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Abstract:	It is composed with three parts: Part I-Standardisation on interoperability, Part II-Reliability regulation, Part III-Standard contribution of privacy legal framework. Part I describes the list of existing standards focusing on data interoperability, PLATOON's standardisation items and its contributions. Part II explains reliability indicators, related regulations, co-creation workshop, experts' interview results and recommendations. Part III summarized developed legal framework and contribution to the criteria of Europrivacy certification scheme in smart grid sector.
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		Modification Reason	Modified by
V0.0	3 May 2021	1st version of TOC	UDGA
V0.1	9 Dec 2021	Update the structure and add some of existing standards and general info about identified standard items.	UDGA
V0.2	30 Mar 2022	Added more existing standards and analysis of Platoon's data models.	UDGA
V0.3	9 May 2022	Added relevant standards and Platoon's strategies on Data models.	UDGA
V0.4	29 Jun 2022	Added Platoon's strategies on IDS standards.	UDGA
V0.5	30 Sep 2022	Updated IDS standards approaches and study results of reliability indicators.	UDGA
V0.6	24 Oct 2022	Restructured documents into three parts and added the results and analysis of co-creation workshop.	UDGA
V0.7	30 Nov 2022	Added study results of reliability frameworks and big data analytical techniques.	UDGA
V0.8	7 Dec 2022	Updated standardisation results, added experts interview results and recommendations.	UDGA
V0.9	8 Dec 2022	MI's inputs on Data Protection	MI
V1.0	11 Dec 2022	Integration of all inputs, refinement of overall document and submission the first version for the internal review.	UDGA
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V1.6	20 Dec 2022	Internal review results	IND
V2.0	21 Dec 2022	Applied internal review comments and made the final version	UDGA

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Terms and abbreviations

API	Application Programming Interface
CEM	Customer Energy Management
CIM	Common Information Model
COSMAG	Comprehensive Architecture for Smart Grid
DA	Distribution Automation
DER	Distributed Energy Resources
DMS	Distribution Management System
DPIA	Data Protection Impact Assessment
DPO	Data Protection Officers
DR	Demand Response
DSO	Distribution System Operator
DSM	Demand Side Management
ECCP	European Centre for Certification and Privacy
EDPB	European Data Protection Board
EMG	Energy Management Gateway
EMS	Energy Management System
EN	European Standard
GA	Grant Agreement
GUI	Graphical User Interface
HVDC	High Voltage Direct Current
IED	Intelligent Electronic Devices
IOT	Internet of Things
IDS	International Data Spaces
IT	Information Technology
LV	Low Voltage
MV	Medium Voltage
NIC	Network Interface Controller
NRA	National Regulatory Authority
PaaS	Platform as a Service
PBR	Performance-Based Regulation
PLC	Power Line Carrier Communication
OPC UA	Open Platform Communications Unified Architecture
SA	Subsystem Automation
SAREF	Smart Applications REFerence (SAREF) ontology
SCADA	Supervisory Control and Data Acquisition
SGAM	Smart Grid Architecture Model
SGCP	Smart Grid Connection Point
TM	Technical Manager
ToE	Target of Evaluation
WP	Work package

Executive Summary

The Task 8.4: "Regulatory and policy framework, lessons learned and recommendations" has three objectives stated in DoA:

- Identification of priorities for standardization and engagement in standardization activities mainly in interoperability issues, data model or smart building.
- Develop recommendations for regulation bodies to improve and/or update the reliability indicators used by electric power utilities on its assets such SAIDI or SAIFI.
- To ensure that the PLATOON foreground is visible to interested parties and to support networking.

This deliverable is a summary of the activities and results performed according to these objectives. Reflecting the two big topics of the objectives, standardization issues of interoperability with visibility, and the regulatory issues of reliability indicators were performed in two tracks. In standardization, interoperability issues and data protection issues were performed. In this regard, this document is composed with three parts as followings:

- PART I: Standardization on interoperability – focusing on energy data interoperability
- PART II: Reliability regulation – focusing on gaps and impact of big data analytics on energy reliability
- PART III: Standardized assessment for data protection – contribution to Europrivacy standardized certification scheme

In more details, PART I describes the study results of existing standards related to PLATOON's scope of data interoperability in the categories of smart grids, big data, semantic interoperability and data governance. PLATOON has set up its standardization goal for data interoperability as to contribute to European Energy Data space. Accordingly, two topics of PLATOON project results were selected: PLATOON ontology and IDS standards. For ontology standardization, One-stop Energy Ontology portal collecting a large set of PLATOON ontology is on finalizing status in the moment of writing this document, that can contribute to the community to use and share common data models. For IDS standards, both technical contributions including three technical components and three use case contributions for ecosystem buildings were submitted. The contributions were highly appreciated and positioned PLATOON as an important player of IDS standard based data space building, with confirmation of further promotion and activities scheduled in the next year. Efforts to increase PLATOON's visibility in the community was performed as well, in parallel with standardization activities through IDSA, BDVA, Open DEI, FIWARE, etc.

PART II starts with explanation of the most referred reliability indicators and relevant regulatory and policy frameworks that can reflect green transformation and digital transformation of energy system. It also summarizes a set of big data analytical techniques relevant to energy reliability. In order to gather lessons learned by project implementation, a co-creation workshop and experts' interview were performed. The summary of the results and analysis were added in the report, which resulted in generating a set of recommendations in energy reliability with a focus of the impact and role of big data analytical techniques that PLATOON is specialized.

PART III briefly lists legal frameworks assessed under WP1 and Data Protection Impact Assessment (DPIA) performed under WP3 for the wrap-up of the background activities. The lack of standardized guidance and/or methodologies was identified as a potential problem for research projects, and PLATOON contributed to Europrivacy Certification Scheme to build a

standardized assessment methodology in smart grid section. As a result, PLATOON's proposal of additional criteria on the use of AI and the use of smart grids in the Target of Evaluation (ToE) were incorporated into Europrivacy's Complementary Contextual Checks and Controls. Eventually, Europprivacy scheme was adopted by the European Data Protection Board (EDPB) as the first European-wide certification according to Article 42 GDPR, providing standardized assessment methodology for data protection impact assessment in smart grid section.

PART I : Standardisation on interoperability

1 Introduction

The anticipated benefits stemming from smart, digital grids can be guaranteed only with appropriate levels of interoperability - i.e., the smart grid actors, components and applications should be able to work together by exchanging data and information. It can be achieved by reaching agreement among them to use the same methods (standards) for exchanging data and information. A smart grid consists of numerous components provided by different actors, working together to provide a smart power system. For such a system to operate and the desired services and functionalities to be provided in a sustainable way, interoperability of components and attached processes to demonstrate such interoperability become of major importance.

In terms of using standards in the development, as a fundamental of EU R&I projects on digitalisation, PLATOON has built upon open-source software and open standards protocols. The architecture was built upon the principle of International Data Space Association (IDSA) for data sharing and interoperability, and the components are designed and developed with open source based, so that the results of the project can be easily distributed and reused.

The focus of standardisation of PLATOON is also fully dedicated to energy data interoperability issues, where the results of PLATOON contribute to the relevant community, actors and stakeholders. Eventually, PLATOON aims to contribute to European Common Energy Data space with its interoperable solutions and data following the European data policy and Green Deal goal.

PLATOON has analysed the most relevant European and International initiatives, related to the interoperability and standardization, in order to identify the most suitable standards for the needs of the projects.

Related technologies and their standardisation in Energy sector are broad and it needs to narrow the targeting topics in order to perform efficient work on standardisation. Task 8.4 studies the existing standards and coordinates contributions of PLATOON results to relevant standard groups, reflecting the experiences and expertise that gained through the project development. As digital energy solutions evolve, it is considered to find missing pieces of such standards to achieve interoperability. It takes three steps that are co-related and co-input each other: Analysis, identification and definitions, and contributions as shown in Figure 1.

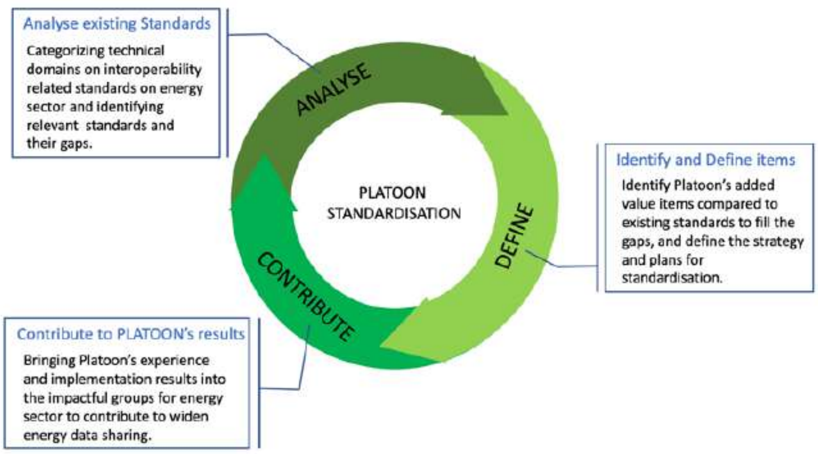


Figure 1 Platoon's standardisation methodology

Standardisation is moving forward and analysis of existing standards should be continued and give inputs to identify and define PLATOON's strong valued items for contributions. Collaborative work was performed for selected items to contribute to more energy data sharing in interoperable manner. Based on the status of each target standards groups, the defined strategy and plans has been dynamically updated for bringing further contributions.

The Part I of this deliverable made brief summary of the selected existing standards in the scope of PLATOON in the Section 2. It explained the selection of target standardisation in the Section 3, described the results of standardisation activities in the Section 4, and provided lesion learned and the paths for further standardisation in the Section 5.

2 Study on Existing standards

For the standardization, it is necessary to find relevant standards and their current status that are widely used in smart grids and energy digitalization. PLATOON is particularly focusing on interoperable solutions on energy digitalisation, so that the study on existing standards is made not only related to typical energy domains but also related to digital platform interoperability through the standardisation area of smart grids, big data, semantic interoperability and data governance.

2.1 Smart grids

IEC has published a large set of standards that are used on smart grid from basic connectivity of meters to its services. IEEE also has wide range of smart grid related standards. This section briefly gives an outlook of relevant standards from different organisations.

2.1.1 CEN-CENELEC-ETSI Coordination Group on Smart Grids (CG-SG)

The Smart Grid Coordination Group (SG-CG) composed by ESOs (CEN, CENELEC and ETSI) working to deliver Smart Grid Architecture Model (SGAM). Since January 2021, the group advises on European standardization requirements relating to smart electrical grid and multi-commodity smart metering standardization, including interactions between commodity systems (e.g., electricity, gas, heat, water), and assesses ways to address them. This includes interactions with end-users, including consumers/prosumers.

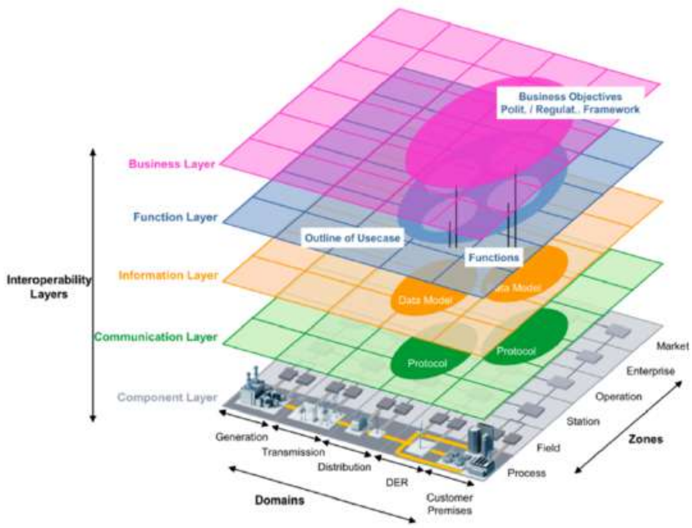


Figure 2 Smart Grid Architecture Model (SGAM) by CEN-CENELEC-ETSI Smart Grid Coordination Group

Its aim is to promote the deployment of open and interoperable data architectures, based on European and international standards. The scope also includes any standards needed to design, operate and maintain electrical grids securely and efficiently. In the specific area of metering, its scope includes electricity, water, gas and heat/cooling metering devices and systems, and associated architectures. PLATOON also referred the concept of the architecture shown in Figure 2.

2.1.2 IEC

IEC covers a large set of energy standards. CEN-CENELEC-ETSI Smart Grid Coordination Group published a report with analysis of standards for smart grid that contains a good summary of the coverage of the IEC standards per layers (Figure 3) and functionalities[1].

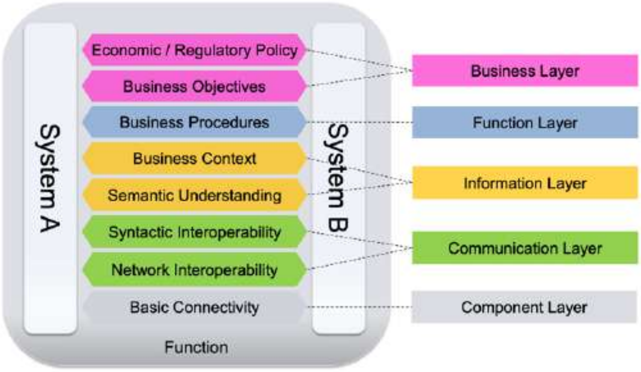


Figure 3 Grouping into Interoperability layers (source: CEN-CENELEC-ETSI Smart Grid Coordination Group, SGCG/M490/G – version 3.1)

Among the large set of IEC standards, the IEC 61850 (Communication networks and systems for power utility automation) standards are a foundational series of publications on communication protocols for intelligent electronic devices and electrical substations, which pave the way for the use of a variety of digital technologies relating to smart energy. They deal with issues such as the integration of renewable energies and distributed energy resources (DERs) within the electrical network. The features of the standards cover data modeling, reporting schemes, fast transfer of event, setting groups, sampled data transfer, commands, and data storage.

