples: Chatbots and deepfake content	AI Act – Chapter 5 – Section 2 Transparency requirements: Clear disclosure to the users AI content should be labelled (e.g., deepfakes)

Table 7: AI Act "High-risk" category

High-risk	
Category description	Category requirements
AI Act – Chapter 3 - Article 6 and Annex 3 "AI systems that are intended to be used as safety components in products or that are themselves products covered by Union harmonisation legislation shall be classified as high-risk." (Article 6, AI Act) It includes the following areas: ○ Biometrics ○ **Critical infrastructure (e.g., energy domain)** ○ Education and vocational training ○ Employment, workers' management and access to self-employment ○ Access to and enjoyment of essential private services and essential public services and benefits ○ Law enforcement ○ Migration, asylum and border control management ○ Administration of justice and democratic processes	AI Act – Chapter 3 - Section 2 and 3 With respect to AI trustworthiness, the specifically mentioned characteristics are: ○ Risk management system (Article 9) ○ Data and data governance (Article 10) ○ Technical documentation (Article 11) ○ Record keeping (Article 12) ○ Transparency and provision of information to deployers (Article 13) ○ Human oversight (Article 14) ○ Cybersecurity (Article 15) ○ Accuracy (Article 15) ○ Robustness (Article 15) Additional requirements apply in Chapter 3 – Section 3. Here are examples: ○ Quality management system (Article 17) ○ Documentation keeping (Article 18) ○ Keep automatically generated logs (Article 19) ○ Fundamental rights impact assessment

Highlight: Critical infrastructure includes: "AI systems intended to be used as safety components in the management and operation of critical digital infrastructure, road traffic, or in the supply of water, gas, heating or electricity." (AI Act – Annex 3)	○ Submission of a request of information upon the registration of high-risk AI systems. The list of requested documents is available in AI Act - Annex 8 and 9.

Table 8: AI Act "Unacceptable risk" category

Unacceptable risk	
Category description	Category requirements
AI Act – Chapter 2 - Article 5 This article describes a long list of prohibited AI practices. These AI systems are banned due to their unacceptable risks to fundamental rights and democracy. *Examples: Social scoring, manipulation AI systems, mass biometric identification in public spaces*	AI systems of this category are prohibited.

In the context of the research, it is essential to mention that AI Act does not apply to:

- AI systems specifically developed and put into service for the sole purpose of scientific research and development,
- any research, testing or development activity regarding AI systems before being placed on the market or put into service,
- any systems released under free and open-source licences, unless they are placed on the market or put into service as high-risk AI system or as an AI system that falls under Article 5 (prohibited AI practices) or Article 50 (transparency obligations for providers and deployers of certain AI systems) of the AI Act.

Related harmonised standard: CEN-CENELEC JTC 21 AI Trustworthiness framework is still under development, and the publication is expected end of 2026. This standard was requested by the EU Commission to support the AI Act technical implementation by providing practical requirements. If this standard is validated and published, it could be used for AI Act conformity demonstration. More information about CEN-CENELEC JTC 21 could be found in section 0.

Relevance for PARMENIDES results market introduction: The AI Act is highly relevant to the PARMENIDES project and solutions as it establishes regulatory frameworks for trustworthy and transparent AI systems. As PARMENIDES integrates AI-driven solutions for energy management, optimisation, and predictive analytics, compliance with the AI Act ensures that these systems are safe, secure, and ethically aligned. This alignment enhances user trust, mitigates risks, and supports PARMENIDES' goal of creating reliable, interoperable, and innovative energy communities within EU legal standards. Expected requirements will differ based on the AI systems risk categories.

2.3.3 Ecodesign for Sustainable Products Regulation (ESPR) - 2024

Regulation content and scope: Ecodesign for Sustainable Products Regulation (ESPR) came into force in July 2024. It is the main pillar of the EU Commission for more environmentally sustainable and circular products on the EU market. ESPR replaces the Ecodesign Directive 2009/125/EC. The ESPR is part of a package of measures to achieve the 2020 Circular Economy Action Plan and to foster the transition to a circular, sustainable, and competitive economy.

This regulation defines ecodesign requirements for almost all product categories:

- Improve product durability, reusability, upgradability and reparability
- Enhance product maintenance and refurbishment
- Make products more energy and resource-efficient
- Remove substances that inhibit circularity
- Increase recycled content
- Make products easier to remanufacture and recycle
- Set rules on carbon and environmental footprints
- Limit the generation of waste
- Improve the availability of information on product sustainability

Furthermore, it also contains new measures, the “digital product passport (DPP)”, “rules to address destruction of unsold consumer products”, and “green public procurement”. DPP is a digital identity card for products, components, and materials with information about them. Examples of information that might be present in a product DPP, especially on sustainability, circularity and legal compliance: technical performance, material specifications and origins, repair activities, recycling capabilities and lifecycle environmental impacts.

Related harmonised standard: The JTC CEN-CENELEC JTC24 is responsible for developing harmonised standards on the DPP framework and system. More information about Cen-Cenelec JTC24 could be found in section 3.4.4.

Relevance for PARMENIDES results market introduction: The ESPR is relevant for PARMENIDES because it sets sustainability and circularity requirements for energy-related products, including smart energy systems. PARMENIDES must ensure its solutions meet ESPR’s energy efficiency, durability, and recyclability standards. The most important point of this regulation regarding PARMENIDES is related to the DPP topics. Some PARMENIDES results will have to comply to DPP as they are digital products and have the aim to be used on the UE market.

2.3.4 Data Act – 2024

Regulation content and scope: The Data Act (Regulation (EU) 2023/2854), adopted in early 2024, is a key legislative initiative of the European Union aimed at fostering a fair and innovative data economy. Its primary objective is to make data more accessible, usable, and shareable across sectors, particularly when it originates from connected products and related services. The regulation grants users whether private individuals, businesses, or public bodies the right to access data generated by devices they own, use, or maintain [1].

The Data Act introduces obligations for manufacturers and service providers to ensure transparent, real-time access to data, promote portability between services, and avoid vendor lock-in. It also encourages interoperability by calling for common data formats, open interfaces (APIs), and harmonised protocols. Importantly, the regulation includes provisions to protect trade secrets, ensure data security, and safeguard data-sharing fairness in B2B and B2G contexts [2].

Related harmonised standard: As of mid-2025, no formal harmonised standards have yet been adopted under the Data Act (Regulation (EU) 2023/2854), but the regulation clearly anticipates their development [1]. Future standards are expected to support its core requirements such as interoperability, real-time access, and data portability by providing technical specifications for machine-readable data formats, open APIs, and secure data-sharing protocols [2]. These standards will likely be developed under mandates from the European Commission through standardisation bodies like CEN, CENELEC, and ETSI.

In the meantime, existing international and European standards can guide early implementation. These include ISO/IEC 19941 (cloud data portability), ISO/IEC 21838 (ontology for knowledge representation), ETSI NGSI-LD (context information for IoT), IEC 62541 (OPC UA for industrial interoperability), and cybersecurity standards like ISO/IEC 27001 and IEC 62443. While not yet officially harmonised under the Data Act, these frameworks align with its goals and can support compliance in areas such as secure data exchange, system interoperability, and user-driven data control [2].

Relevance for PARMENIDES results market introduction: The Data Act provides a legal and technical environment that directly supports the market integration of PARMENIDES project outcomes. One of its core provisions is the right for users including private individuals, companies, and public actors to access and share data generated by connected products and related services they use or maintain [1]. This is particularly relevant for PARMENIDES, which relies on retrieving and processing real-time data from diverse energy devices, such as hybrid storage systems, within local energy communities.

The regulation also promotes data interoperability and portability, which enables seamless integration of PARMENIDES's ontology-based EMS across different platforms and device ecosystems. These conditions reduce vendor lock-in and facilitate wider deployment of PARMENIDES technologies across EU energy markets, supporting the project's objective of replicability and scalability.

Furthermore, the Data Act introduces fairness requirements in B2B and B2G data sharing, while safeguarding trade secrets and security. These provisions strengthen trust among stakeholders especially small technology providers and community-led initiatives which aligns closely with PARMENIDES's goal of creating transparent, collaborative, and decentralised digital energy systems [2]. By removing both legal and technical obstacles to energy data access and use, the Data Act helps pave the way for a fairer and more innovative digital energy ecosystem, in which PARMENIDES results can thrive.

2.3.5 Data Governance Act (2022)

Regulation content and scope: The Data Governance Act (DGA) (Regulation (EU) 2022/868) entered into force in June 2022 and became applicable in September 2023. It is a key part of the EU's data strategy, aiming to facilitate the secure, voluntary, and trustworthy sharing of data across sectors and between public and private actors [3]. Unlike the Data Act, which focuses on data access and usage rights, the DGA focuses on creating frameworks and mechanisms for data sharing in a way that respects privacy, intellectual property, and business confidentiality [4].

The DGA introduces new roles such as data intermediaries, who facilitate data exchange between parties without exploiting the data themselves. It also establishes the European Data Innovation Board to support interoperability and good governance across sectors [4]. Additionally, it promotes data altruism, allowing individuals and organisations to voluntarily share their data for public interest purposes, such as scientific research or policy development [4].

The regulation is designed to build trust in data sharing by creating certified frameworks and registration requirements, especially for entities working with sensitive or non-personal data. This makes it easier for organisations including those in energy, healthcare, and mobility to participate in common European data spaces without compromising compliance or security [4].

Related harmonised standard: As of mid-2025, no official harmonised standards have yet been adopted under the Data Governance Act (Regulation (EU) 2022/868). However, the regulation anticipates the need for common technical and organisational specifications, particularly in relation to data intermediation services, data altruism, and cross-border public sector data sharing [4]. Future standards are likely to be developed by European standardisation bodies such as CEN, CENELEC, and ETSI, either through voluntary industry consensus or following formal standardisation requests issued by the European Commission.

Existing frameworks already offer partial alignment. For example:

- ISO/IEC 27001 and ISO/IEC 27701 support data governance and information security for organisations acting as data intermediaries.
- ISO/IEC 19944 addresses cloud service transparency and data handling roles.
- W3C's DCAT (Data Catalog Vocabulary) is relevant for public sector data spaces and metadata interoperability.
- IEEE 7000 series (data governance and ethical system design) may also contribute to future trusted data-sharing mechanisms.

These and future standards will support the operationalisation of the DGA by providing the necessary certification, compliance, and trust frameworks needed to participate in common European data spaces.

Relevance for PARMENIDES results market introduction: The DGA creates a trustworthy legal environment that supports the uptake of PARMENIDES results in real world energy data ecosystems. By introducing certified data intermediation services, the regulation helps reduce legal uncertainty around secure and fair data sharing particularly important for the decentralised, multi-stakeholder energy systems envisioned in PARMENIDES. Energy communities, storage operators, and local service providers could benefit from engaging through such intermediaries to exchange usage data, forecasts, and flexibility signals without giving up control over their data assets [3].

The DGA also enables data altruism as a legal and technical framework, which could support the voluntary sharing of energy-related data for research and innovation aligned with PARMENIDES's aims to improve system modelling and local optimisation [4]. Moreover, the regulation supports cross-sector and cross-border data sharing, which is key to replicating PARMENIDES use cases across different European pilot sites and digital platforms. By fostering transparency, trust, and standardised governance, the DGA contributes to building the data infrastructure needed to operationalise PARMENIDES's interoperable energy management solutions.

2.3.6 Network and Information Security 2 (NIS 2) - 2022

Regulation content and scope: As detailed in PARMENIDES D5.2 [17], the Network and Information Systems 2 (NIS 2) [27] directive is an extension of the former NIS 1 directive [28]. This new directive took effect across Europe on 18 October 2024, and organisations should be compliant if in the scope.