Also, IEC 61450-25 series that handles application of the IEC 61850 methodology for Wind turbines is importantly noted as the Pilot 1a in PLATOON is on wind farm. The series is composed of 4 parts, handling overall description, information models, information exchange models and mapping to communication profile.

Common Information Model (CIM) related standards that are directly impact PLATOON's ontology. IEC 61970 defines application programming interfaces for the Energy Management System (EMS). It includes a set of Common Information Model (CIM) and Common Interface Specification (CIS). While there are multiple IEC standard series dealing with different parts of the CIM, there is a single, unified information model comprising the CIM behind all these individual standard series is IEC 61970-301: CIM base. It provides a logical view of the physical aspects of an energy management system including SCADA (Supervisory Control and Data Acquisition). IEC 61968 series are standards for information exchanges between electrical distribution systems. It defines interfaces for all the major elements of the interface architecture for Distributed Management System (DMS). IEC 62325-301 corresponds to IEC 61970-301

[1] CEN-CENELEC-ETSI Smart Grid Coordination Group, SGCG/M490/G – version 3.1

and IEC 61968-11 which describe parts of the CIM relevant to modelling interfaces for EMS, DMS and Market Management System (MMS) systems.

2.1.3 IEEE

IEEE Standards Association (SA) produced and is producing a large set of standards in energy utility of energy generation, transmission, distribution, etc. By the paradigm shift toward more decentralised energy infrastructure, it produces a series of standards on Distributed Energy Resources (DER) standards with a few examples of:

- IEEE 1547 series and corresponding implantation guides of DER in IEEE P1547.3.
- IEEE 2030 series handles the integration of power and communication and information technologies, including communication protocols and their operation between DERs and elements of the smart grids.
- IEEE P2418.5 about standard for blockchain in energy provides an interoperable reference framework model for distributed ledger technology in energy sector.

After two years of an incubation project of IEEE Future Directions Committee (FDC), IEEE generated IEEE Smart Grid initiative, a dedicated program on smart grids. It published multiple vision reports on computing, control systems, vehicular, communications such as IEEE Smart Grid Vision for Computing: 2030 and beyond, IEEE Smart Grid Vision for Communications: 2030 and beyond, etc., as well as a set of IEEE Grid Vision 2050 reports. A full list is in https://standards.ieee.org/products-programs/standards-related/research/. IEEE Smart Grid also provides relevant resources of IEEE standards, technical papers, event information on smart grids in the categories of foundational support systems, energy generation, distribution, transmission, operations, market, service provider, and customer, which can be found in https://smartgrid.ieee.org/about-ieee-smart-grid/standards/ieee-approved-proposed-standards-related-to-smart-grid.

Although IEEE has many interesting standards in smart grids, the scope of PLATOON project, particular focuses with energy data interoperability, did not focus in IEEE standardisation, but the readers who are interesting in IEEE smart grid could check the above-mentioned links.

2.1.4 OpenADR Alliance

The OpenADR Alliance was created to standardize, automate, and simplify Demand Response (DR) and Distributed Energy Resources (DER) to enable utilities and aggregators to cost-effectively manage growing energy demand & decentralized energy production, and customers to control their energy future. OpenADR is an open, highly secure, and two-way information exchange model and Smart Grid standard. The OpenADR 2.0a and 2.0b Profile Specifications provide specific implementation related information in order to build an OpenADR enabled device or system.

2.2 Big Data

Big data analysis is one of the key technologies to enable digitalisation of the energy domain. There are several groups working on big data standardisation aimed at exploring a framework for Big Data Standards.

2.2.1 BDVA / DAIRO

With over 230 members across Europe, Big Data Value Association (BDVA) / Data, AI and Robotics (DARIO) is an industry-driven international non-profit organisation. The Big Data

Value reference model has been developed with input from technical experts and stakeholders along the whole big data value chain as well as interactions with other related public-private partnerships (PPPs). It is not taking a role of standards but one of the reference architectures of big data value system. Mostly, it is compatible with ISO/IEC JTC1 WG9 Big Data Reference Architecture.

Although BDVA / DAIRO is not a standard body but has an important role in data space development. PLATOON also collaborated with BDVA and created a Task Force that is explained more in the Section 3.

2.2.2 ISO/IEC JTC1 on Big Data and AI

the ISO/IEC Joint Technical Committee (JTC) 1 established Working Group (WG) 9 to serve as the proponent for JTC 1's standardisation program on big data. Among the standards set within the context of this group, include the ISO/IEC 20546:2019 which sets the big data overview and vocabulary, providing a terminological foundation. It also created the ISO/IEC 20547 series on big data reference architecture with 5 parts: Part 1 - Framework and Application Process, Part 2 - Use cases and Derived requirement, Part 3 - Reference Architecture, Part 4 - Security and Privacy Fabric, and Part 5 - Standards Roadmap, which provides users with a standard to develop and implement big data architectures. The reference architecture provides two architectural viewpoints: (a) a user view defining roles/sub-roles, their relationships, and types of activities within a big data ecosystem; (b) a functional view defining the architectural layers and the classes of functional components within those layers that implement the activities of the roles/sub-roles within the user view.

WG9 was disbanded in 2017 and was transferred to ISO/IEC JTC 1/SC42 "Artificial Intelligence," that completed the establishment in may 2018. It produced and is developing a set of standards on AI. Its focuses are so far more general aspects of AI rather than specific domains such as energy. The scope and the list of the standards can be found in https://jtc1info.org/sd-2-history/jtc1-subcommittees/sc-42/.

2.3 Semantic interoperability

Semantic interoperability is one of the key features to enable data interoperability. PLATOON also worked on semantic interoperability and developed a large set of ontology and semantic tools in the platform. The following sections briefly describe a selected set of standardisation activities.

2.3.1 SAREF

The Smart Applications REFerence (SAREF) ontology (https://saref.etsi.org/) is a shared model of consensus that facilitates the matching of existing assets in the smart applications domain. Among several extensions of the ontology, SAREF4ENER provides a specific set of energy domain. It gives a graph view of SAREF4ENER overview and a list of classes and properties of each ontology. More details can be found about groups of ontologies in Device, Power Profile and Alternatives group and Load Control. The information can be found either in the webpage of SAREF4ENER (https://saref.etsi.org/saref4ener/v1.1.2/) or ETSI technical specification, "ETSI TS 103 410-1, Smart M2M; Extension to SAREF; Part 1: Energy Domain[2]"

[2] https://www.etsi.org/deliver/etsi_ts/103400_103499/10341001/01.01.02_60/ts_10341001v010102p.pdf

PLATOON uses existing SAREF ontologies wherever applicable, not only from SAREF4ENER but from general part of ontology such as SAREF4SYST (SAREF for System). A set of ontologies are updated to apply the use case requirements from the PLATOON pilots. The details of the ontology definition are found in D2.3 developed under Task 2.3.

2.3.2 IEC CIM

As stated in the section 2.1.1, IEC Common Information Model standards (CIM) takes an important role in data model definitions in energy sector. CIM is a set of open standards for representing power system components representing all the major objects in electric utility operations. The up-to-date version and schema of CIM standards are found in https://www.dmtf.org/standards/cim/cim_schema_v2530.

PLATOON also used CIM models in designing its data models for the use cases. PLATOON updated some of the models to fit the use case requirements and link to PLATOON's semantic interoperability development. The details of the models are explained in D2.3.

2.3.3 EUREKA ITEA 12004 SEAS

EUREKA ITEA 12004 Smart Energy Aware Systems (SEAS) project enables energy, ICT and automation systems to collaborate at consumption sites and introduce dynamic and refined ICT based solutions to control, monitor and estimate energy consumption[3]. One of the important results is SEAS ontology (https://w3id.org/seas/). The results is also a base of SAREF4SYST, ontology pattern for systems, connections and connection points, which is stated in the ETSI Technical specification, ETSI TS 103 548 V1.1.2 (2020-06): "SAREF consolidation with new reference ontology patterns, based on the experience from the SEAS project".

PLATOON also reused the SEAS ontology for its definition of data models. The details can be found in D2.3.

2.3.4 IDS Information model

International Data Space (IDS) Information model defines domain-agnostic models aiming at describing, publishing and detecting data assets and reusable data processing software (data app) in IDS. IDS reference architecture defines conceptual representation and IDS ontology provides declarative representation and IDS information model library is for programmatic representation. The concepts and the ontology models are shared in IDS github, https://international-data-spaces-association.github.io/InformationModel/docs/index.html

IDS information models are fully alignment with GAIA-X self-descriptions of the data ecosystem and the contribution and collaboration are further on going.

2.3.5 Smart data model (smartdatamodel.org)

FIWARE has developed common data models developed by its community which are widely used in diverse vertical sectors such as smart cities, smart agriculture, smart water, etc. The collaborative effort by the open-source community has been evolved to 'smartdatamodel.org' with ETSI's NGSI-LD based information models. It takes an agile method for standardisation differentiating it from the traditional standard bodies, and follows the goal of building European Common Data space with the principle of widen the use of interoperable semantics. It has a set

[3] https://itea4.org/project/seas.html

of data models dedicated to energy sectors summarised in the Appendix I-I Table 2 as a current status, that was summarised to find out gaps where PLATOON could contributed. The full sets of data models can be found in its github: https://github.com/smart-data-models/SmartEnergy.

PLATOON considered to contribute to smartdatamodel.org. There was a gap that the group is NGSI-LD based models, while PLATOON defined ontology data models. However, the group started to accept ontology models recently, and positive discussion is ongoing, which is further discussed in the Section 3.

2.3.6 ISO/IEC JTC 1 SC41

ISO/IEC JTC 1 also created SC41 on Internet of Things and Digital Twin. Among its subgroups, WG4 handles IoT interoperability, connectivity, IoT Platform, middleware, conformance and testing, which is most relevant to the scope of PLATOON. Its work programs under development are as followings:

- ISO/IEC 21823-3, Internet of Things (IoT) – Interoperability for IoT Systems – Part3: Semantic interoperability. It provides detail on the basic concepts of Semantic Interoperability for IoT systems, as described in the facet model of ISO 21823 Part 1.
- ISO/IEC 21823-4, Internet of Things (IoT) -Interoperability for IoT Systems - Part 4: Syntactic interoperability. It provides detail on the basic concepts of Syntactic Interoperability for IoT systems, as described in the facet model of ISO 21823 Part 1.
- ISO/IEC 30178, Internet of Things (IoT) – data format, value and coding. It defines a common formats value and coding for IoT.
- ISO/IEC 30161-2, Internet of Things (IoT) – Data exchange platform for IoT services – Part 2: Transport interoperability between nodal points. It specifies requirements, functional blocks, operation mechanism for the transport interoperability among nodal points in the IoT data exchange platform.

These works are ongoing and didn’t fit to the PLATOON’s project time line but can be referred for the related projects in the future.

2.4 Data governance

Digital Sovereignty, data governance and security are key issues in the energy sector. Moreover, in order to realise data interoperability in energy sector, such features are the MUST to provide. International Data Space Association (IDSA) provides the most advanced and promising standards in this technical domain.

2.4.1 IDSA

There are various large initiatives aiming at creating environments for secure data sharing and exchange. The most prominent is the International (formerly Industrial) Data Space (IDS) architecture, which envisions a sector-independent marketplace environment.

In the IDS data governance approach, data sovereignty is a central requirement. Activities are distributed to different roles in a marketplace, which include data owners/providers, data consumers, a broker service provider, a clearing house and an app store provider. The broker is in charge of matching data demand and supply by providing a method for dataset publishing and discovery through descriptive metadata. The clearing house is an optional component that is in charge of monitoring data transactions and can also be used for policy enforcement and data accounting. Clearing house functionalities can also be provided as part of the broker service. The App store enables stakeholders to develop apps that can securely transfer data at source in a standardised manner without exposing access-related security risks.

The most important technical component is the IDS connector, which enables compliance with IDS and participation between different and separate private architectures. A connector can simply be an end-point that is able to receive and execute IDS-compliant apps from recognised consumers to generate results on location and exchange them with the consumer. At consumer side, the connector needs to be able to send data requests to producers in initiated transactions and be able to receive the results in the expected format.

PLATOON is the first EU R&I Energy project adapting IDS architecture, and contributed to its results to IDSA, which is explained in the Section 3.

3 Engagement of Platoon on standardisation

PLATOON has built upon a common reference architecture based on IDS and FIWARE, open-source software provisioning of an interoperability layer based on open standards and open APIs following the “no-vendor lock in” principle, and common data models such as SAREF, CIM, SEAS, etc., which ensure data interoperability and trust among all parties. It allows that the results of the project can be easily distributed and reused and potential new business models with shared data can be generated. Such technical decisions and implementation are well described in the deliverables of each technical tasks and we will focus on standardisation and contributions of PLATOON’s results into the relevant associations, organisations and actors.

While the scope of energy digitalization is very broad, it is important to narrow down relevant standards and ongoing efforts to make interoperable solutions. It also needs to find if the consortium has relevant memberships to bring contributions. For the first step, Task 8.4 made two times surveys with the partners about ongoing standard activities and relevant topics in the scope of PLATOON. While there are some partners who are working on IEC standards, the project consortium thinks that the standards they are engaged are not targeting the interoperability of data federation, where Platoon has strength through the core project concept in digital platform and interoperability.

Four items were recommended in the survey made to consortium partners: PLATOON’s data models, IoT connector, Data connector and IDS connector. After discussion in a dedicated workshop, it was agreed that PLATOON’s data models and the IDS connector brings the most added-value by PLATOON’s genuine update on data interoperability. Thus, the consortium decided the two standardisation items as the standardisation focus of the project. In the following discussions, it also identified there are related components of IDS Connector and the group of IDS component set is considered to be standardised.

The selection was made with consideration to bring the biggest impact on interoperability and data sharing, as well as of the current standardisation status where a bigger gap on the existing standards lies. In short, PLATOON’s standardisation activities have been targeting to contribute to the project’s results toward to build a common European energy data space and positioning PLATOON as one of the references of the energy data space. It is also in line with the European data policy and the movement of building common data space in Europe.

3.1 Platoon’s data models

Many levels of interoperability can be considered, but in all cases, smart grids require interoperability at the highest level, i.e., at information semantic level. It is important to design and use components to support semantic interoperability and the primal requirements is to make syntactic interoperability.

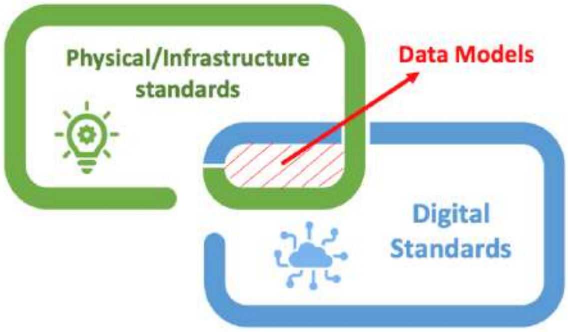


Figure 4 Standardisation of data models linking physical and digital standards

As Figure 4 illustrates that standardisation of data model is the core to link physical / infrastructure standards with digital standards. Thus, the use of standard data models is the first important step for the interoperable data exchange.

3.1.1 Identification of candidates for standardisation

PLATOON's use cases are diverse and needed a large set of data models. The primal strategy was to reuse the existing data models as much as possible, but there were some gaps to cover with the existing models. Accordingly, PLATOON updates and creates new data models. These data models are carefully designed to fit to the pilots' use cases, which are well reflecting the market needs. Thus, consortium agreed the importance and value of the work as a candidate of a standard item.

In order not to reinvent the wheel, PLATOON made a massive survey about existing data models and ontology for PLATOON's use cases. After collecting the existing data models, it analysed them and updated and created data models to fit to the use cases. Regarding the standardisation of PLATOON's data models, ENGIE has strong expertise accumulated through SEAS (Smart Energy Aware System) project, where the results were contributed to SAREF. Platoon reused the SEAS results together with SAREF and IEC CIM data models. The work has been implemented and validated through the use cases. The methodologies and categories of the models are well described in WP2 Task 2.3 documents.

In order to make a detail plan for standardisation, UDGA categorised them what were updated or created by PLATOON from the existing data models, as shown in the table in Annex I-1. This result showed that PLATOON created massive amount of new or updated data models that could bring great values to the community to widen the common data models.

3.1.2 Our approach

Considering the importance of the topics in interoperability, it was agreed to build a Task force in the consortium for the further standardisation on PLATOON's data models. The Task force team includes:

- UDGA – Planning and coordination of standardisation in contributions and actions
- ENGIE – Methodology builder, SEAS data model owner, PLATOON data model task leader
- TECN – PLATOON's technical coordinator and the main developer of vocabulary provider

Several online meetings and email discussions were made to discuss the candidate SDOs to bring the data models. There are ongoing standardisation activities in SAREF and it was discussed. However, ENGIE, the data model developer of PLATOON stated that, in their previous project, SEAS, they put their whole effort in SAFRE. However, it did not give them positive experience in terms of the outcomes compared to the needed efforts. It was also discussed that PLATOON could bring its ontology models to IEC committee, as IEC CIM models are not semantic and PLATOON updated the CIM models to connect its semantic system. However, it was discussed that the focus of IEC is not semantic oriented and the timeline of standardisation may go after the project lifetime. However, the main contributor (ENGIE) has the connecting project and would like to inherit PLATOON's data models and continue the standardisation through it.

smartdatamodel.org was also considered as a candidate place due to its advantage of agile process and its quick growing community. Considering that smartdatamodel.org is focusing on NGSI-LD based data models rather than ontology-based models that PLATOON has been built, it is on discussion to convert the ontology to NGSI-LD. smartdatamodel.org stated that they recently accepted a few ontology models with RDF formats and would willingly to help us to convert RDF to NGSI-LD models. Currently the focus of PLATOON is to finalise its One-stop portal that discusses further in the Section 3.1.3 and it was agreed that the discussion and the collaboration of the standardisation will be continued after it until the end of the project lift time and beyond.

Eventually, the overall consensus of the involved partners was to put the priority of the standardisation into contributing to build 'common energy data space' of Europe, which meant that PLATOON would focus more on sharing the data models to wider community, not stick to a certain SDOs or fora, aiming to directly contribute towards common energy data space as illustrated in Figure 5.

By this overall consensus, the decision for the standardisation of PLATOON's data models was to set as to build an open repository to share the extensive data models of the project results which will be explained more details in the following section, in parallel with introducing PLATOON's ontology in the relevant events of data space and semantic interoperability.

Figure 5 Platoon's goal on data models standardization

3.1.3 The One Stop Portal of PLATOON's data models

As mentioned in the Section 3.1.2, with several discussions on the strategy of data model standardization, it was agreed to put the highest priority to build an open repository for sharing PLATOON ontology to the community. As a result, ENGIE is building a One-stop portal for PLATOON ontology is going to open at *https://www.sedmoon.org*, which will be also accessible through *https://w3id.org/platoon*.

In order to extend its visibility and sustainability, ENGIE will register the portal to w3id by W3C, a decentralized identity management system that allows individuals and/or companies to securely own, store, and share their credentials. The w3id URL, *https://w3id.org/platoon* registered in *https://github.com/perma-id/w3id.org/* is a standard permanent identifier for

PLATOON ontology and will be redirected to the *https://www.sedmoon.org*. It will guarantee a secure, permanent URL re-direction service of PLATOON ontology and ensure the sustainability with more visibility to serve community and the next energy related projects.

The landing page of the One stop portal for PLATOON's ontology is shown in Figure 6. It provides the overview of the methodology to design PLATOON's data models, and categorises the energy ontologies with four topics: Building, HVAC, Grids, and Renewable energy. And, Common ontology is a collection of data models commonly used in all topics as illustrated in the Figure 6.

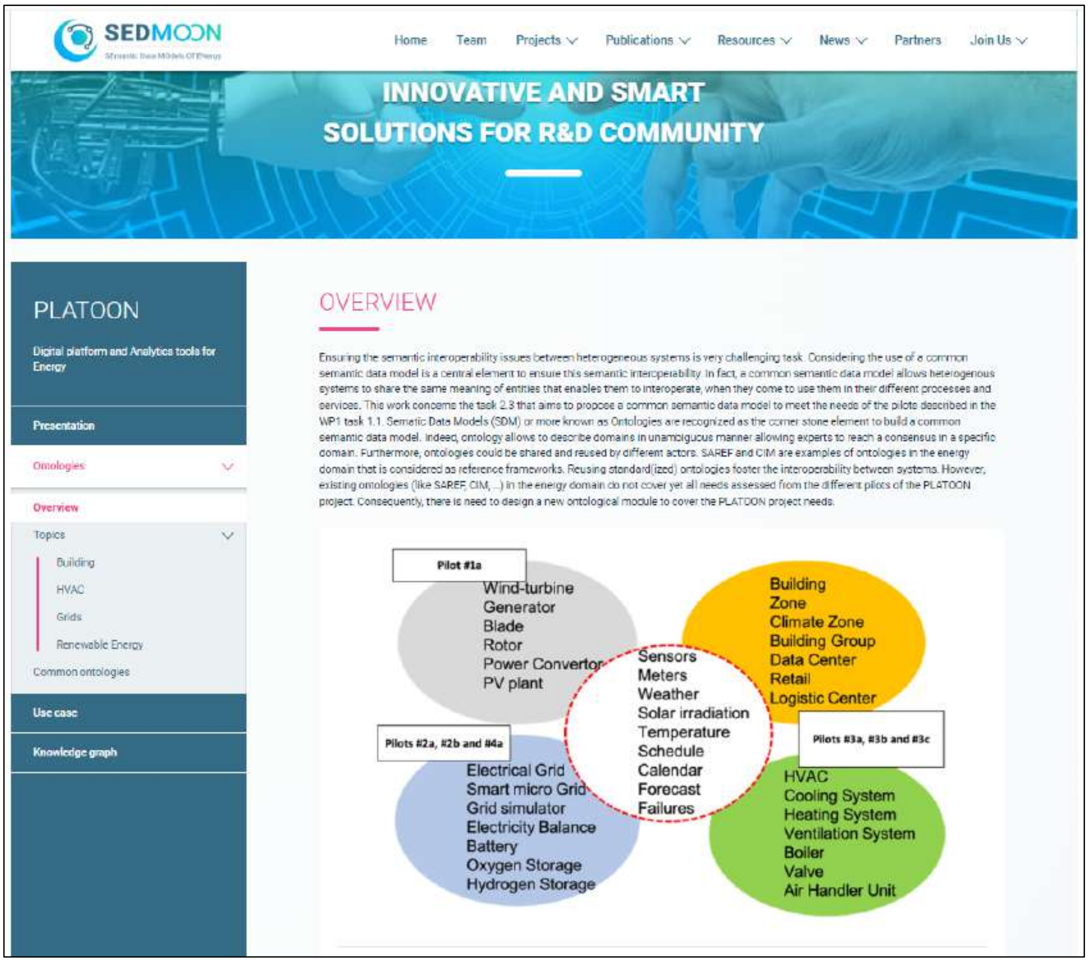


Figure 6 Landing page of One stop portal for PLATOON ontology

The Figure 7 indicates the front page of each topic shown in the menu in the left side from the Figure 6. As shown with two examples of Building and HVAC, it provides explanation of the scope, included ontology, and the relationship. By providing ontology by topics with overview, visitors can see the relationships in one site, and easily search specific ontology in the popular topics.

As the Figure shows, PLATOON brought a large set of existing data models. For examples, *cim:Location* indicates that the model is from IEC CIM, *saref:Device* is SAREF, and *seas:BuildingSpace* is from the ontology defined in SEAS project.

For PLATOON originated models, *plt:xxx* is used in its entity, class, and property names in the data models wherever PLATOON updated or created, in order to indicate PLATOON's development for any further adoption of the data models by others. In this way, PLATOON's contributions remain sustainable through the adopters and inheritors of the data models.