The objective of NIS 1 and now NIS 2 is to strengthen cybersecurity and harmonise the cybersecurity framework implementation across Europe. It is directly linked to the European cybersecurity strategy. This directive is organisation focused. With NIS 2, the application scope is wider, and the number of requirements is more important. NIS 2 includes new notions like personal responsibility and enforcement/fines/offences. In parallel, there are higher expectations for existing requirements like enhanced regulatory supervision, stricter risk management requirements, enhanced incident notification requirements, etc. The NIS 2 directive highlights critical economic sectors (such as healthcare, energy, transport or telecommunications) which must be able to disclose cybersecurity incidents and coordinate with cybersecurity authorities to monitor their resolution.

Relevance for PARMENIDES results market introduction: NIS 2 is organisation-focused; targeted organisations need to comply for financial, strategic, legal and operational reasons. Being aware and compliant means for an organisation controlling obligations, avoiding sanctions, securing operations and strengthening credibility.

Project partners need to question themselves regularly about their category in the NIS 2 classification. This analysis was done in the context of task T5.2 for each project partner participating in one or two pilots. Table 2 presents a summary of pilot partners' NIS 2 category and justification.

Table 4: NIS 2 categories of the PARMENIDES partners involved in pilots

Partner	NIS 2 category	Justification
ENS	**Essential**	ENS is the largest distribution system operator (electricity, gas) in the province of Styria in Austria. Grid assets and communication infrastructure in the low-voltage grid have to be protected via grid operator-specific cybersecurity and privacy. Grid infrastructure and assets are classified as critical infrastructure and are therefore particularly worthy of protection. Almost the entire domestic industry, many commercial enterprises and around 500.000 customers are connected to the grid of ENS. Sector: Energy Entity size: Large
AIT	**Important**	AIT has about 1.500 employees with more than 300 working in the “Center for Energy”. is Austria's largest non-university research institute, focusing on applied research and technological development. It plays a key role in developing innovative solutions across a range of sectors, particularly those that contribute to addressing societal challenges. AIT's activities are organised into several key areas, including Energy, Digital Safety & Security, Health & Bioresources, Innovation Systems & Policy, Technology Experience, Transport Technologies, and Vision, and Automation & Control. On the other hand, AIT develops and deploys solutions with stakeholders in the energy domain. Sector: Research Entity size: Large
MAPS	**Important**	MAPS has 131 employees, an annual turnover of more than 10M€ and less than 50M€. MAPS business sector is “ICT-Service Management (B2B)” in the domain of energy. Sector: ICT-Service Management (B2B) Entity size: Medium
KTH	**Not in scope**	KTH is large entity in the sector of research. However, “education institution” are excluded from the “Research” sector. This means that KTH is not in the scope of NIS 2. Sector: Research Entity size: Large
EXP	**Not in scope**	Experiencia (EXP) has less than 50 employees, an annual turnover under €10 million and focuses its business activities only on UI/UX design. Sector: Research Entity size: Large

2.3.7 Digital Service Act (DSA) - 2023

Regulation content and scope: Digital Service Act (DSA) came into force in August 2023. It aims to regulate digital platforms and their algorithms, including the ones based on/or using AI systems.

This regulation mainly focuses on content moderation, transparency, and user safety on the UE market for digital platforms.

This regulation scope is only focused on "intermediary service" as defined below in the DSA [18]:

> *"means one of the following information society services:*
>
> > *(i) a 'mere conduit' service, consisting of the transmission in a communication network of information provided by a recipient of the service, or the provision of access to a communication network;*
> >
> > *(ii) a 'caching' service, consisting of the transmission in a communication network of information provided by a recipient of the service, involving the automatic, intermediate and temporary storage of that information, performed for the sole purpose of making more efficient the information's onward transmission to other recipients upon their request;*
> >
> > *(iii) a 'hosting' service, consisting of the storage of information provided by, and at the request of, a recipient of the service;"*

Example of intermediary service: internet service providers, cloud services, marketplaces, social networks.

Related harmonised standard: There is no harmonised standard specifically for this regulation yet.

Relevance for PARMENIDES results market introduction: PARMENIDES results are not in the scope of this regulation as none of them are covered by the definition of "intermediary service". However, this section was kept for information purposes and to highlight that it is not relevant for PARMENIDES KERs.

2.3.8 General Data Protection Regulation (GDPR) - 2018

Regulation content and scope: General Data Protection Regulation (GDPR) came into force in 2018. This regulation aims to regulate the collection and use of personal data on the EU market (including AI systems). It applies to EU or non-EU organisations with offices in EU countries or that collect, store, and process personal data of EU data subjects (individuals living in the EU). National data protection and privacy laws have been adapted to this EU Regulation, with minimal differences, and the transposition is a reality in most of the EU countries. GDPR brings individuals more rights but also defines new roles in data protection and data processing. This regulation is based on the following 7 principles:

Table 2: GDPR 7 principles

Principle	Description
Lawfulness, fairness and transparency of the personal data processing	Establish specification for determining the controller, the type of personal data subject to the processing, the data subjects concerned, the entities to which the personal data may be disclosed, the purpose limitations, the storage period and other measures to ensure lawful and fair processing.
Purpose Limitation	Personal data must be collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, following Article 89 (1), not be considered to be incompatible with the initial purposes.
Data minimisation	Personal data shall be adequate, relevant and limited to what is necessary concerning the purposes for which they are processed.
Accuracy	Personal data shall be accurate, where necessary, kept up to date; every reasonable step must be taken to ensure that inaccurate personal data, having regard to the purposes for which they are processed, are erased or rectified without delay.
Storage limitation	Personal data shall be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed.
Integrity and confidentiality (security)	Personal data shall be processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing and accidental loss, destruction or damage, using appropriate technical or organisational measures.
Accountability	The controller shall be responsible for and be able to demonstrate compliance with.

GDPR introduces and clarifies some roles detailed in Table 3, to establish a more structured framework for the personal data management in organisations.

Table 3: Description of some main GDPR roles

New role	Description
Data Protection Officer (DPO)	This new position is compulsory for some organisations and shall have the following tasks: o inform and advise his organisation on GDPR requirements; o monitor his organisation's GDPR compliance; o cooperate with the supervisory authority (Data Protection Authority); o act as the contact point for the supervisory authority on issues relating to processing.
Data Controller	The data controller is the one who determines the purposes and how personal data is processed. He should control and ensure that data

	processing follows GDPR rules. He is in charge of managing agreements with third-party processors.
Data Processor	This position is the one that processes the personal data on behalf of the *data controller*. It could be a third party and the duties of the *data processor* towards the *data controller* must be specified in a contract or another legal act.

Relevance for PARMENIDES results market introduction: GDPR regulation is highly relevant for PARMENIDES because it governs the collection, processing, and storage of personal data, which is critical for the project's smart energy management systems and community energy platforms. PARMENIDES must ensure data privacy, user consent, and secure data handling when managing energy consumption data, especially in residential and community settings. These points were tackled within task T5.2. Compliance with GDPR builds user trust and ensures legal adherence while enabling secure, transparent energy solutions. Some PARMENIDES results will collect, process, store and use personal data on the EU market. The organisation in charge and their products or services will have to be compliant to this regulation.

3 Standardisation landscape

This chapter focuses first on the interoperability standards landscape and second on relevant harmonised standards for the market introduction of PARMENIDES results.

3.1 Landscape on Interoperability Standards

This section provides a landscape analysis of the interoperability standards. This study aims to support the market introduction of the PARMENIDES results, with a specific focus on ICT standards, IoT, cloud computing and digital twin. It then focuses on the energy application and conformity assessment domains. Trialog started a standardisation study [19] on interoperability within Int:Net project and PARMENIDES made some contributions. We reproduce content (in this section 3.1 and 3.2) that are of interest for the objective of this deliverable and the project.

3.1.1 ICT Standards

Interoperability concerns can be traced back to the days of computing network methods in the late 1970s with the creation of an interoperability framework based on the OSI model, as exemplified by

- the joint work in the 1980s of ITU-T X.200 (open systems interconnection basic reference model) and ISO/IEC 7498-1, and
- the publication of internet protocol suite (TCP/IP) or RFC 1122

This was followed by architecture work on RM-ODP (Reference model for Open distributed processing), jointly published by ITU-T (X.901 to X 904) and ISO/IEC (ISO/IEC 10746 series). RM-ODP consisted of 4 parts:

- an overview,
- foundations,
- architecture,
- architecture semantics.

The mentioned standards are listed in Table 5.

Table 5: Examples of distributed systems standards (ITU-T, ISO/IEC, IETF)

Category	Title			Date	URL
Interoperability framework	Open Systems Interconnection (OSI) Basic Reference Model		ITU-T X-200	1988, 1994	https://www.itu.int/rec/T-REC-X.200/
			ISO/IEC 7498-1	1994	https://www.iso.org/standard/20269.html
	Requirements for Internet Hosts -- Communication Layers		RFC 1122	1989	https://www.rfc-editor.org/rfc/rfc1122
Architecture	Open Distributed Processing (ODP) Reference Model	Overview	ITU-T X-901	1997	https://www.itu.int/rec/T-REC-X.901/en
			ISO/IEC 10746-1	1998	https://www.iso.org/standard/20696.html
		Foundations	ITU-T X-902	1995, 2009	https://www.itu.int/rec/T-REC-X.902/en
			ISO/IEC 10746-2	1996, 2009	https://www.iso.org/standard/55723.html

		Architecture	ITU-T X-903	1995, 2009	https://www.itu.int/rec/T-REC-X.903/en
			ISO/IEC 10746-3	1996, 2009	https://www.iso.org/standard/55724.html
		Architectural semantics	ITU-T X-904	1997	https://www.itu.int/rec/T-REC-X.903/en
			ISO/IEC 10746-4	1998	https://www.iso.org/standard/20698.html

3.1.2 Cloud Computing

Recently established subcommittees in JTC 1 have followed the same pattern of standard categories to address high-level guidance on interoperability:

- standards on use cases, vocabulary, concepts;
- standards on architecture; and
- standards on an interoperability framework.

ISO/IEC JTC 1/SC 38 (**Cloud computing and distributed platforms**) was established in 2009, with interoperability concerns relating to the networking of elements providing cloud services. The subcommittee

- started publishing standards on cloud vocabulary with ISO/IEC 17788 in 2014, later replaced by ISO/IEC Ed1 22123-1 in 2021, and 2023;
- started publishing standards on cloud architecture with ISO/IEC 17789 in 2014, later replaced by ISO/IEC 22123-3 in 2023; and then
- started publishing standards on cloud interoperability with ISO/IEC 19941 in 2017, to be replaced by a new edition under development.

The mentioned cloud computing standards are shown in Table 6.

Table 6: Examples of cloud computing standards (ISO/IEC JTC 1/SC 38)

Category	TItle		Date	URL
Use cases, vocabulary and concepts	Overview and vocabulary	ISO/IEC 17788	2014	https://www.iso.org/standard/60545.html
	Vocabulary	ISO/IEC 22123-1	2021, 2023	https://www.iso.org/standard/82759.html
	Concepts	ISO/IEC 22123-2	2021, 2023	https://www.iso.org/standard/80351.html
Architecture	Reference architecture	ISO/IEC 17789	2014	https://www.iso.org/standard/60545.html
		ISO/IEC 22123-3	2023	https://www.iso.org/standard/82759.html
Interoperability framework	Interoperability and portability	ISO/IEC 19941	2017, 2024	https://www.iso.org/standard/87817.html

3.1.3 Internet of Things and Digital Twin

ISO/IEC JTC 1/SC 41 (**Internet of things and digital twin**), was established in 2016, initially focusing on the Internet of Things (IoT), and in 2020 on digital twins. IoT interoperability deals with the connectivity of cyber-physical systems through sensors and actuators. Digital twin interoperability deals with the connectivity of digital twins with the physical entity. The subcommittee

- started publishing standards on IoT vocabulary with ISO/IEC 20924 in 2018, 2021, and in 2023 to cover both IoT and digital twins;
- started publishing standards on IoT architecture with the publication of ISO/IEC 30141 in 2018, later replaced by a second edition in 2024, the development of ISO/IEC 40141 as a guidance document, complemented by the publication of ISO/IEC 30147 and ISO/IEC 30149 on trustworthiness.
- started publishing standards on IoT interoperability with the publication of ISO/IEC 21823 series (IoT interoperability), with part 1 on the framework in 2019, part 2 on the transport facet in 2020, part 3 on the semantic facet in 2021, part 4 on the syntactic facet in 2022, and part 5 on the behavioural and policy facets (under development).

Table 7: Examples of internet of things standards (ISO/IEC JTC 1/SC 41)

Category	Title		Date	URL
Use cases, vocabulary and concepts	IoT Vocabulary	ISO/IEC 20924	2018, 2021	https://webstore.iec.ch/en/publication/66217
	IoT and digital twin - Vocabulary	ISO/IEC 20924	2024	https://webstore.iec.ch/en/publication/70408
Architecture	IoT Reference architecture	ISO/IEC 30141	2018, 2024	https://www.iso.org/standard/88800.html
	Digital twin reference architecture	ISO/IEC 30188	Development	https://www.iec.ch/dyn/www/f?p=103:38:411109607072878::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,104896
	Guidance on reference architecture	ISO/IEC TR 40141	2024	https://www.iec.ch/ords/f?p=103:38:710954471973193::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,126453
	IoT Trustworthiness Integration in ISO/IEC/IEEE 15288 system engineering processes	ISO/IEC 30147	2021	https://webstore.iec.ch/en/publication/62644
	IoT Trustworthiness principles	ISO/IEC TS 30149	2024	https://webstore.iec.ch/en/publication/67281
Interoperability framework	Framework	ISO/IEC 21823-1	2019	https://webstore.iec.ch/en/publication/60604
	Transport interoperability	ISO/IEC 21823-2	2020	https://webstore.iec.ch/en/publication/61085
	Semantic interoperability	ISO/IEC 21823-3	2021	https://webstore.iec.ch/en/publication/61088
	Syntactic interoperability	ISO/IEC 21823-4	2022	https://webstore.iec.ch/en/publication/65649
	Behavioural and policy interoperability	ISO/IEC 21823-5	Development	https://www.iec.ch/ords/f?p=103:38:604746112772042::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,108353

At this point there is no specific standard on digital twin interoperability. It is however addressed in ISO/IEC 30188 (Digital twin reference architecture) which is under development. Mentioned Internet of things standards are showed in Table 7.

3.2 Energy application domain standards

In the energy domain, IEC committees such as System Committee (SyC) Smart Energy and TC57 (**Power systems management and associated information exchange**), address architecture, interoperability, information models and ontologies, or interoperability profiles:

- Standards on architecture with the publication of the smart grid architecture model and associated interoperability framework by the CEN-CENELEC-ETSI SG-CG (smart grid coordination group) in 2012/2016 and transposed into an international System Reference Deliverable with IEC SRD 63200 in 2021
- Standards on interoperability with the publication in 2004 of the IEC 61850 standard series[49] in the power utility automation domain, e.g., IEC TR 61850-1 in 2017, IEC 61850-5 in 2013, or IEC 61850-7-1 in 2011.
- Standards on information models and ontology with
    - the ongoing development of a guide and plan to develop smart energy ontologies (IEC 63417),
    - the publication of core data models in the power utility domain, e.g., IEC 61850-7-2, and IEC 61850-7-3 and 7-4 for substations in 2010, with extensions to distributed energy resources with the IEC 61850-7-420 in 2021, to hydro power plants with IEC 61850-7-410 in 2012 or to wind farms IEC 61400-25 in 2016, and many other domains to come through transitional namespaces in the IEC 61850-90 series (Power quality, Condition maintenance and sensor network, Flexible alternate current transmission systems),
    - the publication of the common data dictionary, e.g., IEC 61360-1 in 2017, IEC 61360-4 online or IEC 61360-7 in 2024,
    - the publication of CIM or common information model, e.g., IEC 61970-1 and IEC 61970-2 in 2005, IEC 61970-301-v7 in 2020, IEC 61970-302-v2 in 2024, IEC 61970-401 in 2022, IEC 61970-600-1 in 2021, IEC 61970-552 in 2016, IEC 61968-1 in 2020,
    - the publication of CGMES or common grid model exchanged standard, with IEC 61970-600-1 in 2021,
    - the publication of IRM or interface reference model, with IEC 61968-1 in 2020, and extensions for distribution with ISO 61968-11 in 2013
- Standards on interoperability profiles with the publication of power systems profiles, e.g., IEC 61850-7-7 in 2018, IEC 61968-13 in 2021, 61968-100 in 2022, 62361-103 in 2018)

Mentioned energy standards are showed in Table 8. Note that these standards are often the outcome of other initiatives such as the utility communication architecture (UCA) in 1998. A resulting CIM users group was formed in 2005 and its equivalent for IEC 61850 in 2005 as well. The CIM users group provides today a forum in stakeholder cooperate and leverage the IEC CIM international standards[50] while the IEC 61850

[49] https://iec61850.dvl.iec.ch/
[50] https://cimug.ucaiug.org/

users groups is very active in supporting interoperability and conformance testing of IEC 61850 implementations.

Table 8: Examples of energy standards (IEC SyC Smart energy, IEC TC57 and others)

Category	Title		Id	Data	URL
Architecture and interoperability framework	CEN-CENELEC-ETSI Smart Grid Coordination Group Smart Grid Reference Architecture		SGAM	2012	https://www.cen-cenelec.eu/media/CEN-CENELEC/Area-sOfWork/CEN-CENELEC_Top-ics/Smart%20Grids%20and%20Me-ters/Smart%20Grids/ref-erence_architec-ture_smartgrids.pdf
	Power Utility Reference architecture		IEC 62357-1	2016	https://prod-ucts.iec.ch/view/pub/26251
	Definition of extended SGAM smart energy grid reference architecture model		IEC SRD 63200	2021	https://web-store.iec.ch/en/publica-tion/62757
	Guide and plan to develop Smart energy Ontologies		IEC 63417	Under development	https://www.iec.ch/dyn/www/f?p=103:38:5009880199818::::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:11825,23,105467
Interoperability	Communication networks and systems for power utility automation	Introduction and overview	IEC TR 61850-1	2013	https://web-store.iec.ch/en/publica-tion/6007
		Communication requirements for functions and device models	IEC 61850-5	2013	https://web-store.iec.ch/en/publica-tion/6012
		Basic communication structure - Principles and models	IEC 61850-7-1	2011	https://web-store.iec.ch/en/publica-tion/6014
Information Model and ontology	Communication networks and systems for power utility automation	Basic information and communication structure - Abstract communication service interface (ACSI)	IEC 61850-7-2	2010	https://web-store.iec.ch/en/publica-tion/66525
		Basic communication structure - Common data classes	IEC 61850-7-3	2010	https://web-store.iec.ch/en/publica-tion/6016
		Basic communication structure - Compatible logical node classes and data object classes	IEC 61850-7-4	2010	https://prod-ucts.iec.ch/view/pub/6017
		Basic communication structure - Hydroelectric power plants - Communication for monitoring and control	IEC 61850-7-410	2012	https://prod-ucts.iec.ch/view/pub/23693
		Basic communication structure - Distributed energy resources and distribution automation logical nodes	IEC 61850-7-420	2021	https://prod-ucts.iec.ch/view/pub/34384

		Configuration description language for communication in power utility automation systems related to IEDs	IEC 61850-6	2009	https://products.iec.ch/view/pub/63319
		Transitional namespaces for new domains (condition maintenance, sensor network, FACTs, power quality, microgrids, thermal energy…)	IEC TR 61850-90 series	Transitional	https://products.iec.ch/home
	Standard data element types with associated classification scheme	Definitions - Principles and methods	IEC 61360-1	2017	https://webstore.iec.ch/en/publication/28560
		Common data dictionary	IEC 61360-4	On line	https://cdd.iec.ch/
		Data dictionary of cross-domain concepts	IEC 61360-7	2024	https://webstore.iec.ch/en/publication/72956
	Energy management system application program interface (EMS-API)	Guidelines and general requirements	EC 61970-1	2005	https://webstore.iec.ch/en/publication/6208
		Glossary	EC 61970-2	2005	https://webstore.iec.ch/en/publication/6209
		Common information model (CIM) base	IEC 61970-301 v7	2020	https://webstore.iec.ch/en/publication/62698
		Common information model (CIM) dynamics	IEC 61970-302 v2	2024	https://webstore.iec.ch/en/publication/68152
		Profile framework	IEC 61970-401	2022	https://webstore.iec.ch/en/publication/62719
		CIMXML Model exchange format	IEC 61970-552	2016	https://webstore.iec.ch/en/publication/25939
		Common Grid Model Exchange Standard (CGMES) - Structure and rules	IEC 61970-600-1	2021	https://webstore.iec.ch/en/publication/63866
	Application integration at electric utilities - System interfaces for distribution management	Interface architecture and general recommendations	IEC 61968-1	2020	https://webstore.iec.ch/en/publication/32542
		Common information model (CIM) extensions for distribution	IEC 61968-11	2013	https://webstore.iec.ch/en/publication/6199
Interoperability profiles	Communication networks and systems for power utility automation	Guideline for definition of Basic Application Profiles (BAPs) using IEC 61850	IEC TR 61850-7-6	2019	https://webstore.iec.ch/en/publication/62972
		Machine-processable format of IEC 61850-related data models for tools	IEC TR 61850-7-7	2018	https://webstore.iec.ch/en/publication/29018
	Application integration at	Common distribution power system model profiles	IEC 61968-13	2021	https://webstore.iec.ch/en/publication/34213

	electric utilities - System interfaces for distribution management	IEC implementation profiles for application integration	IEC 61968-100	2022	https://webstore.iec.ch/en/publication/67766
	Power systems management and associated information exchange - Interoperability in the long term	Standard profiling	IEC TR 62361-103	2018	https://webstore.iec.ch/en/publication/61296
	Security profiles	Power systems management and associated information exchange - Data and communications security	IEC 62351 series	2007	https://webstore.iec.ch/en/publication/6912

3.3 Conformity Assessment Standards

Conformity assessment activities aim to provide confidence in an object of conformity. There can be different objectives:

- Compliance with a standard. From this perspective, *conformity assessment* focuses on verifying that requirements specified in a standard are met. This is supervised by CASCO[51], the ISO committee that develops policy guidance and publishes standards on conformity assessment. Many of CASCO published documents are common to ISO and IEC. CASCO provides strict rules on the principle of separation between requirements to be evaluated, and requirements of the evaluation process itself. They apply for instance on management systems standards such as ISO/IEC 27001 on information security in 2005, ISO/IEC 27701 on privacy information in 2019 with a new edition planned in 2025, or ISO/IEC 42001 on artificial intelligence.
- Interoperability assurance which focuses on verifying that requirements related to interoperability constraints are met. Examples in the health domain, are the implementation of terminological terms with ISO 12310 in 2015, HL7 v2 conformance methodology in 2020, HL7 v3 on constraints on messages in 2015, HL7 electronic health records profiles from 2015 onwards. Examples in energy from the power utility automation 61850 standards are IEC 61850-10 in 2012, IEC 62351-100-3 in 2020, IEC 62351-100-4 in 2023.

[51] https://www.iso.org/fr/casco.html

The examples of conformity related standards from ISO/IEC JTC1 (ICT), HL7 (health) or TC57 (Energy) are provided in Table 9.