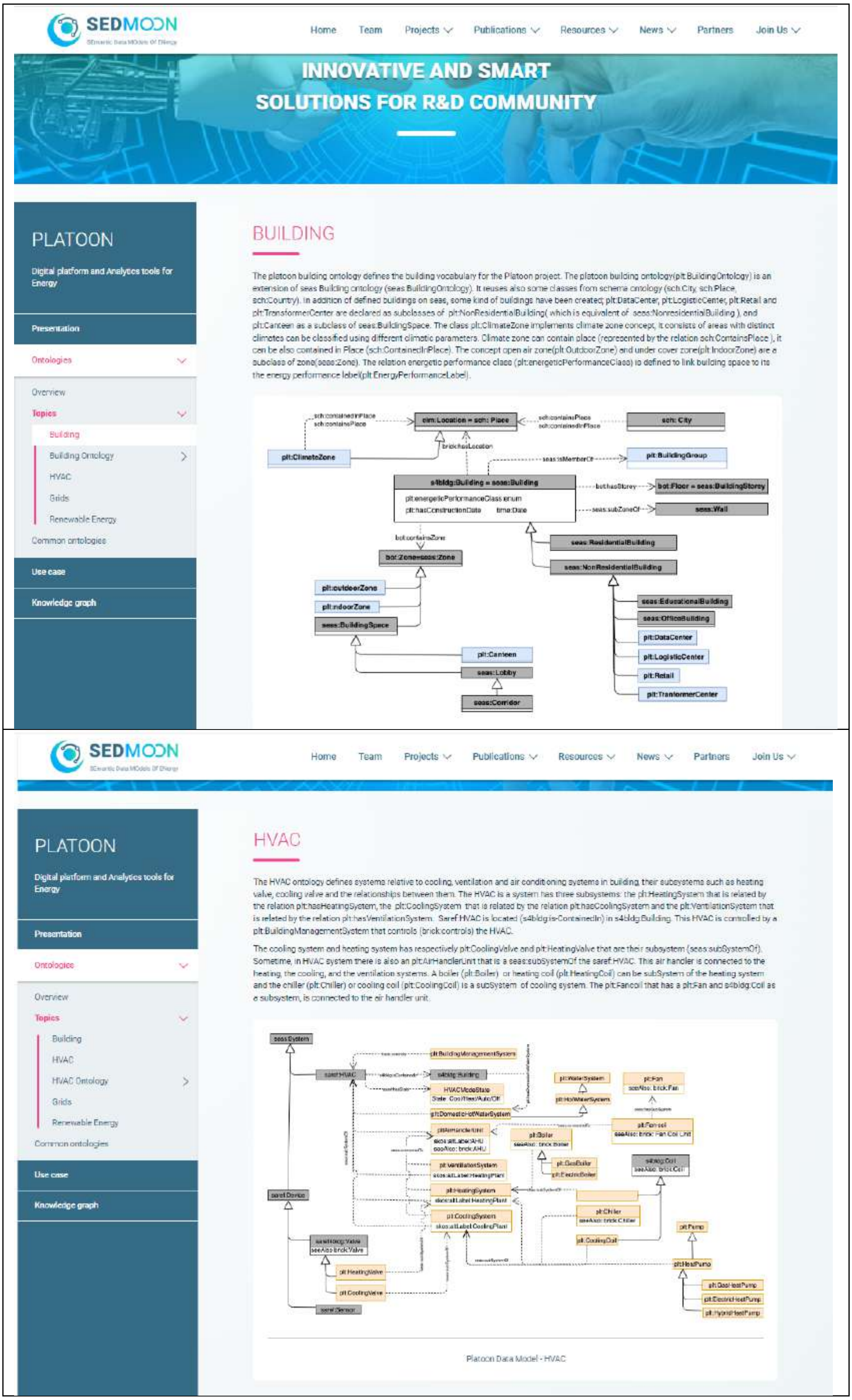


Figure 7 Ontology overview and relation graph of the ontology per topic

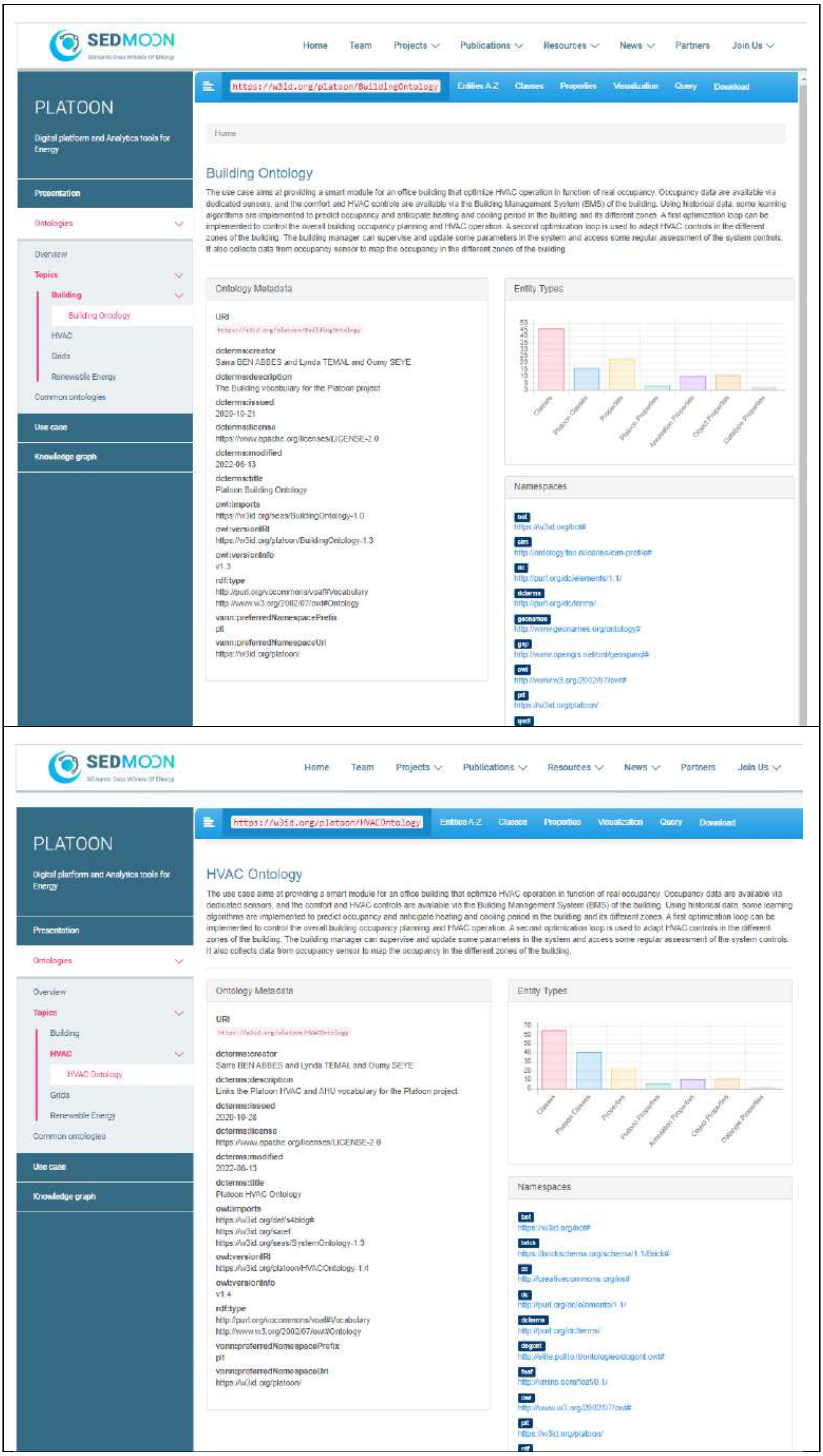


Figure 8 Ontology page: Metadata, statistics of entity types, and namespaces

The Figure 8 shows with two examples of Building and HVAC, under the overview page of each topic, it provides brief description of the ontology, ontology metadata, statistics of meta data entity types, and namespaces. These features will make visitors search needed ontologies by topics and easy to understand the background information.

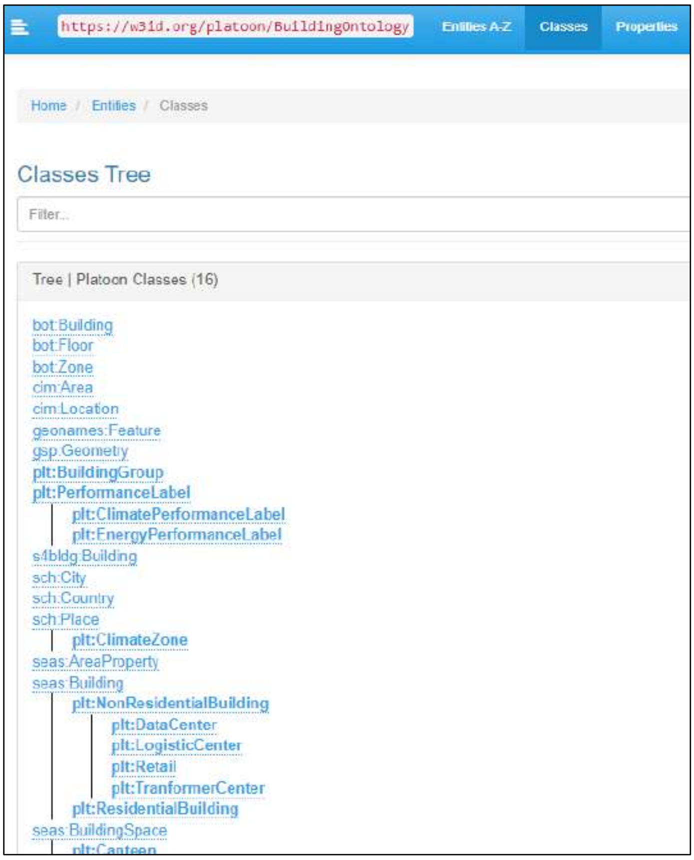


Figure 9 Ontology details: Class tree

The Figure 9 shows class tree of BuildingOntology. The portal provides details of each ontology with entities, classes and properties of the models. It also provides knowledge graph visualisation, so that the users can easily see the relations of the elements of the models.

As shown in the above screenshots, the PLATOON's ontology portal contains a full set of the project result of developed ontology data models. Thanks to the large set and diverse topics of PLATOON's pilot use cases, it covers big amount of data models that energy sector needs, and it is believed that this portal is an important asset for widening the use of common data models in diverse energy projects.

3.1.4 Increasing the Visibility of PLATOON's ontology

As PLATOON's standardisation goal is to contribute to the energy data space, it is important to participate in some key events to discuss European energy data space and increase its visibility in the community. In this regard, the following three presentations on PLATOON ontology have been made:

- IoT Week 2022: IoT Week is one of the popular events for all cross-domain technologies and services with diverse stakeholders. Erik Maqueda Moro from TECN presented "Data Spaces: Common data models for Energy".

- FIWARE Global Summit 2022: FIWARE Global Summit is one of the popular events to gather the community of academia, researchers, industries, policy makers, public sectors, etc. There was “Energy Data Space” session in the event and Eunah Kim from UDGA presented “Energy Data Ontology by PLATOON,” in order to promote the ontology work done by PLATOON.
- KGSWC 2022: KGSWC is an Ibero-American Knowledge Graphs and Semantic Web Conference held in 21-23 November 2022. Sarra BenAbbes and Lynda Temal from ENGIE presented PLATOON’s semantic data model titled “Semantic data models construction in the H2020 PLATOON project” about a specific methodology to create harmonized semantic data models that include all the needs of use cases, done in the context of the PLATOON project.

3.2 IDS Standards

The IDSA is a coalition of more than 130 member companies with a goal to bring a global standard for international data spaces (IDS) and interfaces, as well as fostering the related technologies and business models that will drive the data economy of the future across industries. The sector-independent governance approach developed by the IDSA and endorsed by a large number of European data economy stakeholders are being adapted to the energy sector. At the core of this model is the concept of data sovereignty as a prerequisite for all data exchange taking place within an ecosystem.

It is a leading association and their de factor standards are well respected by energy sectors, and contributions of real experience on implementing the standards are seeking and the community is growing fast. The IDS Connector is the central technical component for secure and trusted data exchange, and it is a basis of IDS standards for data sharing. The connector sends the data directly to the recipient from device or database in a trusted, certified data space, so the original data provider always maintains control over the data and sets the conditions for its use.

3.2.1 Identification of the candidate items

Regarding the digital platform, International Data Spaces Association (IDSA) is selected as the candidate of PLATOON’s standardisation for the common energy data space. PLATOON is the first European Energy R&I project that takes IDSA architecture concepts for data sharing and integrated the core components into PLATOON’s architecture for the energy digitalisation.

UDGA had a discussion with IDSA about their current focuses on standardisation. In order to identify the relevant options for standardisation of PLATOON’s work, technical data were collected first. PLATOON was not limited to implement and deploy the standards, but improved the current standards and applied them into three diverse use cases in PLATOON pilots. The main updates by PLATOON are as followings:

- Trusted Connector (TRUE Connector) + CaPe (main development from ENG)
- Metadata registry (main development from IAIS)
- Vocabulary provider (main development from TECN)

The components are implemented in the following three use cases in three pilots:

- Pilot 1a: Predictive maintenance of wind farms
- Pilot 2b: Electricity grid stability, connectivity and life cycle
- Pilot 3c: Energy Efficiency and Predictive Maintenance in the smart tertiary building Hubgrade

Thus, it was agreed to bring our project results to IDSA in its standardisation and also contribute to our use cases as reference cases of IDSA standard implementation in energy domain.

3.2.2 Our approach

In order to bring the maximum results of standardisation in IDSA, two tracks of activities were driven as shown in Figure 10 with responsible partners:

- Technical Contribution Task Force: The group is composed with the main developer of the core components related to IDS Standards in PLATOON.
  - UDGA – Planning, coordination and liaison
  - TECN – The main developer of vocabulary provider
  - ENG – The main developer of True Connector and CaPe
  - IAIS – Main developer of Metadata registry
- Ecosystem Building Task Force: The group is composed with three pilot use cases that PLATOON's IDS solutions are implemented and tested.
  - UDGA – Planning, coordination and liaison
  - VUB, TECN, ENGIE – Pilot 1a: Predictive maintenance of wind farms
  - SAMPOL, IND, TECN – Pilot 2b: Electricity grid stability, connectivity and life cycle
  - GIR, SIS, TECN – Pilot 3c: Energy Efficiency and Predictive Maintenance in the smart tertiary building Hubgrade

Several online meetings were held in each group and active email discussion were made. The goal was set up to make PLATOON highly visible in IDS community and the related community of Energy Data space.

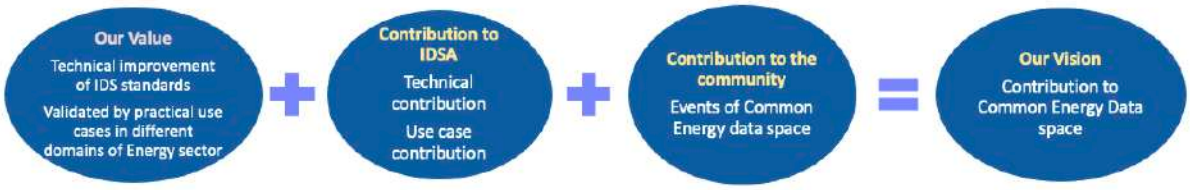


Figure 10 Standardisation goal of PLATOON's development of IDS standards

With help from TECN, ENG, IAIS, VUB and SAM, the basic information was gathered for both technical information and use case information. These components were developed with open sources and integrated in the use cases to validate their requirements and goals.

3.2.3 Result of the technical contribution

The collected information was restructured to emphasize the added values of PLATOON and a contribution was summited to IDSA after several iterations of information exchanges. The submitted core contents are as followings: (It is noted that the submitted Architecture and Figures are skipped here as it is not the core information of this deliverable.):

A. CaPe integrated TRUE Connector by ENG

- Technical background

  As one of the IDS connectors, ENG provides TRUE Connector in open-source version (existing contributions). It exchanges data among different entities and companies in secure way (digital certificate & cryptography).

And there is a separate component named CaPe for consent management that users can control their own data and services. Before Platoon, in order to exchange privacy data, there was no relation between CaPe and IDS connector. CaPe separately made requests on privacy data for providing services before exchanging data.

- Achievement by PLATOON

  Through Platoon, IDS Connector (TRUE Connector) has been extended to provide new capabilities required in PLATOON. It is integrated with CaPe and made the data exchange flow simpler.

  In addition, it developed a new, open-source Data Usage Control module as an evolution of the open-source IDS data space connector that supports usage policies. The target of Data Usage Control (UC) component is to enforce restrictions on data usage and data processing, after access to data has been granted.

  CaPe extends the feature of UC component in the specific case of a request involving Personal Data, the component also enforces the compliancy with data usage/data processing Consents given by Data Owner, according to the GDPR regulation, by interacting with the Consent Manager component.

- Benefits of this development

  It made advancement on personal data management by the integrated TRUE Connector and CaPe. So, IDS connector works not only manufacturing data but also personal data to manage user data consents in compliance with GDPR.

B. Metadata registry by IAIS

- Technical background

  Searching for suitable data and components is a major challenge and Fraunhofer has been developing Metadata broker for searching and finding within IDS where decentralized solutions with equal rights for publishing and searching for resources and components. The IDS Metadata Broker provides the necessary interfaces for communicating with any other IDS connector.

- Achievement by PLATOON

  Through PLATOON, the Metadata registry that was derived from IDS metadata broker has been developed. The Metadata registry is one of the main components in the PLATOON Marketplace and is a registry for resources and connectors, e.g., data consumers and data providers with an IDS connector can register their resources in the Metadata registry.

  In contrast to the IDS Metadata Broker, the Metadata registry has been tailored to keep the main functionalities of metadata handling for connectors and data/app resources and querying for the metadata. In addition, unlike the IDS Broker, Metadata Registry not only works with the metadata of a Data Resource but also with an App Resource. It handles the metadata for connectors and data/app resources and enables querying for the metadata.

- Benefits of this development

  Good data quality begins with the metadata since it characterizes the data to make it more understandable to the data consumers.

  PLATOON enables its participants to assess the quality of data sources utilizing publicly available information and its transparency concerning the brokerage functionality it offers through the Metadata Registry.