Table 9: Examples of conformity related standards (ICT JTC1, Health HL7, Energy IEC TC57)

Category	Title		Date	URL
ICT	Information security management systems — Requirements	ISO/IEC 27001	2005, 2013, 2022	https://www.iso.org/standard/27001
	Extension to ISO/IEC 27001 and ISO/IEC 27002 for privacy information management — Requirements and guidelines	ISO/IEC 27701	2019	https://www.iso.org/standard/71670.html
	Privacy information management systems — Requirements and guidance	ISO/IEC 27701 Ed2	2025	https://www.iso.org/standard/85819.html
	Artificial intelligence — Management system	ISO/IEC 42001	2023	https://www.iso.org/standard/81230.html
Health	Principles and guidelines for the measurement of conformance in the implementation of terminological systems	ISO/TR 12310	2015	https://www.iso.org/standard/51346.html
	HL7 V2 Implementation Guide Quality Criteria, Release 1		2020	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=608
	HL7 Version 2 Conformance Methodology Release 1		2020	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=533
	HL7 Version 3 Standard: Refinement, Constraint, and Localization (RCL) to V3 Messages, R2		2015	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=76
	HL7 Electronic Health Records profile standards https://www.hl7.org/implement/standards/product_section.cfm?section=11	EHR Behavioral Health Functional Profile, Release 1	2014, 2024	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=14
		EHR System Long Term Care Functional Profile, Release 1 - US Realm	2015	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=134
		EHR System Problem-Oriented Health Record (POHR) Functional Profile, Release 1	2023	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=630
		EHR-S FM R2.1 Functional Profile: Problem-Oriented Health Record (POHR) for Problem List Management (PLM), Edition 1	2023	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=630
		EHR-S Functional Profile: Meaningful Use, Release 1 - US Realm	2015	EHR-S Functional Profile: Meaningful Use, Release 1 - US Realm
		EHR-System Public Health Functional Profile, Release 2	2015	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=278
		EHRS-FM R2.0.1: Usability Functional Profile, Release 1	2022	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=611
		EHRS-FM Release 2 Functional Profile: 2015 Meaningful Use, Release 1 – US Realm	2020	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=474
		EHRS-FM Release 2: Immunization Functional Profile, Release 1	2020	https://www.hl7.org/implement/standards/product_brief.cfm?product_id=521

		Electronic Health Record System Functional Model (EHR-S FM) Release 2.1		2020	Electronic Health Record System Functional Model (EHR-S FM) Release 2.1
	Communication networks and systems for power utility automation	Conformance testing	IEC 61850-10	2012	https://webstore.iec.ch/en/publication/6008
Energy	Power systems management and associated information exchange	Conformance test cases for the IEC 62351-3, the secure communication extension for profiles including TCP/IP	IEC 62351-100-3	2020	https://webstore.iec.ch/en/publication/61597
	Data and communication security	Cybersecurity conformance testing for IEC 62351-4	IEC 62351-100-4	2023	https://webstore.iec.ch/en/publication/63323

3.4 Relevant harmonised standards for the market introduction of PARMENIDES results

Regulation influences standardisation, particularly in Europe, with the concept of *harmonised standards*, which are developed by a European Standardisation Organisation (CEN, CENELEC or ETSI)[52], following a request from the European Commission concerning a union legislation. Manufacturers, other economic operators or conformity assessment bodies use these harmonised standards to demonstrate that products, services or processes comply with this legislation. Table 10 below lists examples of harmonised standard requests made by the European Commission.

Table 10: Examples of recent standardisation requests in Europe (from Int:Net standard interoperability landscape [19])

European Union regulation			European Commission standardisation request		
Regulation (EU) 2024/1689 on Artificial Intelligence (AI Act)	2021-04 2024-07	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401689	Draft standardisation request to the European Standardisation Organisations in support of safe and trustworthy artificial intelligence	2022-12	https://ec.europa.eu/docsroom/documents/52376
Proposal for regulation on horizontal cybersecurity requirements for products with digital elements	2022-09 -	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022PC0454	Draft standardisation request to European Standards Organisations in support of Union policy on cybersecurity requirements for products with digital elements	2024-04	https://ec.europa.eu/docsroom/documents/58974
Regulation (EU) 2023/1542 on batteries and waste batteries	2023-07	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=	Draft standardisation request as regards digital product passports	2023-10	https://ec.europa.eu/docsroom/documents/56175

[52] https://www.cencenelec.eu/about-cen/, https://www.cencenelec.eu/about-cenelec/, https://www.etsi.org/

		CELEX%3A32023R1542			

The following sections focus on standardisation groups developing harmonised standards relevant for PARMENIDES results. Table 11 provides an overview of the selected standardisation groups and their scope.

Table 11: Overview of the standardisation groups (details could be found in the dedicated sections)

Standardisation group	Harmonised Area	Description / Notes
CEN-CENELEC JTC13	Cybersecurity and privacy	It focuses specifically on cybersecurity and data protection standards within Europe, aiming to develop harmonised standards that support the implementation of EU regulations such as RED and CRA.
CEN-CENELEC JTC25	Data management, Dataspaces, Cloud and Edge (DDCE)	It focuses on developing standards for data management, dataspaces, cloud computing, and edge technologies. It aims to support the digital transformation of industries by creating interoperable, secure, and efficient data ecosystems across Europe.
CEN-CENELEC JTC21	AI trustworthiness framework	Its goal is to create clear, practical rules and guidelines to ensure AI technologies are safe, trustworthy, and ethical across Europe.
CEN-CENELEC JTC24	Digital Product Passport (DPP)	It is responsible for developing harmonised standards on the Digital Product Passport (DPP) framework and system
ISO/IEC JTC1/SC27	Cybersecurity for smart systems	This group sets globally recognised standards (not harmonised standards) like ISO/IEC 27001 and 27701 to support secure and privacy-aware systems. Their work spans cryptography, risk management, and technologies like IoT and cloud computing.

3.4.1 Harmonised standards CEN-CENELEC JTC 13 Cybersecurity and Data Protection

The CEN-CLC JTC 13 Cybersecurity and Data Protection committee works on cybersecurity and data protection standards for all industries. It adapts international standards (like those from ISO/IEC JTC 1 SC 27) for Europe and creates new standards when necessary. The committee also helps implement EU regulations such as GDPR, eIDAS, RED, and NIS, collaborating with ENISA and the European Commission to build Europe's cybersecurity rules. In this context, a series of harmonised standards is in development to support CRA compliance by CEN-CENELEC JTC 13 WG6 and 9. This series of standards is divided into horizontal and vertical ones.

The Joint Technical Committee CEN-CENELEC JTC 13 is responsible for developing standards on the following topics:

- Management systems, frameworks, methodologies
- Data protection and privacy
- Services and products evaluation standards suitable for security assessment for large companies and SMEs
- Competence requirements for cybersecurity and data protection
- Security requirements, services, techniques and guidelines for ICT systems, services, networks and devices, including smart objects and distributed computing devices

The committee’s activities are organised into nine dedicated working groups:

- WG 1: Chair's Advisory Group
- WG 2: Cryptography
- WG 3: Management systems and controls sets
- WG 4: Security evaluation and assessment
- WG 5: Data Protection, Privacy and Identity Management
- WG 6: Product security
- WG 7: Ad hoc group EU 5G Certification scheme support group
- WG 8: Special Working Group RED Standardization Request
- WG 9: Horizontal cybersecurity for products with digital elements

3.4.2 Harmonised standards CEN-CENELEC JTC 25 Data management, Dataspaces, Cloud and Edge (DDCE)

The CEN-CENELEC JTC 25 Data Management, Dataspaces, Cloud and Edge (DDCE) is a joint technical committee focused on developing standards for data management, dataspaces, cloud computing, and edge technologies. It aims to support the digital transformation of industries by creating interoperable, secure, and efficient data ecosystems across Europe. The committee works closely with stakeholders to align standards with EU policies and technological advancements.

The Joint Technical Committee CEN-CENELEC JTC 25 is responsible for developing standards and harmonised standards in the area of data management, dataspaces, cloud and edge. The following topics are covered:

- Data governance, data quality and data lifecycle management
- Interoperability, portability and switchability
- Organisational frameworks and methodologies, including IT management systems
- Processes and products evaluation schemes
- Smart technology, objects, distributed computing devices, data services

The committee’s activities are organised into four dedicated working groups:

- WG 1: Advisory group
- WG 2: Dataspaces
- WG 3: Data management and governance
- WG 4: Cloud & Edge

3.4.3 Harmonised standards CEN-CENELEC JTC 21 AI Artificial Intelligence

The CEN-CENELEC JTC21 is a European committee focused on Artificial Intelligence (AI) standards. Its goal is to create clear, practical rules and guidelines to ensure AI technologies are safe, trustworthy, and ethical across Europe. The committee works to support EU policies, like the AI Act, and helps businesses and developers build AI systems that are reliable, transparent, and respect fundamental rights.

The committee's activities are organised into nine dedicated working groups:

- WG 1 - Strategic Advisory Group (SAG): Focuses on overarching strategies and cross-sectoral challenges
- WG 2 - Operational Aspects: Addresses practical implementation issues
- WG 3 - Engineering Aspects: Concentrates on technical design and development
- WG 4 - Foundational and Societal Aspects: Examines ethical and societal impacts of AI
- WG 5 - Cybersecurity for AI Systems: Ensures secure AI deployment

The key standards under development by JTC 21 supporting EU AI Act are the following ones:

- AI Trustworthiness Framework
- AI Risk Management: Addressing operational risks
- AI Quality Management System: Ensuring robust processes for AI development
- AI Conformity Assessment: Facilitating compliance verification

Focus on CEN-CENELEC JTC21 AI Trustworthiness framework: CEN-CENELEC JTC 21 AI Trustworthiness framework is still under development, and the publication is expected by the end of 2026. This standard was requested by the EU Commission to support the AI Act technical implementation by providing practical requirements. When this standard is validated and published, it will be used for AI Act conformity demonstration.

The draft table of contents of this standard, early 2025, is the following one:

- AI system lifecycle
- Risk management system for AI system
- Governance and quality datasets
- Record keeping through logging capabilities
- Transparency and explainability
- Human oversight of AI system
- Accuracy specifications of AI system
- Robustness specifications for AI system
- Cybersecurity specifications for AI system
- Quality management system for providers of AI systems, including post-market monitoring process
- Conformity assessment for AI systems
- Requirements by lifecycle stages
- Requirements by AI Act Article

3.4.4 Harmonised standards CEN-CENELEC JTC 24 Digital Product Passport (DPP)

The Joint Technical Committee CEN-CENELEC JTC 24 is responsible for developing harmonised standards on the Digital Product Passport (DPP) framework and system, and more specifically on the following topics:

- Unique identifiers
- Data carriers and links between physical product and digital representation
- Access rights management, information, system security, and business confidentiality
- Interoperability (technical, semantic, organisation)
- Data processing, data exchange protocols and data formats
- Data storage, archiving, and data persistence
- Data authentication, reliability, integrity
- Application Programming Interfaces (APIs) for the product passport lifecycle management and searchability
- The data delivering system, data specification method while ensuring cross-sectoral
- Cross-system interoperability

The committee's activities are organised into four dedicated working groups:

- WG 1: Strategic Advisory Group
- WG 2: Unique identifiers and data carriers
- WG 3: Security
- WG 4: Interoperability framework

The Ecodesign for Sustainable Products Regulation (ESPR is relevant for PARMENIDES because it sets sustainability and circularity requirements for energy-related products, including smart energy systems. PARMENIDES must ensure its solutions meet ESPR's energy efficiency, durability, and recyclability standards. The most important point of this regulation regarding PARMENIDES is related to the DPP topic. Some PARMENIDES results will have to comply to ESPR (including DPP) as they are digital products and have the aim to be used on the EU market.

3.4.5 ISO/IEC JTC1/SC27 - Information security, cybersecurity and privacy protection

ISO/IEC JTC 1/SC 27 is a key international body responsible for developing standards in cybersecurity, information security, and privacy. Operating under the joint structure of ISO and IEC, this subcommittee plays a central role in setting globally recognised frameworks that enable secure and trustworthy digital environments.

As smart systems, artificial intelligence, and interconnected infrastructures become more embedded in daily life, the need for robust and adaptable security standards is increasingly critical. SC 27 contributes to this effort by defining principles and technical specifications that help ensure emerging technologies are not only innovative but also resilient, secure, and aligned with international best practices. Its work is instrumental in supporting both industry and regulators as they navigate the challenges of digital transformation [5].