Especially in competitive environments, this transparency may force data providers to take data maintenance more seriously.

C. Vocabulary Provider by TECN

- Technical background

  Currently, there is no open-source version of an IDS Vocabulary Provider. There is only an open-source Vocabulary Manager called Vocol, but the link to the IDS reference architecture is missing. The latter is offered as a service called Vocoreg , but it is not open source.

- Achievement by PLATOON

  PLATOON has developed a complete open-source IDS Vocabulary Provider based on Vocol and extended it by adding an extra layer to make it compatible with the IDS ecosystem. The IDS Vocabulary Provider plays an essential role.

  It is the link between the Data Governance, Security, Privacy and Sovereignty layer (based on IDS reference architecture) and the Interoperability layer.

  It provides direct Machine to Machine communication allowing to query and exchange metadata according to the PLATOON Data Models through the IDS connectors.

  Graphical User Interface (GUI), where users can manage vocabularies (upload/upgrade/delete), search for specific terms, visualize the vocabularies in a network graph and execute SPARQL queries.

- Benefit of this development

  The IDS Vocabulary Provider enhances the capabilities of the PLATOON Marketplace regarding interoperability.

  It allows the data/data analytics tools users/consumers to easily understand the data and data analytics tools published in the Marketplace, which facilitates the implementation and integration of these datasets and data analytics tools.

After the analysis of the PLATOON's added value per component and as a whole, PLATOON submitted its proposal of technical contributions to IDSA in the early November 2022. After review the contribution, PLATOON was invited to present the technical contributions to its quarterly meeting of Architecture WG on 7th December 2022. UDGA, TECN and ENG presented PLATOON's contribution in the meeting. The work done by PLATOON was well appreciated.

TRUE connector by ENG and the Metadata registry by IAIS are already in IDSA github as open-source contributions. The added features by PLATOON (CaPe integration with TRUE connector and App store feature with Metadata registry) are going to be further contributed. For Vocabulary registry, it turns out that IDSA is a current to-do item of IDSA standardisation. Thus, IDSA suggested to the technical partner (TECN) to involve in further discussion and standard development and will send the regular meeting invitation for the standard development. Due to the time limit of PLATOON, it was discussed to continue this standard development through the new projects (OMEGA-X and ENERSHARE) where the technical partner is involved. Although the technical adaptation is not done during the project lifetime, it made the ground work for the standardisation of PLATOON's results in IDS standard development.

3.2.4 Results of ecosystem building contributions

The contributions to IDSA Ecosystem building brought several results as summarised in the following sections.

3.2.4.1 Presentation and submission PLATOON's input

With collaborative communications with IDSA, UDGA attended weekly Ecosystem Building conf calls and arranged a presentation as a commitment that PLATOON contributes to the ecosystem building. The concept of PLATOON, brief technical concepts and the three selected use cases were presented in the conf call on 14th Nov 2022 co-presenting by UDGA and TECN.

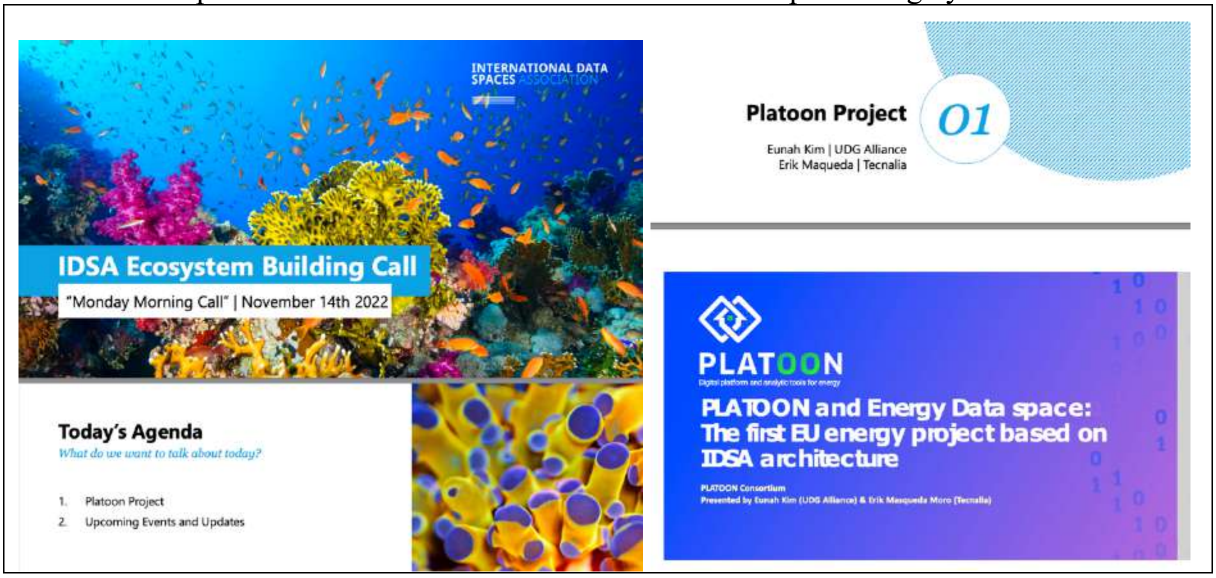


Figure 11 PLATOON's presentation of Data Space Ecosystem Building call

There were 39 participants in the call, who all work on IDS based data space. The presentation received very positive feedbacks from the audiences with a lot of virtual applauses. The questions and comments received shown in the Figure 12 captured from the meeting minutes.

1. 2. Comments and Questions:

- **Lars Nagel**: Thank you both for the presentation. This is a really important project and you have done tremendous efforts in showcasing what data sovereignty can be used for and how it can be implemented. The technical insights are really impressive, and we are happy to share them. I am happy to see how this moves in the radar, and others are able to see them. We also see that we move from single use cases to data spaces. You also mentioned other projects that rest on this project, so congratulations for this.
- **Akira Sakaino**: I think Platoon is a very interesting solution in the recent energy and climate crisis. Has Platoon's operating company already been established in EU? Who is supposed to operate Platoon commercially?

- **Sonia Jiménez**: I also wanted to ask if the architecture from the pilot was implemented, and if is there a company for the solutions. Also, in order to test the architecture and integrations, how did you manage? How did the actual integration happen?
- **Erik Maqueda**: There is not yet an operating company. We implemented it in different pilots, but they all rely on a common framework. The strategy we used is that we had a work package to build a sandbox, and we integrated the components before implementing them in the pilots.
- **Sonia Jiménez**: Where the data models you used developed in this project?
- **Erik Maqueda**: Yes. Starting from the use cases, defining which data was going to be used, which parameters and we did research on existing standards. We extended the ones that were not defined. As a result, we came up with a data model based on some standards and also extended it. We will standardize this and share it; this is fully open source.
- **Sonia Jiménez**: Was the vocabulary hub developed by Tecnalia and is it open-source?
- **Erik Maqueda**: Yes, this will be published, and right now it is in the GitHub repository of the project. When Eunah explained the different components, we have already contributed to the IDS GitHub.
- **Anil Turkmayali:** Erik, we would be happy to help about forking it (I will also contact you regarding the ongoing work being conducted on our weekly Vocabulary Hub workshops)

Figure 12 Discussion after presentation

In addition, IMEC from Belgium separately contacted for further discussion and possible collaboration. The meeting has been set up in Jan. 2023. Although it's the after the project lifetime, it will be carried out as a sustainable action of the project results.

3.2.4.2 IDSA Data space radar

Taking the advantage of the diversity of PLATOON's use cases in different energy domains, three use cases (pilot 1a: wind farm, pilot 2b: smart grid, pilot 3c: smart building) were submitted to the IDSA Data space radar (https://internationaldataspaces.org/adopt/data-space-radar/). The three use cases are all included in the Data space radar in Energy sector as shown in the Figure 13, Figure 14, and Figure 15, which is expected to increase their visibility.

A. Use case 1: Wind farm

The Figure 13 is the result of the inclusion of this use case in the IDSA data space radar, and submitted contribution is as followings:

- Use Case Name
  PLATOON:Wind Energy
- Headline
  Predictive Maintenance of Wind Farms by PLATOON
- Define the maturity level of your use case.
  ☑ Pilot - IDS-based solution has been implemented and first prototypes have been tested in a use case pilot.
- Challenge – What business opportunity or challenges do the involved organizations attempt to address with sovereign data sharing?
  The goal of this pilot is to provide predictive maintenance of wind turbines with a focus on the generator and power converter, which can be applied to other pilots or use cases. However, nowadays, energy data does not generally comply with the FAIR principles. In fact, it is normally kept in silos within companies and it is hardly reused for other purposes than the ones initially conceived for. In addition, in certain cases access to data is limited to some influential big companies. This is a big innovation barrier for academia, RTOs and SMEs as they cannot leverage this data to develop new products and services. This situation around data is one of the main blockers for the energy transition.
- Solution/success – How does your data space use case address this challenge or opportunity? How do the IDS Solutions contribute to this?
  IDS solutions are used as the basis of PLATOON's solution for data sharing. PLATOON leverages sovereign data sharing as an enabler to develop innovative data analytics tools by combining data from multiple stakeholders from the energy value chain to unlock new value and further optimise the energy sector. Furthermore, apart from sovereign data sharing PLATOON also considers sovereign exchange of services (data analytics tools) allowing data providers to access a wide ecosystem of service providers. These innovations will contribute to accelerate the energy transition to achieve the goals set in the Green Deal.
- Benefits – What is the new business value of your data space?
  PLATOON developed wind turbine digital twin with accurate physical and data-driven digital twins and models (physics-based simulation model, supervised data-driven model and normal behaviour data-driven model) that provides anomaly detection and fault diagnosis and isolation. Several business models have been defined in PLATOON regarding data/service sharing. In a nutshell, data is considered as an exchange token to

get access to improved products (e.g. Wind Turbine Components with extended lifetime and enhanced performance) or data analytics services (e.g. HVAC operation optimisation, predictive maintenance tools) that can further optimise the Operation and Maintenance Cost and Improve the efficiency across the whole energy value chain.

- Technical Background – Which IDS components (building blocks) are used in your data space? Please also list their versions.
  Several IDS components have been developed PLATOON which have been added into IDSA Github:
  TRUE (TRUsted Engineering) open source IDS Connector developed in PLATOON project based on the Market 4.0 connector enhanced with privacy data exchange through CAPE) and data usage control app. https://github.com/PLATOONProject/true-connector - https://github.com/International-Data-Spaces-Association/true-connector
  Also, a specific implementation of the TRUE connector for edge computing has been developed by Barbara IoT as part of one of the PLATOON Open Calls (https://github.com/PLATOONProject/fep_trueconnector).
  Metadata registry: Open Source metadata registry developed in PLATOON that combines both Open Source Broker (also developed in PLATOON and Apstore https://github.com/PLATOONProject/Metadata-Registry - https://github.com/International-Data-Spaces-Association/metadata-broker-open-core
  In addition, an open-source PLATOON IDS Vocabulary Provider has been developed in PLATOON based on Vocol further enhanced with IDS capabilities. This currently available in https://github.com/PLATOONProject/PLATOON_IDS-Vocabulary-Provider
  Apart from these components, PLATOON has used Fraunhoffer AISEC V3.0 DAPS and IDS Clearing House Service (https://github.com/International-Data-Spaces-Association/ids-clearing-house-service).
- Prerequisites – What are the prerequisites? Please provide details on necessary conditions to run this data space.
  PLATOON has built a federated dataspace that relies on each partner providing their own platforms that be on cloud/edge/premise. In addition, the prerequisites to join the PLATOON dataspace are to comply with the PLATOON common Reference Architecture, Common APIs specification and Common Semantic Data models.
- Implementation Process – How did you implement the use cases?
  The first step for the implementation process was to adapt the legacy systems to the PLATOON common Reference Architecture, Common APIs specification and Common Semantic Data models. Then the second step was to integrate the IDS connector with the legacy systems adapted to PLATOON prerequisites. Finally, the IDS connectors were connected with the rest of the common IDS components explained in the technical background.
- Further Exploitation – Do you think that this solution could be adapted to be applied / used in other contexts and/or to solve other challenges/problems?
  Although the solution has been developed for the energy sector all of the components (except the Semantic Data models and data analytics tools) can be applied in other sectors (e.g. smart cities, mobility, etc.).

Figure 13 Data space radar: PLATOON Wind Energy included

B. Use case 2: Smart grids

The Figure 14 shows the inclusion of this use case into IDSA Data Space Radar. The core contents of the submitted contribution is as followings: (note: IDS solutions, technical background, prerequisites, implementation process, exploitation are the same with the wind farm, so they are omitted here.)

- Use Case Name
  PLATOON: Smart Grids
- Headline
  Electricity Grid stability, Connectivity and Life cyle by PLATOON
- Define the maturity level of your use case.
  ☑ Pilot - IDS-based solution has been implemented and first prototypes have been tested in a use case pilot.
- Challenge – What business opportunity or challenges do the involved organizations attempt to address with sovereign data sharing?
  This pilot use case focuses on (1) predictive maintenance MV-LV electric transformers and (2) non-technical loss detection in smart grid. Instead of keeping data and tools in silos within companies, it is needed to make them reusable for other purposes than the ones initially conceived for. In addition, it needs to overcome the current innovation barrier in energy market around data exchange to foster innovative data services that can further optimise the smart grids operation and maintenance. In order to enable to overcome such challenges in energy market and provide the required services, it is important to have interoperable solutions with embedded data security for transmitting sensible data, which prompts digital transition of energy domain.
- Benefits – What is the new business value of your data space?

Several business models have been defined in PLATOON regarding data/service sharing. In a nutshell, data is considered as an exchange token to get access to improved products. For this use case, sensible data handling is important and it integrates data security and privacy data handling into the IDS solutions, so that sensible data in smart grid are well managed. Several data analytics tools are developed (e.g., electrical transformer RUL estimation, electrical transformer health index calculation, transformer oil analysis, electrical transformer health monitoring tool, maintenance activities impact assessment, asset operation optimization tool, prosumer segmentation model, technical loss model, global loss assessment model, NTL identification model). Thanks to PLATOON's IDS solutions enhancing privacy data handling, sensible data in smart grid can be exchanged, the results from the different methodologies can be compared, and it enables easy knowledge transfer with reusable and shared data.

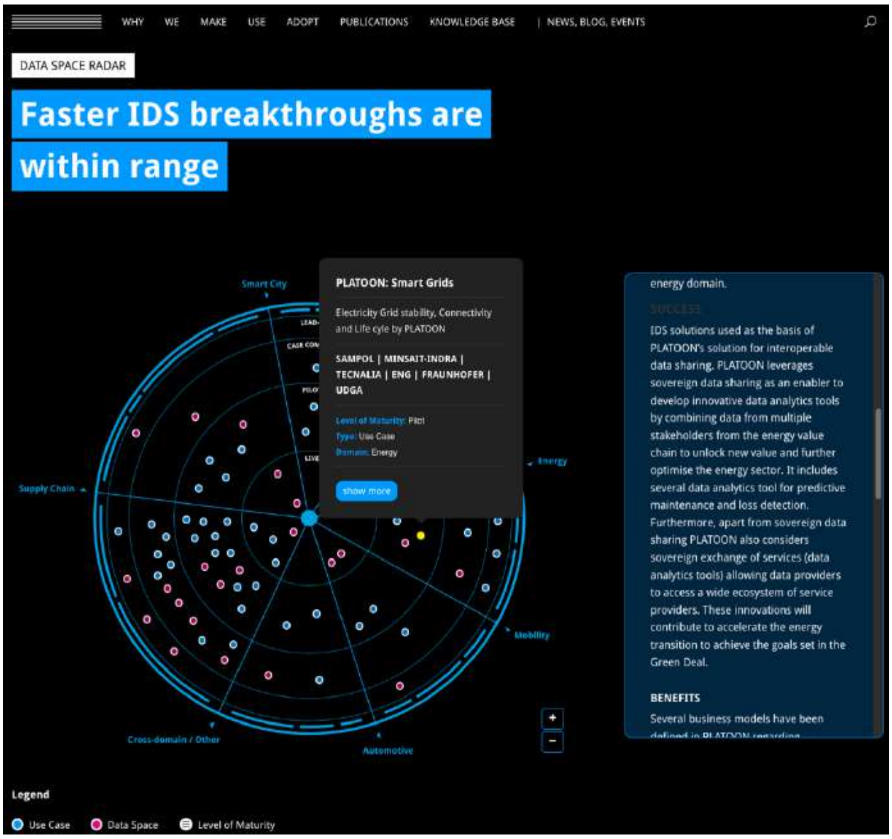


Figure 14 Data space radar: PLATOON Smart Grids included

C. Use case 3: Smart buildings

The Figure 15 shows the including of this use case into IDSA Data Space Radar. The core contents of the submitted contribution is as followings: (note: Technical background, prerequisites, implementation process, exploitation are the same with the other use cases, so they are omitted here.)

- Use Case Name
  PLATOON: Smart Buildings
- Headline
  Energy Efficiency and Predictive Maintenance by PLATOON in the Smart Tertiary Building Hubgrade
- Define the maturity level of your use case.

☑ Pilot - IDS-based solution has been implemented and first prototypes have been tested in a use case pilot.

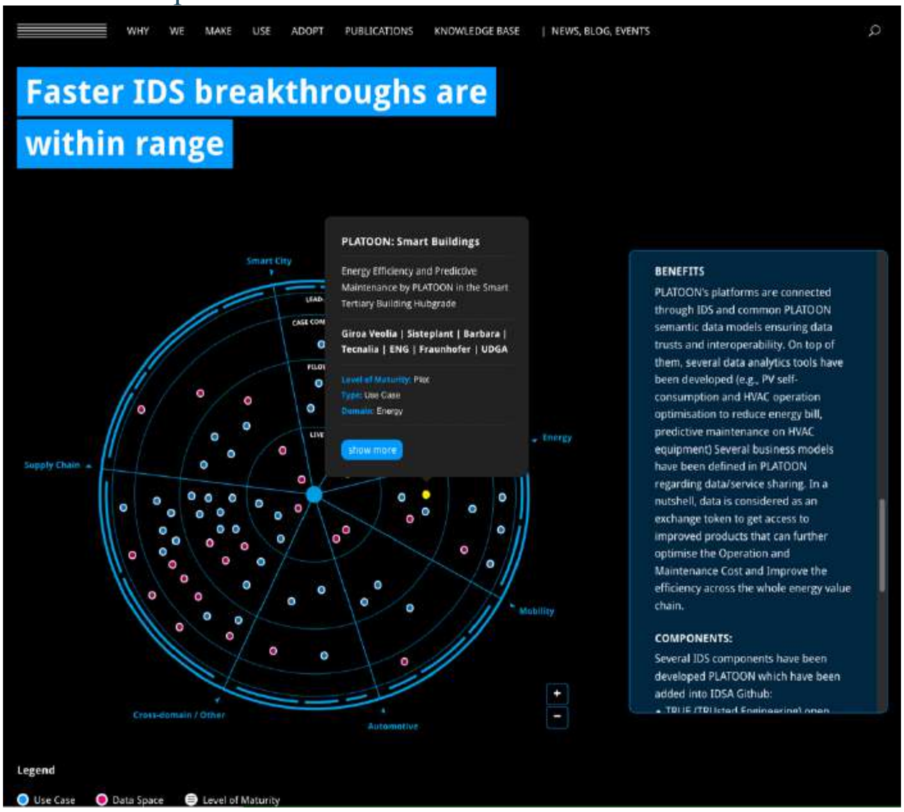


Figure 15 Data space radar: PLATOON Smart Buildings included

- Challenge – What business opportunity or challenges do the involved organizations attempt to address with sovereign data sharing?

  This pilot focuses on optimization of energy management system and predictive maintenance on smart buildings. The goal is to offer a better service to customers by reducing energy bill, increasing RES usage and reducing maintenance costs and downtimes. These challenges and goals are shared in many smart building customers. However, nowadays, energy data does not generally comply with the FAIR principles. In fact, it is normally kept in silos within companies and it is hardly reused for other purposes than the ones initially conceived for. This is a big innovation barrier for academia, RTOs and SMEs as they cannot leverage this data to develop new products and services. This situation around data is one of the main blockers for the energy transition. Additionally, some specific applications cannot expose an external internet connection and/or require low latencies, which makes necessary to host the data operations into edge.

- Solutions/Success– How does your data space use case address this challenge or opportunity? How do the IDS Solutions contribute to this?

  This use case can connect three different domains : Energy, Smart building and Smart city, which is fully in line with the objectives of common data space. IDS solutions used as the basis of PLATOON's solution for data sharing. PLATOON leverages sovereign data sharing as an enabler to develop innovative data analytics tools by combining data from multiple stakeholders from the energy value chain to unlock new value and further optimise the energy sector. Furthermore, apart from sovereign data sharing PLATOON also considers sovereign exchange of services (data analytics tools) allowing data providers to access a wide ecosystem of service providers. These innovations will contribute to accelerate the energy transition to achieve the goals set in the Green Deal.

- Benefits – What is the new business value of your data space?

  PLATOON's platforms are connected through IDS and common PLATOON semantic data models ensuring data trusts and interoperability. On top of them, several data analytics tools have been developed (e.g., PV self-consumption and HVAC operation optimisation to reduce energy bill, predictive maintenance on HVAC equipment) Several business models have been defined in PLATOON regarding data/service sharing. In a nutshell, data is considered as an exchange token to get access to improved products that can further optimise the Operation and Maintenance Cost and Improve the efficiency across the whole energy value chain.

3.2.4.3 DataSpacesTuesday post

IDSA selected a promising use case from the Data Space Radar and promoted them in DatSpaceTuesday post. Among PLATOON's three use cases, Wind farm use case has been selected and promoted in #DataSpaceTuesday post with the title of 'PLATOON and Energy Data Space' on 29 Nov 2022 as the Figure 16 shows.

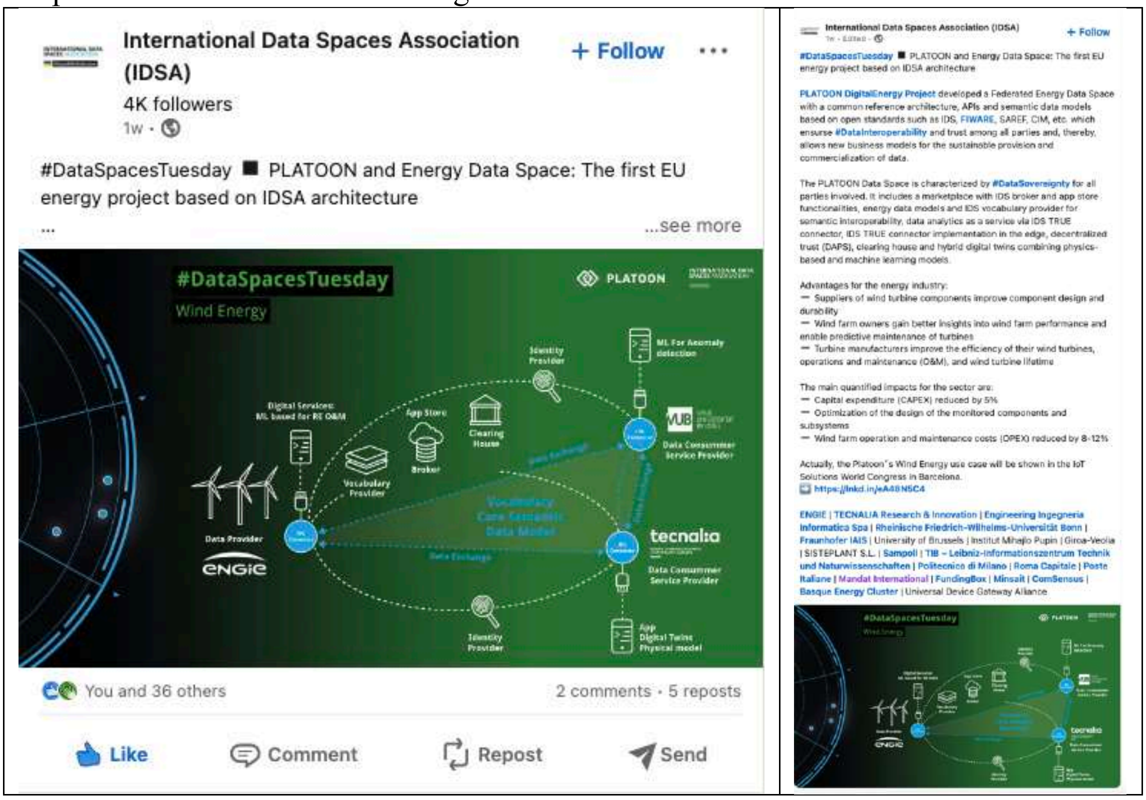


Figure 16 PLATOON and Energy Data Space - IDSA DataSpaceTuesday Post

For the post, PLATOON provided the following information:

> PLATOON developed a Federated Energy Data Space with a common reference architecture, APIs and semantic data models based on open standards such as IDS, FIWARE, SAREF, CIM, etc. which ensurse data interoperability and trust among all parties and, thereby, allows new business models for the sustainable provision and commercialization of data. The PLATOON Data Space is characterized by data sovereignty for all parties involved. It includes a marketplace with IDS Broker and App Store functionalities, energy data models and IDS Vocabulary Provider for semantic interoperability, Data analytics as a service via

IDS TRUE connector, IDS TRUE connector implementation in the edge, decentralized trust (DAPS), Clearing House and hybrid digital twins combining physics-based and machine learning models.

- Advantages for the energy industry:
- Suppliers of wind turbine components improve component design and durability
- Wind farm owners gain better insights into wind farm performance and enable predictive maintenance of turbines
- Turbine manufacturers improve the efficiency of their wind turbines, operations and maintenance (O&M), and wind turbine lifetime
- The main quantified impacts for the sector are:
- Capital expenditure (CAPEX) reduced by 5%
- Optimization of the design of the monitored components and subsystems
- Wind farm operation and maintenance costs (OPEX) reduced by 8-12%

In addition to the Data Space Radar, it was also good opportunity to increase visibility and showed the sign of the value of the PLATOON's results.

3.2.4.4 IoT World Congress and Data Spaces Report in 2023

In addition to the linked in post, it is also confirmed that the use case will be showcased in the IoT World Congress in Jan-Feb 2023 by IDSA.

IDSA also informed us that they would like to include the wind farm use case into Data Space Report that will be published to disseminate the newest and most important use cases on Data Space Radar. All related partners consented the publishment and it will be included in the next IDSA report that will be published in Jan 2023.

3.2.4.5 Presentation of TRUE Connector

ENG made a separate presentation on TRUE Connector in the Ecosystem building call on 19 Dec 2022. PLATOON was introduced as one of the core validation projects of its connector as shown in the Figure 17. Gabriele De Luca from ENG put efforts to explain about PLATOON's validation of the TRUE connector.

Figure 17 PLATOON in the presentation of TRUE Connector

3.3 BDVA and other contributions in data sharing

This section provides brief introduction of selected contributions and visibility of PLATOON related to data sharing and data space activities, that are not mentioned in the section 3.1 and 3.2. These activities are linked to WP9 and introduced here briefly to show the engagement of PLATOON in the relevant bodies and organizations matching to its direction of standardization.

A. BDVA Energy Task Force

ENGIE made big effort to bring PLATOON into GAIA-X and BDVA. As a successful result, ENERGY Task Force was launched by PLATOON in BDVA.

Figure 18 BDVA Energy Task Force by PLATOON

B. BD4NRG

PLATOON is listed as one of the synergy groups for BD4NRG, the project handles big data management challenges for energy sector with 35 partners started in Jan 2021.

As shown in the Figure 19, it includes a brief explanation of PLATOON and provides a link to the project web site.