Regulation content and scope: ISO/IEC JTC 1/SC 27 develops internationally agreed standards that support organisations in managing information security and privacy across a wide range of digital contexts. These include cloud services, the IoT, smart infrastructures, and AI-driven systems. Its standards serve as practical tools for designing and implementing security measures, assessing risk, and ensuring data protection in line with global expectations [5]

The committee's activities are organised into five dedicated working groups:

- WG 1 – Information security management systems (e.g. ISO/IEC 27001, 27002)
- WG 2 – Cryptographic and security mechanisms
- WG 3 – Security evaluation and testing (e.g. ISO/IEC 15408 – Common Criteria)
- WG 4 – Security controls and services for technologies such as IoT (e.g. ISO/IEC 27402)
- WG 5 – Identity management and privacy technologies (e.g. ISO/IEC 29100, 24760) [5]

These standards are widely adopted and often referenced in national and regional regulatory frameworks. In the EU, they support compliance with key legal instruments such as the General Data Protection Regulation (GDPR), the NIS2 Directive [6] (Directive (EU) 2022/2555), and the EU Cybersecurity Act (Regulation (EU) 2019/881)[7]. Moreover, SC 27 outputs provide the technical foundation for EU cybersecurity certification schemes like EU Common Criteria (EUCC) and EU Cybersecurity Certification Scheme for Cloud Services (EUCS), developed under the coordination of European Union Agency for Cybersecurity (ENISA) [8] This makes the subcommittee's work highly relevant for initiatives aiming to build secure, interoperable, and trusted digital solutions across the EU.

4 Current certification approaches

4.1 Certification process introduction

Certification involves a detailed evaluation process designed to determine whether specific products, services, or systems meet regulatory or industry standards. For PARMENIDES, this typically refers to components such as the energy management system (EMS), control software, or hybrid storage modules, rather than the entire system. Certification represents formal recognition that these components adhere to established quality and compliance benchmarks, as defined by international frameworks such as ISO/IEC 17000:2020 [9].

Certification is very important for PARMENIDES as it provides third-party validation of compliance with rigorous EU regulations or standards, such as cybersecurity (CRA), AI trustworthiness (AI Act), data protection (GDPR), and Digital Product Passport (DPP).

Beyond compliance, certification enhances interoperability, enabling seamless integration with smart grids and energy communities. It also strengthens stakeholder confidence (e.g., investors, regulators, and end-users) by demonstrating reliability, transparency, and alignment with EU sustainability goals.

Ultimately, certification acts as a catalyst for innovation, ensuring PARMENIDES solutions are future-proof, scalable, and competitive in the evolving energy sector. It bridges the gap between technological advancement and regulatory adherence, fostering trust and market adoption.

4.2 Types of Certifications

Certification frameworks can generally be classified into mandatory and voluntary schemes [10], [11].

Mandatory certification is legally required to confirm that a product, system, or service meets the essential safety, cybersecurity, and data protection requirements established by regulatory authorities. Within the context of PARMENIDES, this applies to components or services that must comply with binding EU legislation, such as the CRA, the GDPR, or the AI Act, before they can be deployed or marketed across Member States.

Voluntary certification, on the other hand, is initiated by manufacturers, developers, or service providers who wish to demonstrate additional quality or performance attributes beyond legal obligations. For example, voluntary certification may highlight adherence to AI trustworthiness, data interoperability principles [12], or environmental sustainability standards [13]. In PARMENIDES, voluntary certification mechanisms could be leveraged to demonstrate the robustness, explainability, or ethical alignment of AI-driven predictive maintenance solutions, complementing regulatory compliance with demonstrable excellence.

Understanding both certification types is crucial for the project's objectives, as it enables partners to identify appropriate compliance pathways, validate emerging digital technologies, and ensure the successful integration of PARMENIDES solutions into the EU energy and industrial ecosystem.

4.3 Certification Process (Typical Flow)

- **Documentation Review**: Submit EMS architecture, control logic documentation, communication protocols, safety concepts, and revision/change management procedures.
- **Test Definition & Planning**: Define test scenarios covering normal operations, grid disturbances, cybersecurity attacks, and failure conditions.
- **Laboratory Testing**: Perform functional tests, stress tests, and communication tests in a controlled environment to verify that EMS meets the design's operational and safety claims.
- **On-Site / Factory Assessment**: Inspect integration with real hardware (inverters, BMS, grid interface) to confirm the EMS functions correctly in the actual hybrid system.
- **Audit & Certification Issuance**: Based on successful tests, a certification body issues a conformity statement or certificate for the EMS. For management processes, a separate ISO 50001 audit could also lead to a management certification.

4.4 Conformity assessment processes

Conformity assessment refers to the structured evaluation of products, systems, or services to ascertain that they satisfy relevant regulatory requirements and harmonised standards. It plays an essential role in certification and regulatory compliance within the European energy, data and AI domains. By confirming that components meet defined criteria for quality, safety and performance, it supports trust, interoperability and acceptance in the market. For hardware components, such as those comprising the hybrid energy storage systems deployed at the pilot sites, the conformity assessment typically involves documentation review, standardised testing, site audits, and final certification [14]. For software, AI, and data components, similar principles apply, with particular emphasis on cybersecurity, data protection, and AI trustworthiness standards.

Typical Steps and Requirements

Conformity assessment generally involves the following steps:

1. **Definition of Scope and Applicable Standards**
    - The organisation identifies the product, system, or service subject to assessment and the relevant regulatory or harmonised standards (e.g., ISO 50001 for energy management [15], EN 50160 for grid compatibility, ISO/IEC 27001 [5] for information security, or requirements under the EU AI Act) [16].
2. **Testing and evaluation**
    - Notified Bodies (NBs) or accredited testing laboratories conduct independent assessments, performing tests, inspections, and audits to verify compliance. These bodies are formally designated under EU law; the AI Act sets specific requirements for notified bodies (e.g., independence, competence) in Article 31 [16].
    - Tests may include performance verification, interoperability checks, cybersecurity assessments, and energy efficiency measurements, depending on the domain.
3. **Technical Documentation and Evidence**

- Organisations prepare technical files demonstrating compliance (design specifications, test reports, risk assessments, operational procedures).
- In the AI context, providers submit technical documentation to notified bodies for assessment under Annex VII of the AI Act, which includes review of quality management systems and technical documentation [17].

4. **Self-Assessment / Internal Declaration of Conformity**
   - For lower-risk products or where legislation allows, manufacturers may perform self-assessment (internal control). This is explicitly mentioned in EU guidance [10].
   - Under the AI Act, certain high-risk AI systems may follow internal control (without a notified body) per Annex VI [18].
5. **Certification and CE Marking (if applicable)**
   - Once compliance is confirmed (by testing, documentation review, or self-assessment), the organisation can obtain formal certification. Where relevant, it can affix the CE marking, enabling free circulation in the EU [10].
   - For AI systems, a notified body issues a union technical documentation assessment certificate under Annex VII if the system conforms to the required standards [17].
6. **Surveillance and Continuous Compliance**
   - Conformity assessment is ongoing: periodic audits, re-testing, and monitoring ensure that systems (e.g., EMS, AI systems) remain compliant. Notified bodies shall carry out these surveillance activities (Annex VII) [17].
   - For AI Act bodies, documentation must be kept up-to-date so that notifying authorities can “monitor and verify continuous compliance” (per Article 29) [19].

Role in Regulatory and Standards Alignment

Conformity assessment processes align project outcomes with both regulatory obligations and harmonised standards. For PARMENIDES, this ensures that energy management, AI systems, and cybersecurity components not only meet legal requirements (e.g., GDPR, AI Act) but also follow international best practices in energy efficiency, grid interoperability, and data protection. By engaging notified bodies, accredited labs, and internal validation procedures, the project ensures its solutions are reliable, scalable, and market-ready across EU Member States.

4.5 Relevant certification schemes for PARMENIDES results

Certification schemes relevant to PARMENIDES span both the energy domain and the digital trust and security domain, reflecting the integrated nature of the EMS4HESS and data-driven decision-support tools developed in the project.

Energy Sector Certification Schemes

The energy domain includes well-established certification frameworks focused on energy efficiency, power quality, and interoperability with smart grids and renewable energy systems. A key standard is ISO 50001, which provides a structured approach for implementing an EMS and achieving continuous improvements in energy performance. Compliance with ISO 50001 demonstrates systematic energy monitoring, optimisation processes, and alignment with EU sustainability objectives [15].

For power system quality and grid interactions, EN 50160 defines voltage characteristics in public electricity distribution networks within Europe, acting as a reference for ensuring grid-compliant behaviour of devices and systems [20]. Additional grid conformity and certification schemes for renewable energy systems and grid integration are defined at the national level, such as conformity assessments conducted in line with VDE-AR-N 4105/4110 in Germany and the TOR (Technische und Organisatorische Regeln) guidelines in Austria, which ensure the safe and reliable operation of distributed energy resources and energy storage units in smart energy environments [21]. These schemes are particularly relevant to PARMENIDES pilot sites and the interoperability targets of EMS4HESS.

Together, these certification mechanisms support the reliability, safety, and performance of PARMENIDES technologies when interfacing with smart grids and renewable energy infrastructures.

Data, Cybersecurity, and AI Certification Schemes

Beyond energy-specific certification, PARMENIDES must align with frameworks governing data management, cybersecurity, and trustworthy AI. ISO/IEC 27001 provides an internationally recognised methodology for establishing an Information Security Management System (ISMS), ensuring secure handling of operational and user data [5]. Complementary cybersecurity guidelines, such as ISO/IEC 27032, address ecosystem-level cybersecurity and cooperation between system stakeholders [22]. For system and software security assurance, the Common Criteria (ISO/IEC 15408) framework offers a globally accepted certification scheme for evaluating security functions of IT systems and components [23].

In addition, PARMENIDES solutions must align with EU regulatory requirements, particularly the GDPR, for which dedicated compliance verification and certification services increasingly exist within the EU market [24]. Looking ahead, the upcoming EU AI Act will introduce harmonised rules and certification pathways for AI systems assessed as high-risk, including AI-based optimisation and predictive algorithms in energy systems. Future AI certification frameworks will focus on transparency, robustness, fairness, and human oversight all highly relevant to the project’s data-driven functionalities [25].

By aligning with these certification schemes, PARMENIDES strengthens trust, ensures regulatory preparedness, and enhances the market readiness of its technological outputs.

4.6 Example of grid connection certification process and the specific requirements

Grid Connection Requirements and Certification Process in Austria:

In Austria, ESS connected to the grid are generally subject to the applicable Technische und Organisatorische Regeln (TOR) and related grid codes, similarly to power-generating or consuming facilities. Depending on their operating mode, such systems may be treated as generators or as loads and are required to comply with the relevant grid connection procedures and performance requirements for low-voltage distribution networks, unless specifically exempted [27].More technically, grid connection requirements for ESS in Austria depend on the connection level and system size. For low-voltage-connected ESS, as used in the PARMENIDES pilot sites, requirements typically focus on basic voltage and frequency support, reactive power capability within defined limits, and compliance with grid protection and disconnection rules. Advanced functionalities such as fault ride-through, black-start capability, or island operation are generally required only for larger systems connected at medium- or high-voltage levels. These requirements, originally defined for generation units, may also apply to ESS when they provide grid-supportive functions, depending on their classification and operating mode [27].

Grid Connection Requirements for Energy Storage Systems in Sweden:

In Sweden, ESS that connect to the grid are currently regulated under general electrical safety laws, rather than through a dedicated ESS-specific grid code. These systems must follow the rules set by the Swedish Electrical Safety Board (Elsäkerhetsverket), particularly the regulation ELSÄK-FS 2022:1, which requires compliance with SS 436 40 00 Sweden's national version of the international IEC 60364 standard for electrical installations [28].