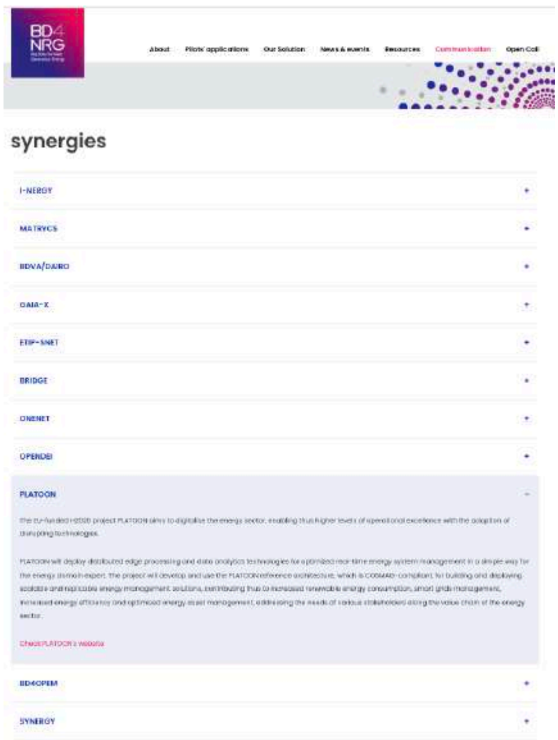


Figure 19 PLATOON as a synergy group of BD4NRG

C. Open DEI initiative

With cooperation with OPEN DEI, PLATOON co-chaired OPEN DEI WG3 (Linking Ecosystems) specifically focused in providing added value to energy stakeholders through efficient data sharing, processing and analysis. TECN presented PLATOON in the conference on data sharing & governance for energy applications. The details included in WP9 activities.

D. Data Spaces Discovery Day

As an action to increase PLATOON's visibility in energy data space, TECN and Basque Energy Cluster co-organized Data Spaces Discovery Day in Barcelona on 28th Sep 2022, with the topic of "How to implement IDS with focus on energy data spaces". The event details are reported in WP9.

4 Conclusion

PLATOON aimed to develop a federated data platform for Energy with particular focuses on (a) energy data interoperability enabling data exchange and integrated value chains between platforms, (b) decentralised trust with enhancement of privacy and data sovereignty among multiple data owners and providers for multi-party data exchanges among the energy value chain via IDS based connectors, and (c) development and deployment of data analytics tools and edge computing to optimise the energy system management.

The goal of its standardisation activities was set to support the project goals and contribute to the relevant communities of the targeting technical domains. As results of discussion with project partners, and studies on relevant standards in diverse standard bodies, fora and associations (stated in the Section 2), PLATOON has set up standardisation goals as contribution to European Energy Data Space (stated in the Section 3). According to it, target items were selected to maximize the goal and achieved some meaningful results such as One Stop portal for Energy data ontology, technical contribution for the development of IDS standards and contributions of use case implementations for ecosystem building led by IDSA as detailed in the Section 3. It also combined activities to increase the visibility of the selected items in relevant communities.

Eventually, the standardisation paths were not targeting traditional SDOs but rather focusing on common places to build European data spaces. It was not because the role of traditional SDOs is less important on energy data space, but because it wanted to have short term impact (during the project lifetime) toward the movement of European data spaces, particularly considering that the traditional standardisation activities are often discontinued after the project ends due to the gap of project lifetime and the required long-term dedication for the traditional standardisation processes.

The planned paths were not always smooth, though. While PLATOON chose ontology data models and built a set of semantic tools including semantic adapter and federated query processing, the common data models for European projects mostly follow two directions: NGSI-LD based data models and Ontology based data models. Considering that the collection of common data models is mainly by contributors who bring use case requirements in the involved projects, inputs are splitting to two communities, which could hinder the collection of common data models compared to one synchronised place.

At least, there was good news recently that smartdatamodel.org who leads NGSI-LD based data models has started to accept ontology models and to help to convert NGSI-LD models. UDGA introduced the news to the main developer of PLATOON's data models. However, due to the different formats and methods to express metadata, it needs some time to understand the different formats, and the contributions couldn't build in short time, especially the developer of PLATOON ontology organisational restructure added the time constraints as the communications for collecting information was not smooth for some period. The arranged appointment with smartdatamodel.org is postponed due to the delay of the prioritised work (one stop portal), but it was confirmed that it can be a common place for both contributors of NGSI-LD based data models and Ontology based data models, and PLATOON is seeking to bring its large set of data models to the common place. It is believed that the one-stop portal of PLATOON's ontology is a good source to generate further contributions and to make PLATOON's ontology continue to serve the community.

As the first EU energy project based on IDSA architecture, PLATOON's contributions to IDS standards and ecosystem received big attentions and appreciation. Three technical items successfully presented and got confirmed for the further inclusion. Two items are already listed in the open-source repository, and the technical partner of another item was confirmed to be invited to the further meetings of standard developments. Besides, three use cases are included in the Data space radar, which will be continued to refer after the project lifetime. Especially, the wind farm use case has already promised promotions in Jan – Feb 2023, and the upcoming IDSA Data space report. These achievements are meaningful as PLATOON and its results remain in IDSA and continue to give inputs to the community, although PLATOON will end in the end of December 2022.

PLATOON paved a good path for collaboration with GAIA-X, BDVA, OPEN DEI and IDSA, the big players of European Common Data Spaces, the knowledge and results gained by PLATOON are expected to be continuously used for European Energy Data Spaces.

Annex I-1. Updated or created data models by PLATOON

PLATOON collected a large set of existing data models and reused as much as possible. In order to reflect use case requirements from PLATOON pilots, it updated existing models or created new models. The Table 1 is a summary of updated and created data models by PLATOON. It can be used to indicate which models are developed by PLATOON for further standardisation.

Table 1 Updated and created data models by PLATOON

Ontology	Description	Source	property	Updates by Platoon
Meter Ontology	imports seas:SmartMeterOntology and reuses saref:Meter concepts. It reuses different meter concepts defined in seas ontology	SAREF	plt:ThermalMeter plt:ThermalEnergyMeter	subclass of saref:Meter
Sensor Ontology	reused some existing sensor concepts (dogont:TemperatureSensor, saref:Sensor), and the rela-tion seas:observesProperty to link a Sensor to its observed property	SAFEF / SEAS	plt:WeatherVane	subclass of saref:Sensor for the observation of wind direction property(seas:WindDirectionProperty)
		SAFEF / SEAS	plt:Anenosensor	subclass of saref:Sensor for the observation of wind speed proper-ty(seas:WindSpeedProperty)
		SAFEF / SEAS	plt:PyranoSensor	subclass of saref:Sensor for the observation of solar radiation proper-ty(plt:SolarRadiationProperty)
		SAFEF / SEAS	plt:CurrentSensor	subclass of saref:Sensor for the observation of current property(seas:CurrentProperty)
		SAFEF / SEAS	plt:VoltageSensor	subclass of saref:Sensor for the observation of voltage property(seas:VoltageProperty)
		SAFEF / SEAS	plt:SpeedSensor	saref:Sensor for the observation of speed property(seas:SpeedProperty])
		SAFEF / SEAS	plt:VibrationSensor	subclass of saref:Sensorfor the observation of vibration property(plt:VibrationProperty)
weather ontology	reuses some weather properties defines on seas ontology. The weather measures are implement-ed using pattern of seas:Property and seas:Evaluation representation on seas:EvaluationOntology.	SEAS	plt:AirTemperatureProperty plt:AirTemperatureEvaluation plt:hasIndoorAirTemperature, plt:hasOutdoorAirTemperature plt:hasDewPointTemperature plt:hasNormalAirTemperature plt:hasCoolingAirTemperatureSetpointForUnoccupiedStatus plt:hasCoolingAirTemperatureSetpointForOccupiedStatus plt:hasHeatingAirTemperatureSetpointForStandBy plt:hasHeatingAirTemperatureSetpointForUnoccupied plt:hasHeatingAirTemperatureSetpointForOccupied plt:hasCoolingAirTemperatureSetpoint plt:hasHeatingAirTemperatureSetpoint	
HVAC Ontology	defines the HVAC vocabulary for PLATOON, importing seas:SystemOntology and saref ontology			
Electric Power System Ontology	defines electric power system concepts. Plt:ElectricPowerSystemOntology imports seas:ElectricPowerSystemOntology and seas:StreetLightSystemOntolo	SEAS	plt:ChargingStation plt:WaterProductionSystem plt:PowerCenter plt:ElectricBike plt:ElectricHub plt:HeatPump plt:ArrayBox	declared as subclass of the reused class seas:ElectricPowerSystem, a system that exchange electricity with other systems.

	gy, extending seas:ElectricPowerSystemOntology		plt:SolarOptimizer plt:PowerConvertor	
		SEAS	plt:RenewableEnergySource plt:NaturalGasMicroCHPSystem plt:DispatchableUnit plt:NonDispatchableUnit	declared as subclasses of the reused class seas:ElectricPowerProducer an electric power system that is capable to produce electricity.
		SEAS	plt:ElectricIndoorLightingSystem	defined has a subclasses of seas:LightActuator. An Electric Indoor Lighting System is a lighting System which is used to light under cover Zone.
			plt:LightingSystemGroup	a group system which has member only Light source
			plt:isConnectedInParallel	links an electric power system, such as solar array, to its connected in parallel electric power system
			plt:isConnectedInSeries	links two electric power systems connected in series
Electric Power Transformer Ontology	electric power transformer vocabulary for the PLATOON project	SEAS	plt:SecondaryWinding plt:PrimaryWinding	subclasses of seas:ElectricPowerSystem and subsystems of seas:ElectricPowerTransformer
		SEAS	plt:Insullation plt:Casing	as subsystems of seas:ElectricPowerTransformer
		SEAS	plt:ElelectricalSubstation	subclass of seas:ElectricPowerSystem and connected to seas:ElectricPowerTransformer
Energy Measure Ontology	describes properties related to the energy measures : electric energy consumption, electric energy load, power, thermal energy, electric energy production…, and a set of subclasses of seas:Evaluation to register the values of the energy measurements properties and their temporal contexts.			
Storage Ontology	imports seas:BatteryOntology, plt:EnergyMeasureOntology, plt:ElectricPowerSystemOntoloy	SEAS	plt:StorageSystem plt:OxygenStorageSystem plt:HydrogenStorageSystem plt:ThermalStorageSystem plt:SolarStorageSystem	subclass of seas:System
			plt:LithiumIonBattery	subclass of seas:Battery
			plt:stateOfChargeRatioSetpoint	links the storage system to its setpoint of the charging state (seas:PercentageProperty) as subclass of battery
Event Ontology	It describes scheduled and unscheduled events which occur on PLATOON low levels use cases		plt:Event plt:ScheduledEvent plt:NormalStopEvent plt:DemandResponseDerogationEvent plt:ScheduledMaintenance plt:MaintenanceStopEvent plt:UnScheduledEvent plt:WeatherStopEvent, plt:ComponentFaultStopEvent plt:Alert	
Failure and Damange Ontology	implements failures and damages concepts and properties. This ontology imports the PLA-TOON	IEC CIM	plt:LoosenessFailure plt:ImbalanceFailure plt:EfficiencyDegradation plt:OilOverTemperatureFailure	Subclass of cim:FailureEvent

	EventOntology because a failure is an unscheduled event, and some damages can lead to some events		plt:Damage plt:DegradationConstantDamage	any change in a thing that degrades it away from its initial state
			plt:causes plt:affects plt:hasDamage plt:hasSeverityLevel plt:isDamageOf	object of properties
KPI Ontology	subclass of s4city:KeyPerformanceIndicator	SAREF4 CITY	plt:Indicator plt:OverHeatingIndicator plt:OverCoolingIndicator plt:EnergyLosses plt:BenchmarkingAnalysis plt:RankingIndicator plt:AnomalyIndicator plt:AverageForTypologyIndicator plt:DeviationIndicator	saref4city:hasKPI, saref4city:isKPIOf, saref4city:quantifiesKPI, saref4city:hasCalculationPeriod, saref4city:refersToTime, saref4city:assesses
Wind turbine Ontology	to define wind turbine, its components and relations between components. It imports ontowind ontology and seas:SystemOntology. It extends ontowind ontology by specific wind turbine	Ontowind	plt:OnshoreWindTurbine plt:OffshoreWindTurbine	as subclasses of reused class ontowind:WindTurbine
Grid Ontology	micro grid vocabulary for the PLATOON project. The grid ontology imports plt: ElectricPow-erSystemOntology	SEAS	plt:ElectricalGrid	as a subclass of seas:ElectricPowerSystem
			plt:SmartMicroGrid	as subclass of plt:ElectricalGrid and connected, by the relation seas:connectedTo, to the electric power systems : plt:ElectricalGrid, plt:ChargingStation, seas:ElectricVehiculeChargingStation, plt:BikeChargingStation, plt:PowerCenter, seas:ElectricPowerProducer
			plt:ElectricGridSimulator	a subclass of seas:ElectricPowerSystem and the simulator, by the relation plt:simulates, of a plt:ElectricalGrid

Appendix I-1 Summary of NGSI-LD energy data models

The following table is a summary of current status of common data models in energy sectors registered in smartdatamodel.org. Considering the importance of its role in European common data space, smartdatamodel.org can be considered as a possible candidate to contribute PLATOON's data models. In order to contribute to data model, this table is made to figure out which models are currently provided and which models are missing.