Although there are no specific classification rules for ESS generators or consumers, the technical requirements for connecting to the grid are broadly the same as for other complex electrical systems. These include protections for short-circuit conditions, grounding and earthing arrangements, overvoltage safety, and ensuring the system doesn't disrupt grid frequency or voltage quality [29].

In practice, this means that grid-connected ESS must be designed to meet high safety and compatibility standards. Operators typically work with local DSOs or Svenska kraftnät the national transmission system operator, to ensure the installation meets the necessary technical and administrative requirements [30]. Even without a specific ESS framework, these systems are generally treated as active grid assets that are expected to behave like either controllable loads or generation units, depending on how they're used.

Grid Connection Requirements and Certification Process in Germany:

In Germany, grid-connected energy storage systems must comply with the national Technical Connection Rules (Technische Anschlussregeln, TAR) issued by VDE-FNN. Depending on the voltage level, this includes VDE-AR-N 4105 for low-voltage connections, VDE-AR-N 4110 for medium-voltage, and VDE-AR-N 4120 for high-voltage systems. These rules treat ESS similarly to generation units, requiring functions such as voltage support, reactive-power capability, frequency-dependent active-power control, and fault-ride-through performance [31].

The certification process typically involves component and system verification conducted by accredited bodies such as the VDE (Verband der Elektrotechnik Elektronik Informationstechnik; Association for Electrical, Electronic & Information Technologies) Testing and Certification Institute or TÜV. Compliance is demonstrated through equipment certificates, system certificates, and verification according to FGW Technical Guidelines (e.g., FGW-TR8), all of which confirm conformity with the required TAR standards before final grid approval is granted [32].

Recent regulatory updates in Germany (NELEV and EAAV amendments, 2024) have introduced a simplified verification route for certain generation and storage units, reducing administrative burden and shortening connection timelines. These rules clarify documentation requirements and streamline the interface between project developers and network operators [33]. Additional guidance from VDE-FNN provides instructions for integration and operation of ESS in low-voltage networks, supporting consistent application by DSOs and installers. Equivalent national rules apply in Austria and Sweden, but the specifics differ from the German framework.

4.7 Energy Management System Certification and Evaluation in Hybrid Storage Systems

The EMS is a critical component, for example it orchestrates charge/discharge strategies, manages state-of-charge, ensures safe operation, supports energy sharing, optimises energy flows monitors performances/status, optimises energy costs, ensures gird compliance, facilitates smart automation, and enables provision of grid services. Certification and evaluation of the EMS is therefore not just a software exercise but a vital part of system integration and regulatory compliance.

4.7.1 Key Evaluation Dimensions for EMS

1. Functional Design and Control Logic: The EMS must demonstrate well-defined logic for managing hybrid assets (e.g., batteries), forecasting energy flows, dispatching based on operational constraints, and responding to grid signals or market signals. Evaluators will check whether the EMS handles all expected modes (charging, discharging, idle) in accordance with the project's hybrid energy storage system architecture

2. Communication & Interoperability: Because EMS interacts with inverters, battery-management systems (BMS), and possibly grid operators, it must support standard communication interfaces (e.g., IEC protocols). This ensures interoperability and reliable remote control/monitoring. Lack of robust communication can severely impair performance or certification. VDE specifically highlights that energy management in customer plants with storage is a core development area [35].

3. Safety, Grid Compliance & Control Performance: The EMS must prove that it maintains system safety during disturbances (e.g., overvoltage, undervoltage, frequency events) and that its control loops (for power dispatch, reactive control, state-of-charge limits) do not compromise grid stability. Certification often includes functional testing under abnormal operating conditions. Certification bodies such as TÜV NORD provide such testing services [36].

4. Cybersecurity & Software Reliability: In modern hybrid-storage systems, EMS software is network-connected, so cybersecurity is critical. Evaluation includes authentication mechanisms, secure update procedures, data integrity, and access control. Moreover, software quality (versioning, documentation, and validation) must meet industrial norms. Though EMS-specific grid-code regulations may vary, evaluation bodies often apply general best practices from software certification and control system standards.

5. Management System Certification (ISO): Besides technical certification, the organisation operating the EMS may also seek *management system* certification, such as ISO 50001 (EMS standard). ISO 50001 certification demonstrates that the organisation has implemented structured processes for continuity, energy efficiency, and improvement. TÜV Saarland, for example, offers ISO 50001 certification for EMS [15].

4.7.2 Relevance for the Parmenides Project

The PARMENIDES project aims to develop advanced hybrid storage and control systems. While the project itself did not perform EMS certification, including information about certification in this deliverable helps show how systems can meet regulatory and technical standards. This context highlights that hybrid systems are designed with safety, reliability, and grid compliance in mind, which is relevant for stakeholders such as TSOs, DSOs, and potential investors.

4.8 Certification gaps and challenges

Despite the availability of established certification frameworks across the energy, data, and cybersecurity domains, several gaps remain and are particularly relevant to PARMENIDES. These limitations may hinder the deployment and market acceptance of innovative energy management and hybrid energy storage solutions unless addressed through targeted actions and collaboration with regulatory bodies and standardisation organisations [37], [38].

Identified certification gaps:

- **Certification of AI-Driven systems in the energy domain:** PARMENIDES employs AI systems for various applications related to the energy domain, including management, estimation, and forecasting. While there are emerging frameworks for AI trustworthiness and cybersecurity under the EU AI Act and ISO/IEC standards [39], [40] there is still no specific certification pathway for AI applications in energy systems. This includes the validation of AI algorithms for real-time decision-making, forecasting, and system interoperability, which remain critical for regulatory confidence and safe deployment [41].
- **Certification for cross-domain semantic interoperability for data exchange:** Current certification schemes cover domain-specific areas; however, cross-domain interoperability across energy, ICT, and appliance ecosystems is still underdeveloped. The JRC CoC ESA a relevant example of efforts to harmonise interoperability requirements [42].

- **Certification of energy community:** Existing certification schemes are primarily designed for traditional energy actors such as DSOs, TSOs, and individual producers. Emerging energy communities require adapted or entirely new certification schemes to assess governance, data handling, cybersecurity, and interoperability in decentralised multi-actor configurations [43].
- **Certification of hybrid energy storage systems:** Current standards typically address electrical storage (e.g., battery systems) and thermal storage separately. There is a lack of coordinated certification paths for hybrid energy storage systems that combine multiple storage vectors, despite their increasing role in Europe's energy transition [44].
- **Auditors' certification skills:** Rapid regulatory changes under recent EU legislation create challenges in ensuring auditor competence. Certification bodies face difficulty keeping auditors fully trained in new cybersecurity, AI, and digital-product regulations (such as CRA and AI Act), which affects the consistency and reliability of the certification process [45].

4.9 Conclusion

Certification of energy storage systems, hybrid storage solutions, and their associated EMS plays a key role in the PARMENIDES project. It ensures that both hardware and software components meet European regulatory requirements and international standards, covering performance, safety, interoperability, and cybersecurity.

Through conformity assessment processes, which include documentation review, standardised testing, site audits, and final certification, the project can demonstrate compliance with mandatory EU legislation, such as GDPR, the CRA, and the AI Act. Voluntary certification schemes can further highlight additional qualities, such as energy efficiency, AI trustworthiness, and seamless integration with smart grids. These processes help to build stakeholder confidence and support the reliable deployment of hybrid storage technologies across different European markets.

For EMS in hybrid-storage systems, certification and evaluation confirm that control logic is robust, communication is reliable, grid operation is safe, and cybersecurity measures are adequate. Aligning EMS and ESS certification ensures interoperability and supports the adoption of innovative control strategies, making the overall system more scalable and trustworthy.

Overall, following a comprehensive certification approach allows PARMENIDES to bridge the gap between technological innovation and regulatory compliance. This approach helps deliver EMS and hybrid storage solutions that are safe, reliable, and ready for the evolving European energy landscape.

5 PARMENIDES contribution to standardisation

5.1 Strategy

The strategy of PARMENIDES was driven by partners with extensive experience in standardisation, actively contributing to and often leading initiatives in this area. PARMENIDES partners were already deeply involved in standardisation efforts before the project began and will remain engaged afterwards.

The selected strategy to contribute to standardisation was composed of the following points:

- Internal workshops were organised to foster partners' collaborations on specific topics (e.g., ontologies, KERs)
- Participation/contribution to standardisation groups and other bodies (e.g. , AIOTI, BDVA)
- Participation/contribution to new standardisation projects
- Participation to standards revision projects
- Identification of possible contributions to standardisation based on project results and KERs

5.2 Standardisation ecosystems and groups targeted by the project

According to PARMENIDES' scope, the following ecosystems were identified as relevant:

- Energy
- Interoperability (including semantic interoperability)
- Artificial intelligence
- Data
- IoT
- Digital twin
- Privacy
- Security
- Trustworthiness
- Architecture

Here is a non-exhaustive list of standardisation groups relevant (not sorted by relevance) for the project:

- CEN-CENELEC JTC21 Artificial Intelligence
- CEN-CENELEC-ETSI CG (Coordination Group) on SG (Smart Grids)
- CEN-CENELEC JTC25 Data management, Dataspace, Cloud and Edge
- IEC SyC Smart Energy
- ISO/IEC JTC1 SC27 Information security, cybersecurity and privacy protection
- ISO/IEC JTC1 SC42 Artificial Intelligence
- ISO/IEC JTC1 SC41 Internet of Things and digital twin
- ISO/IEC JTC1 SC32 Data management and interchange
- ISO/IEC JTC 1 SC 7 Software and systems engineering
- ISO/IEC JTC1 SC38 Cloud computing and distributed platforms
- ISO/IEC JTC 1 WG 13 Trustworthiness

- ETSI TC DATA (SAREF)

5.3 Continuous contribution to standardisation

This section provides an overview of the active participations to standardisation groups.

Standardisation groups where PARMENIDES partners were and are active:

- ISO/IEC JTC1/SC38 Cloud computing WG5 Data in cloud computing and related technologies
- ISO/IEC JTC1/SC41 IoT and Digital Twin WG5 Digital twin
- ISO/IEC JTC1/SC41 IoT and Digital Twin WG4 interoperability
- ISO/IEC JTC1/SC41 IoT and Digital Twin WG3 architecture
- ISO/IEC JTC1/SC27 Cybersecurity and privacy WG4 application security
- ISO/IEC JTC1/SC27 Cybersecurity and privacy WG5 privacy
- ISO/IEC JTC1/SC42 AI WG3 trustworthiness
- ISO/IEC JTC1/SC42 AI WG5 Computation approaches
- CEN/CLC JTC21 AI WG4 Trustworthiness
- CEN/CLC JTC21 AI WG1 Strategy
- ISO/IEC JTC1/SC44 Consumer protection in the field of privacy by design
- CEN/CLC CG on Smart Grid
- IEC SyC Smart Energy & ISO/IEC JTC1/SC41 JWG3 Smart Energy Roadmap
- IEC SyC Smart Energy CAG7
- ISO/IEC JTC1/SC41 AG6
- IEC SyC Smart Energy ahG11 (temporary ad-hoc flex group)
- IEC SyC Smart Energy WG6 Generic smart grid requirements
- IEC SyC Smart Cities
- ISO/IEC JTC1/SC42 AI WG5 Computation approaches and computational characteristics of AI systems
- ISO/IEC JTC1/SC41 IoT and Digital Twin WG4 IoT interoperability
- ISO/IEC JTC1/SC41 IoT and Digital Twin WG5 IoT Applications
- IEC TC 57 Power systems management and associated information exchange, WG 21 Interfaces & protocol profiles relevant to systems connected to the electrical grid

Other groups were targeted for active contributions such as:

- Pantera: Umbrella project, reviewing Regulations, Codes and Standards (RCS) in the Smart Grid domain that will form valuable content to the EIRIE platform
- Netzregelung: Grid control 2.0 - "Further development of grid codes, internationalisation and dissemination of results – Dissemination of document
- Austria Energy Association: Elaboration of a DSO-customer-interface, Journal paper available
- Int:net: Interoperability Maturity Model, testing network; adaptation of VLab
- Building SMART & Power Transmission: Extend the BIM standard in the scope of high-voltage power transmission; BIM standard could be used as an input of the ontology

- OVE – the Austrian Electrotechnical Association: Relevant to the topic of energy community participation in the grid, as well as examples of EC for PARMENIDES.
- Flex Community: Definition and standardisation of the FlexOffer protocol, conference on flexibility
- Alliance for Internet of Things Innovation (AIOTI): European association that promotes and supports the development and adoption of IoT technologies and innovation across industries.
- JRC CoC Energy Smart Appliance
- BRIDGE WGs and especially

5.4 Targeted contributions to standardisation

This section details three specific actions that were identified as possible contributions to standardisation.

- Action 1 – Use cases [20]: Identify if and how the PARMENIDES use cases could contribute to standardisation.
- Action 2 – Architecture [21]: Identify if and how the PARMENIDES architecture could contribute to standardisation.
- Action 3 – PARMENIDES Energy Community Ontology (PECO) [22]: Identify if and how PECO could contribute to standardisation.

5.4.1 Action: Use cases

Based on PARMENIDES' use cases, an action was defined to identify if and how they could contribute to standardisation. As a basis for the assessment and the mapping, the standard IEC SRD 62913 series Generic smart grid requirements [23] was selected as a reference in terms of use cases.

IEC SRD 62913 series has been broken down into domains to provide a neutral term for document management purposes. It consists of the following parts:

- Part 1 Generic Smart Grid Requirements - Specific application of the Use Case methodology for defining Generic Smart Grid Requirements according to the IEC System approach [24]
- Part 2 Generic Smart Grid Requirements, itself composed of 5 subparts, which refer to the clusters which regroup several domains [25]:
    - Part 2-1: Grid related domains, these include Transmission Grid Management, Distribution Grid Management, Microgrids and Smart Substation Automation
    - Part 2-2: Market related domain
    - Part 2-3: Resources connected to the grid related domains, these include Bulk Generation, Distributed Energy Resources, Smart Home / Commercial / Industrial / DR-Customer Energy Management, and Energy Storage
    - Part 2-4: Electric Transportation related domain
    - Part 2-5: Support Functions related domains, these include Metering Management and Asset Management

IEC SRD 62913 Generic smart grid use cases and requirements

The IEC SRD 62913-1 [24] outlines a standardised use case methodology for defining generic requirements in smart grid systems, ensuring consistency and interoperability across different domains like energy management, distributed resources, and grid automation. It uses as input the use case methodology defined as part of the IEC SRD 62559 [26], and provides a more detailed methodology for describing use cases and extracting requirements from these use cases.

This standard provides a structured framework for IEC technical committees to identify, manage, and name requirements, leveraging tools such as the extended Smart Grid Architecture Model (SGAM) and linking use cases to broader standardisation efforts.

The most interesting document in the context of the PARMENIDES project is Part 2-3 of IEC SRD 62913, focusing on "Resources connected to the grid related domains, these include Bulk Generation, Distributed Energy Resources, Smart Home / Commercial / Industrial / DR-Customer Energy Management, and Energy Storage".

PARMENIDES use cases and IEC SRD 62913-2 use cases

The four PARMENIDES use cases detail different levels of automation and means to manage flexibility among an energy community. As a reminder, the PARMENIDES use cases are:

- UC 1 - Passive Energy Community Customer Optimization
- UC 2 - Active Energy Community Participation
- UC 3 - Automated Energy Community Participation with Human Inputs
- UC 4 - Fully Automated Energy Community Participation

Table 12: PARMENIDES Use case descriptions.

Use case	Description
UC 1 - Passive Energy Community Customer Optimization	The "**Passive**" Use Case is implemented in both the EMS4HESS* and HEMS**. The EMS4HESS constantly monitors the energy data sent from the HEMS, the flexibility profile of the HESS, and signals from the DSO/Supplier. **There is no intent to activate flexibility, so energy data is only used to calculate relevant charges and allocate fees as needed. Any available flexibility cannot be dispatched/activated in a short period, and any optimization is done ex-post, depending on EC Management and individual participants' appreciation of billed energy consumption.** As the main objective is cost optimization, it can be done ex-ante through joint purchase agreements, supply and/or sale from shared energy assets, and peer-to-peer sharing of generated electricity. The EC Management takes on an administrative role to leverage the combined demand to be given preferential electricity rates and/or take advantage of economies of scale in the purchase of shared electricity generation and/or storage assets.
UC 2 - Active Energy Community Participation	This use case is based on Use Case 1 (Passive) and **extended by the manual activation of available flexibilities**. The "**Active**" Use Case is implemented in the GCM System, EMS4HESS, and HEMS. The GCM system monitors grid and asset utilization and flexibility potential based on data received from grid monitoring devices and the EC's HESS and calculates load flow, estimates missing grid and asset parameters, forecasts, and recommendations and incentives. The EMS4HESS constantly monitors the energy data sent from the HEMS, the flexibility profile of the HESS, and signals from the DSO/Supplier. **A DSO/Supplier or GCM signal triggers the EMS4HESS to generate insights to send to respective EC Participants to act on, based on the EC Management's system priorities, which may be maximizing self-consumption, self-sufficiency, or other custom metrics. There is an intent to activate flexibility albeit manually and on the prerogative of the EC Management and individual EC Participants.** Thus, the outcome of any flexibility activation requests, incentivization,

	and intended optimization may only be appreciated expost, as far as any implicit distributed flexibility (e.g., time-of-use optimization, in-home self-balancing, peak shaving, emergency power supply) can deliver.
UC 3 - Automated Energy Community Participation with Human Inputs	This use case is based on Use Case 1 (Passive) and Use Case 2 (Active) and **is extended by the automated activation of available flexibilities**. Automated flexibility activation for grid-friendly behaviour has the highest priority. The "**Automated with Human Inputs**" Use Case is implemented in the GCM System, EMS4HESS, and HEMS. The GCM system monitors grid and asset utilization and flexibility potential based on data received from grid monitoring devices and the EC's HESS and calculates load flow, estimates missing grid and asset parameters, forecasts, and recommendations and incentives. The EMS4HESS constantly monitors the energy data sent from the HEMS, the flexibility profile of the HESS, and signals from the DSO/Supplier. **A DSO/Supplier triggers the EMS4HESS via GCM signal to explore optimization pathways based on preferences and constraints provided by the Participants and the EC Management. If called for, the EMS4HESS will also operate within the constraints/limits set by the DSO/Supplier. Without DSO/Supplier signals, the EMS4HESS shall still constantly explore optimization pathways based on the same constraints and preferences and shall inform the Participants whenever an optimization opportunity is available. Using trade-off exploration based on optimization considerations, the EMS4HESS simplifies its insights and sends only options to the Participants through HEMS notifications. Any implementation of an optimization activity has to be confirmed by the Participants unless they choose automatic implementation based on their pre-provided preferences.** The outcome of any flexibility activation requests, incentivization, and intended optimization may be appreciated almost real-time, as far as any implicit distributed flexibility (e.g., time-of-use optimization, in-home self-balancing, peak shaving, emergency power supply) can deliver.
UC 4 - Fully Automated Energy Community Participation	This use case has the highest priority and supports the resilient grid operation. Therefore, full automation is necessary, any manual human interaction is not possible, and no further flexibility activation is possible when facing grid issues. Use Case 1 (Passive) provides the baseline for accounting. Use Case 2 (Active) and Use Case 3 (Automated with human inputs) can follow with lower priority when no grid support is needed. The "**Full Automation**" Use Case is implemented in the GCM System, EMS4HESS, and HEMS. The GCM system monitors grid and asset utilization and flexibility potential based on data received from grid monitoring devices and the EC's HESS and calculates load flow, estimates missing grid and asset parameters, forecasts, and recommendations and incentives. The EMS4HESS constantly monitors the energy data sent from the HEMS, the flexibility profile of the HESS, and signals from the DSO/Supplier. **A DSO/Supplier or GCM signal triggers the EMS4HESS to explore optimization pathways based on preferences and constraints provided by the Participants and the EC Management. If called for, the EMS4HESS will also operate within the constraints/limits set by the DSO/Supplier. Without DSO/Supplier signals, the EMS4HESS shall still constantly explore optimization pathways based on the same constraints and preferences. Using trade-off exploration based on optimization considerations, the EMS4HESS automatically implements the most optimal option based on the respective Participants' predetermined preferences and constraints.** Participants can track any implemented flexibility activity through the HEMS and can modify their preferences through it. The EMS4HESS does not require Participants' consent before activating flexibility. The outcome of any flexibility activation requests, incentivization, and intended optimization may be appreciated almost real-time, as far as any implicit distributed flexibility (e.g., time-of-use optimization, in-home self-balancing, peak shaving, emergency power supply) can deliver.

IEC SRD 62913-2 documents and especially part 2-3 were reviewed to identify the coverage of PARMENIDES use cases. It has been identified that the standard does not directly mention energy community. However, the energy community notion is covered by distributed energy resources (DERs) (i.e., by neglecting internal processes).

From a generic perspective energy community use cases are already covered by the use cases of the document and especially the DER section. Below are some relevant examples of relevant use cases:

- DER owner sells energy to the grid based on energy tariff
- Aggregator manages DER systems in order to sell energy to the grid based on contracts
- DER owners/operators receive pricing information for energy and respond by changing DERs and loads
- DER owners/ operators receive pricing information for ancillary services and respond appropriately
- DER owners/ operators maintain the DERs to provide optimal availability and capabilities

However, the PARMENIDES use cases are focused on the types of flexibility management into the energy community. They especially detail different levels of automation from zero to maximum. This notion of automation could be found very briefly in some examples but without going into detail. Table 13 presents some of the use cases which approaches Parmenides' use cases without covering them.

Table 13: IEC 62913-2-3 uses cases description examples

IEC 62913-2-3 use cases	Description
Home behaviour to the Resident/Client's preferences	How the Resident/Client customises the management of his appliance(s) namely during dynamic peak periods and the monitoring of events, according to his preferences (decision between comfort and economic optimisation). He may choose to respond to events in manual mode or automatic mode, and may in this second case delegate the customisation to an authorised Third Party. Needed system use cases: • Responses (price signals, DR requests, emergency signals)
Manage flexibility on electricity demand and generation within the Smart Home from market signals	The Business Use Case describes how the client/Resident responds to market signals (price incentives or DR requests) and adapts the behaviour of the Smart Home. Needed system use cases: • Manage the flexibility of the Smart Home on electricity demand and generation from prices incentives • Manage the flexibility of the Smart Home on electricity demand and generation from DR requests • Manage opt-outs to automatic responses (only prices signal and DR requests, emergency excluded), including manual actions
Manage flexibility on electricity demand and generation within the Smart Home from emergency signals	The Business Use Case describes how the client/Resident responds to emergency signals and adapts the behaviour of the Smart Home. Needed system use cases: • Manage the flexibility of the Smart Home on electricity demand and generation from emergency signals
Provide enriched Smart Home data to relevant Parties in order to make the Resident/Client more active	The Business Use Case describes how the Resident/Client or an authorised Third Party receives electricity data regarding the electric behaviour of the Smart Home. The occurrence of events is monitored and the Client/Resident is warned if an event occurs. Needed system use cases: • Provide alarms related to the smart home electricity behaviour to the client or resident • Provide a Third Party with enriched Smart Home electricity data
Customer preferences to minimize customer costs and/or maximize customer convenience	The Business Use Case describes how the Resident/Client customises the management of his appliance(s) namely during dynamic peak periods and the monitoring of events, according to his preferences (decision between comfort and economic optimisation). He may choose to respond to events in manual mode or automatic mode, and may in this second case delegate the customisation to an authorised Third Party. Needed system use cases:

	• Manage the flexibility of the Smart Home on electricity demand and generation from price incentives. • Manage the flexibility of the Smart Home on electricity demand and generation from DR requests. • Manage opt-outs to automatic responses (only prices signal and DR requests, emergency excluded), including manual actions.

While the standard does not use the term "energy community" explicitly, its scope and use cases directly support the technical and operational frameworks that enable energy communities.

Recommendations for BRIDGE and IEC SRD 62913-2 series

- Add the notion of energy community to IEC SRD 62913-2 series (e.g., Part 2-3).
- Add new use cases defining the different types and levels of automation of flexibility management and engagement into energy community/DER/Smart Home/Smart building.

These points will be raised to the BRIDGE initiative and the IEC SRD 62913 standardisation group.

5.4.2 Action: PARMENIDES Architecture

Trialog is actively contributing to the SC41 AG35 Pattern Repository called “Architecture template” in the context of PARMENIDES contribution to standardisation.

SC41 AG 35 Pattern Repository [27] aims at:

- Specify the SMART standard needs for architecture patterns.
- Specify a demonstration combining RAs with patterns from other domains.
- Engage with Online Standards Development (OSD) support on the possibility of editing a pattern as a separate project.
- Engage with OSD support on the possibility of generating a document combining several OSD documents.
- Undertake a demonstration

The overall objective is to avoid silos and push forward reusability.

Based on ISO/IEC 30141 Internet of Things (IoT) — Reference architecture [28], pattern template (section A.2 and A.3), Trialog has contributed by proposing an architecture pattern template and by proposing possible evolutions for a more complete and clear representation of a pattern.

To support this work and based on the PARMENIDES architecture, Trialog has created a PARMENIDES architecture pattern based on the pattern template of the section A.2 and A.3 in ISO/IEC 30141 Internet of Things (IoT) — Reference architecture. This pattern will be proposed as an example in this new standard to support the overall document.

According to the work achieved within the project for the architecture definition, the PARMENIDES architecture model is a specialisation of SGAM, ISO/IEC 30141 and Smart Home/Building IoT Reference Architecture (SHBIRA).

Table 14: Standardisation PARMENIDES architecture pattern

Information	Name	PARMENIDES Reference architecture (PARMENIDES: Plug&plAy eneRgy ManagEmeNt for hybrID Energy Storage)
	Related patterns	**Smart energy Grid Architecture Model (SGAM)** (standardised pattern) Unified standard allowing for the representation of a smart grid architecture. **SC41 30141 IoT Reference Architecture** (standardised pattern): This standard provides a standardised IoT Reference Architecture using a common vocabulary, reusable designs and industry best practices. It uses a top-down approach, beginning with collecting the most important characteristics of IoT, abstracting those into a foundational view, then providing five more views including a construction view with a set of architecture and design patterns for building IoT systems. **Smart Home/Building IoT Reference Architecture (SHBIRA):** Proposal from the Interconnect project in Deliverable D2.1 Secure Interoperable IoT Smart Home/Building and Smart Energy system Reference Architecture – Chapter 4.3. SHBIRA provides a viewpoint that enables to see the relationship of the digital/IoT platforms. By complying it to the SHBIRA it is possible to add interoperability in a general and unified way instead of specifically per-interface/service.
Problem		Semantic interoperability was necessary among the project architecture and the pilots, with a specific focus on the energy community topic in the project. PARMENIDES aims to develop a new ontology by extending existing ontologies to provide a knowledge base, with a focus on the electricity and heating domain for buildings, customers, and energy communities. It supports different use cases, focusing on the utilisation of Hybrid Energy Storage Systems (HESS). Besides the representation of storage technologies, information about energy community customers, their behaviours, and components including their relation are part of the ontology, providing a standardised vocabulary of the domain of energy communities. The name of this ontology is PARMENIDES Energy Community Ontology (PECO).
Known context	Specific context	PARMENIDES is a European HORIZON project funded by the European Commission in 2022. Project duration January 2023 to December 2025.
	Related context	Energy domain – Energy community SGAM pattern is used universally in the energy domain

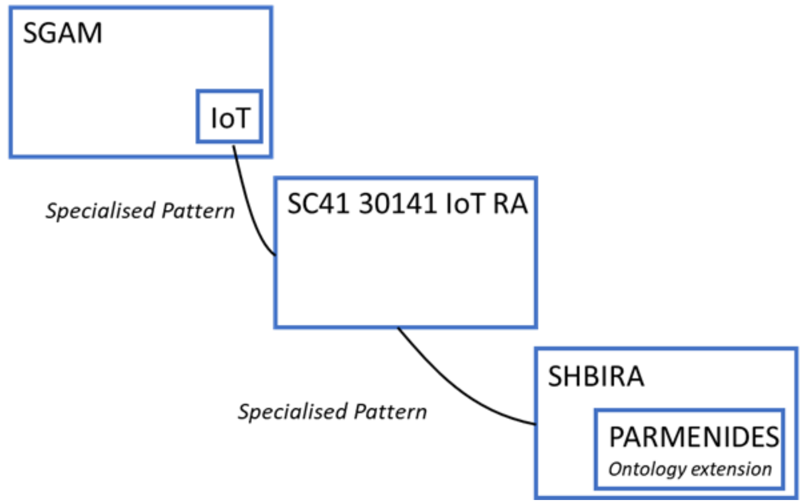
<table>
<tr><td rowspan="4">Solution</td><td>Architecture models</td><td>

Figure 1: PARMENIDES Reference Architecture context</td></tr>
<tr><td>Examples</td><td>PARMENIDES pilot implementation could be found in Deliverable D3.1 – PARMENIDES System Architecture – Chapter 6</td></tr>
<tr><td>Rationale for the pattern</td><td>Add ontology in the SHBIRA pattern.
SHBIRA pattern was used in order to describe the DER (Distributed Energy Resources) area, which was the main focus of PARMENIDES project. The SGAM pattern was not precise enough on this specific part.</td></tr>
<tr><td>Guidance</td><td>PARMENIDES pattern is oriented for Energy communities.
PARMENIDES adds an ontology (PECO) to the SHBIRA architecture.
PARMENIDES uses SHBIRA to describe the DER area of the architecture.
The PECO ontology is used for interoperability in the project energy community.</td></tr>
</table>

5.4.3 Action: interoperability – PECO

PARMENIDES Energy Community Ontology (PECO) was developed within the project. This ontology is based on SAREF concepts. SAREF ontology is composed of SAREF-core and domains' extensions.

Smart Applications REFerence (SAREF)

The SAREF suite of ontologies forms a shared model of consensus intended to enable semantic interoperability between solutions from different providers and among various activity sectors in the Internet of Things (IoT), thus contributing to the development of dataspaces.

SAREF is published as a set of open standards produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M) and now managed by ETSI TC DATA. The ETSI portal for SAREF exposes the SAREF ontologies and points to the different SAREF-related deliverables.

Figure 3, presents the structure of SAREF[53] and its extensions:

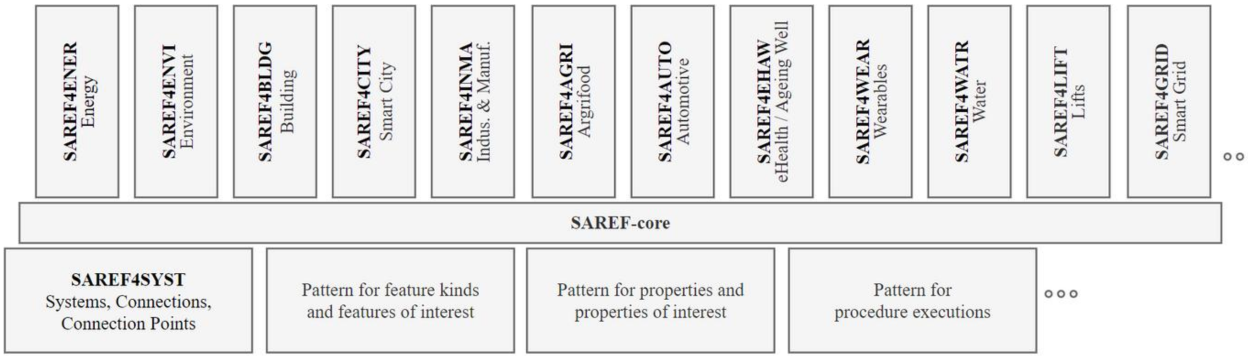


Figure 3: SAREF structure and its extensions

SAREF Core:

SAREF Core specifies recurring core concepts in the smart applications domain, and the main relationships between these concepts. The figure before provides an overview of SAREF Core.

SAREF extensions:

- SAREF4ENER: SAREF extension for the Energy domain
- SAREF4ENVI: SAREF extension for the Environment Domain
- SAREF4BLDG: SAREF extension for the Building domain
- SAREF4CITY: SAREF extension for the Smart Cities domain
- SAREF4INMA: SAREF extension for the Industry and Manufacturing domains
- SAREF4AGRI: SAREF extension for the Smart Agriculture and Food Chain domains
- SAREF4AUTO: SAREF extension for the Automotive domain
- SAREF4EHAW: SAREF extension for the eHealth/Ageing-well domain
- SAREF4WEAR: SAREF extension for the Wearables domain
- SAREF4WATR: SAREF extension for the Water domain
- SAREF4LIFT: SAREF extension for the Smart Lifts domain
- SAREF4GRID: SAREF extension for the Smart Grid domain

PECO and SAREF

Certain topics were identified as missing from SAREF and its extensions, such as energy communities, hybrid energy storages and energy tariffs. PECO filled this gap by modelling concepts needed for these topics and aligning it with SAREF. It has been identified near the end of the project that PECO could be disseminated to SAREF, as some concepts developed for the purpose of the project could be generalised and reused in the general energy community context.

[53] https://saref.etsi.org/

The following two options were identified:

- **Option 1 – Propose a new SAREF extension:** PECO (with some refinements) could be submitted to become a new extension of SAREF with a specific focus on energy communities and/or energy tariffs. Process for accomplishing this would have to follow the procedures outlined in standard ETSI TS 103 673: "SmartM2M; SAREF Development Framework and Workflow, Streamlining the Development of SAREF and its Extensions".
- **Option 2 – Disseminate PECO new concepts to SAREF existing extensions:** This option would entail the identification of new PECO concepts missing from SAREF and disseminating them to SAREF through the ETSI Forge.

Some meetings were organised with some ETSI TC DATA (SAREF) members to define these options, clarify the methodology and possibilities. They were very interested in PECO and its scope.

Project partners assessed these possibilities and agreed on the high added value of these two options. However, it has been decided not to proceed with this activity, due to the lack of resources and time in the project. Indeed, this dissemination activity was not originally planned and both options would require extensive use of time and effort expenditure. PECO developers remain committed to continuing development, refinement and usage of PECO in activities following the PARMENIDES project and intend to revisit the standardisation topic at another occasion.

Conclusion

This dissemination activity could be accomplished at a later date within another EU project, with the objective to refine and generalise PECO ontology to propose it to SAREF maintainers as a new extension(s) to fill the energy community and energy tariff gaps.

6 Report conclusion

This report analysed the regulation, standardisation, and certification schemes needed to support the market introduction of PARMENIDES Key exploitable results. It went through the most relevant regulations regarding the KER. The project KERs will have to be aligned with these regulations to be allowed on the European market. This analysis took into consideration the energy and data, interoperability, trustworthiness, privacy, cybersecurity, and AI aspects. The section on standardisation provides an overview of the current standards and standardisation groups relevant to the project, focusing primarily on harmonised standards. Certification is a crucial aspect for PARMENIDES KERs, making the solutions more trustworthy and ready for real-world use. The study has done a specific focus on EMS and hybrid storage certification processes in Europe.

Some PARMENIDES partners are continuously working with SDOs. Some specific actions were identified to contribute to standardisation based on project results and activities. These contributions were mainly focused on the use cases, the architecture, and PECO.

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7 Annex

7.1 List of Figures

7.2 List of Tables


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