Table 2 Energy related NGSI-LD Data models

Area	Data model name	Description	link
Battery	Battery	Represent a physical battery with its hardware specifications	https://github.com/smart-data-models/dataModel.Battery/blob/master/Battery/doc/spec.md
	BatteryStatus	Represent a status for a physical battery.	https://github.com/smart-data-models/dataModel.Battery/blob/master/BatteryStatus/doc/spec.md
	StorageBatteryDevice	to describe the technical characteristics of the battery and the charging and discharging conditions of the energy.	https://github.com/smart-data-models/dataModel.Battery/blob/master/StorageBatteryDevice/doc/spec.md
	StorageBatteryMeasurement	to measure the remaining energy capacity in a battery, which can be redistributed in the form of electrical energy. These functions apply from a source which depends on the type of battery (reference to the attribute 'batteryType' of the Data Model StorageBatteryDevice)	https://github.com/smart-data-models/dataModel.Battery/blob/master/StorageBatteryMeasurement/doc/spec.md
Energy	ACMeasurement	to measure the electrical energies consumed by an electrical system which uses an Alternating Current (AC) for a three-phase (L1, L2, L3) or single-phase (L) and neutral (N). It integrates the initial version of the data Modem, extended to also perform single-phase measurements. It includes attributes for various electrical measurements such as power, frequency, current and voltage.	https://github.com/smart-data-models/dataModel.Energy/blob/master/ACMeasurement/doc/spec.md
	InverterDevice	to describe the mechanical, electrical characteristics of an Inverter according to *DC - Direct Current Information* supplied as input and *AC - Alternating Current Information* returned as output. *Remark*: This Data Model can be used directly as a main entity to describe the device [Inverter] or as a sub-entity of the Data Model {DEVICE} using a reference by the [refDevice] attribute.	https://github.com/smart-data-models/dataModel.Energy/blob/master/InverterDevice/doc/spec.md
	SolarEnergy	for Solar Energy generation	https://github.com/smart-data-models/dataModel.Energy/blob/master/SolarEnergy/doc/spec.md
	TechnicalCabinetDevice	to describe the technical characteristics of the Device, designed to be placed in an urban or interurban environment. The main objective of these cabinets for this Data Model is to protect the electrical equipment necessary for the control, surveillance, reading and management of urban lighting, signaling, video and electrical distribution. The scope of use of some of these cabinets can extend to an additional protection for installations of modular apparatuses of telephony, data processing, meteorological stations, photo-voltaic stations, wind turbines stations, telecommunications, networks, data, bre Optics , etc. *Remark* : This Data Model can be used directly as a main entity to describe the device Technical Cabinet or as a sub-entity of the Data Model DEVICE using a reference by the refDevice attribute. It can also refer to the list of all the components it contains, with the refDeviceList attribute, using the Data Model 'DEVICE'	https://swagger.lab.fiware.org/?url=https://smart-data-models.github.io/dataModel.Energy/TechnicalCabinetDevice/swagger.yaml
	ThreePhaseAcMeasurement	An electrical measurement from a system that uses three phase alternating current.	https://github.com/smart-data-models/dataModel.Energy/blob/master/ThreePhaseAcMeasurement/doc/spec.md
EnergyCIM	Adaption of Data models from CIM	energy data models from CIM*	https://github.com/smart-data-models/dataModel.EnergyCIM/tree/master
Green Energy	GreenEnergyGenerator	A generic generator station which can generate energy from green energy	https://github.com/smart-data-models/dataModel.GreenEnergy/blob/master/GreenEnergyGenerator/doc/spec.md
	GreenEnergyMeasurement	An instantaneous measure of power generation using green energy sources	https://github.com/smart-data-models/dataModel.GreenEnergy/blob/master/GreenEnergyMeasurement/doc/spec.md
	PhotovoltaicDevice	to describe the mechanical, electrical and thermal characteristics of photo-voltaic panels according to STC - Standard Test Condition and NOCT - Normal Operating Cell Temperature. Remark : This Data Model can be used directly as a main entity to	https://github.com/smart-data-models/dataModel.GreenEnergy/blob/master/PhotovoltaicDevice/doc/spec.md

		describe the Photovoltaic Device or as a sub-entity of the Data Model DEVICE using a reference by the refDevice attribute. The measures performed for STC and NOCT are Pmax (Maximum Nominal Power), Umpp (Optimal operating voltage), Impp (Optimal Operating Current), Uoc (Open Circuit Voltage), Isc (Short Circuit Current). Additional Information about Data Model: This Data Model can be used directly as a main entity to describe the device [PHOTOVOLTAIC] or as a sub-entity of the Data Model [DEVICE] using a reference by the refDevice attribute.	
	PhtovoltaicMeasurement	The Data Model is intended to measure the continuous power transferred by the photo-voltaic panel to an Inverter Device.	https://github.com/smart-data-models/dataModel.GreenEnergy/blob/master/PhotovoltaicMeasurement/doc/spec.md

***IEC 62325-301** "CIM extensions for markets" standard, which is an abstract model that caters for the introduction of the objects required for the operation of electricity markets; and **IEC 62325-450** "Profile and context modelling rules," the International Standard for the generation of profiles.

PART II : Energy Reliability

1 Introduction

This document summarised its study on energy reliability indicators, regulatory and policy frameworks, and big data analytics techniques related to energy reliability. It also describes the lessons learned from the project pilots in relation to big data analytics techniques and its applications. With the results, it generates a set of recommendations for regulatory bodies around energy quality and reliability through different tools like indicators used by electric power utilities.

1.1 Objectives

- Identification and assessment of regulatory frameworks across Europe on energy reliability indicators
- Understanding of the impact of big data analytical techniques on energy reliability
- Assessment of regulatory frameworks and possible barriers related to reliability from the project pilot sites
- Possible recommendations to the regulatory bodies to improve and/or update the reliability indicators used by electric power utilities such SAIDI or SAIFI

1.2 Methodology

The report was elaborated through a combination of three main efforts. The first effort is an iterative desktop research to understand the regulatory context and complement the knowledge gained from the two other efforts by identifying related research studies and cases. The second effort consisted of an activity to kick-off the feedback from the consortium with a co-creation activity, during the workshop in Bilbao. The third effort conducted a written interview with experts in relevant fields to gather deeper understanding and their positions towards the findings and recommendations from the co-creation activity.

2 Reliability indicators

Reliability can be defined as the ability of the power system components to deliver electricity to all points of consumption, in the quantity and with the quality demanded by the consumer. Reliability is often measured by the interruption indices defined by the international standard called IEEE 1366. These indices are based on the duration of each power supply interruption and the frequency of interruption and depending on each country's regulation and context, variations exist. All three major functional components of the power system – generation, transmission, and distribution, contribute to reliability.

The purpose of these indices is to provide incentives to improve the end-customer service. For that reason, it is important to understand the concept of "Customer", "Outage" and "Interruption". A customer is defined as "A metered electrical service point for which an active bill account is established at a specific location." [12]. An outage is defined as the loss of power of a component of the grid and does not necessarily mean interruption of service for the end customer. An interruption is defined as the loss of electric power experienced by one or more customers [13]. For this reason, the indices focus on measuring interruptions and not outages.

This definition does not include any of the power quality issues such as: sags, swells, impulses, or harmonics.

Interruptions are divided in planned and unplanned interruptions. They are as well sub-divides into momentary, sustained, and major events. A momentary interruption is defined as lasting less than 5 minutes, corresponding to the time taken by automatic re-closure schemes to restore temporary faults; a sustained interruption lasts longer than 5 minutes (NERC 1996). These indices are calculated using details of consumer interruptions collected from past years or several years data.

Some of the most used and important indicators in Europe include [14]:

Table 3 Reliability indicators

Acronym	Indicator
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
CAIDI	Customer Average Interruption Duration Index
MAIFI	Momentary Average Interruption Frequency Index
ENS	Energy Not Supplied
VoLL	Value of Lost Load

To understand each indicator it is first necessary to understand the variables that are measured to generate them, also to know as fundamental factors[12], which are:

CI : Customers Interrupted

$$CI = \sum N_i$$

Where N_i is the number customers who suffered an interruption.

CMI : Customer Minutes Interrupted

$$CMI = \sum U_i * N_i$$

Where N_i is the number of interrupted customers and U_i is the annual outage time for location *i*. For instance, if an outage affected 100 customers and lasted 10 minutes, the CMI is equal to 1000. CMI of different events is usually added up before calculating the indices.

CS: Customers Served (IEEE 1366 calls this N_T)

$$CS = \sum N_t$$

Where N_t is the number customers served by the company.

Getting an accurate measure of the fundamental factors is challenging and different methodologies are used across countries. On a study developed by the Energy Community (EnC) in the EU and EEA, roughly half of the Distribution System Operators (DSO) can identify network users affected by means of an automated system[15]. With these fundamental factors in place, calculating the indices becomes a simple equation in most cases, as described below:

SAIDI: The System Average Interruption Duration Index (SAIDI) is the average outage duration for each customer served. It is calculated as:

$$SAIDI = \frac{CMI}{CS}$$

As an example, consider a DSO that serves 10,000 customers. Two interruptions occur. The first one affects 10 customers for 100 minutes. The second one affects 100 customers for 20 minutes. Then the SAIDI would be computed as:

$$SAIDI = \frac{CMI}{CS} = \frac{10 * 100 + 100 * 20}{10000} = \frac{3000}{10000} = 0.3 \text{ minutes}$$

SAIFI: System Average Interruption Frequency Index (SAIFI) is the average number of interruptions that a customer would experience. It is calculated as

$$SAIFI = \frac{CI}{CS}$$

As an example, consider a DSO that serves 10,000 customers. Two interruptions occur. The first one affects 10 customers for 100 minutes. The second one affects 100 customers for 20 minutes. Then the SAIFI would be computed as:

$$SAIFI = \frac{CI}{CS} = \frac{10 + 20}{10000} = \frac{30}{10000} = 0.003 \text{ interruptions}$$

CAIDI: The Customer Average Interruption Duration Index (CAIDI) is related to SAIDI and SAIFI. It is calculated as

$$CAIDI = \frac{SAIDI}{SAIFI} = \frac{CMI}{CI}$$

CAIDI gives the average outage duration that any given customer would experience. CAIDI can also be viewed as the average restoration time. CAIDI is measured in units of time, often minutes or hours. It is usually measured over the course of a year [15].

As an example, consider a DSO that serves 10,000 customers. Two interruptions occur. The first one affects 10 customers for 100 minutes. The second one affects 100 customers for 20 minutes. Then the CAIDI would be computed as:

$$CAIDI = \frac{CMI}{CI} = \frac{10 * 100 + 100 * 20}{110} = \frac{3000}{110} = 27.2727 \text{ minutes}$$

MAIFI: The Momentary Average Interruption Frequency Index (MAIFI) is very similar to SAIFI but it tracks the average for interruptions under 5 minutes long, which are considered to be momentary. It is calculated as

$$MAIFI = \frac{CI_{<5min}}{CS}$$

Consider a second example, where a DSO serves 10,000 customers. Two interruptions occur. The first one affects 10 customers for 100 minutes. The second one affects 1,000 customers for 1 minutes. Then the MAIFI would be computed as:

$$MAIFI = \frac{CI_{<5min}}{CS} = \frac{1000 * 1}{10000} = \frac{1000}{10000} = 0.1 \text{ momentary interruptions}$$

ENS: Energy not supplied is the total volume of energy that is not supplied to customers due to faults or failures. This indicator is usually estimated because during an interruption there is no energy consumption. Methods vary depending on the aggregation level and this is an indicator that can be improved by the big data analytics developed in the Platoon Project. In general, it can be calculated as:

$$ENS = \text{SAIDI} * \frac{W}{t}$$

Where W is the energy supplied over the observed period and t is duration in hours. Once this indicator is calculated, it can be used to get the cost of energy not supplied (CENS) also known as Value of Lost Load (VoLL).

As an example of computing the **ENS**, consider A DSO serves 10,000 customers. One interruption occurs. The interruption affects 100 customers for 60 minutes who consumed an average of 20kWh in that hour. Then, the ENS would be computed as:

$$ENS = \text{SAIDI} * \frac{W}{t} = \frac{CMI}{CS} * \frac{W}{t} = \frac{100 * 60}{10000} * \frac{20}{1} = 0.6\, minutes * 20\, kW = 0.2 \text{ kWh}$$

Then the energy not supplied for that system, would be a total of 0.2kWh per customer.

VoLL: Value of lost load is the value of the energy not supplied to the customers as explained in the previous indicator. Methods vary depending on the aggregation level, on the assumed value of energy, and the purpose of the indicator from each regulation framework. In general, it can be calculated as:

$$VoLL = \text{ENS} * \frac{€}{\text{kWh}}$$

From the previous example, with a price of 0.1 €/kWh the VoLL would be computed as:

$$VoLL = 0.2 \text{ kWh} * 0.1 \frac{€}{\text{kWh}} = 0.02\, €$$

Then value of lost load, would be a total of 0.02 euros per customer. This indicator can be used as a basis for setting reward and penalty in incentive based regulation [15]

3 Regulatory and Policy Framework

As stated by the International Energy Agency, the European power grid is the largest and most complex physical network ever made by human kind [16]. And, as reported by Eurelectric, the network counts with over 2,400 electricity distribution companies, 260 million connected customers [17]. When a major drift in the grid composition is underway, it is a major challenge to ensure quality and reliability under such complexity.

Technological advancements together with the pressure to achieve the Sustainable Development Goals are part of the causes of this major shift in the European grid mix. The first one, includes breakthroughs in renewable energy technologies like Photovoltaics, Windfarms, and others. However, other technology advancements in adjacent fields like IoT and Big data, also create tools to support quality and reliability. The latter happens through different mechanisms ranging from National policy changes to Global commitments. The scope of this deliverable centres on EU directives related to big data and grid quality and reliability.

3.1 Existing Regulation of Reliability Indicators across Europe

It is important to emphasize that Continuity of Supply indicators vary, and their calculation methodologies differ from one country to the other [14]. These variations can be explained by the separated development of the grids themselves and the rules set by each National Regulatory Authority (NRA) were developed separately according to each country's needs and approaches to reliability measurement.

Another factor that makes the methodologies differ is the advancement of technologies and the speed of deployment. For instance, with the rollout of the Advanced Metering Infrastructure (AMI), new possibilities open for different methodologies of measuring and approaching each indicator, some of them explored together with a SCADA system for precise calculation of the reliability indices [29]. On the other hand, the measurement is still carried out manually in some of the lagging areas, adding a human factor to the monitoring results.

NRAs then take these indicators as reference to establish regulation frameworks to incentivize DSOs to comply with a continuous improvement of the network reliability. European level regulation on the internal market of electricity already recognizes Performance-Based Regulation on Article 18(8) of the Electricity Regulation adopted in 2019 [33], to encourage members to consider output-based incentives for DSOs to raise efficiencies and find optimal solutions to meet their customer demands.

Although a more specific classification is seen in Figure 20, all the regulatory models in Europe can be classified as incentive-based with differences in how the incentive is defined.

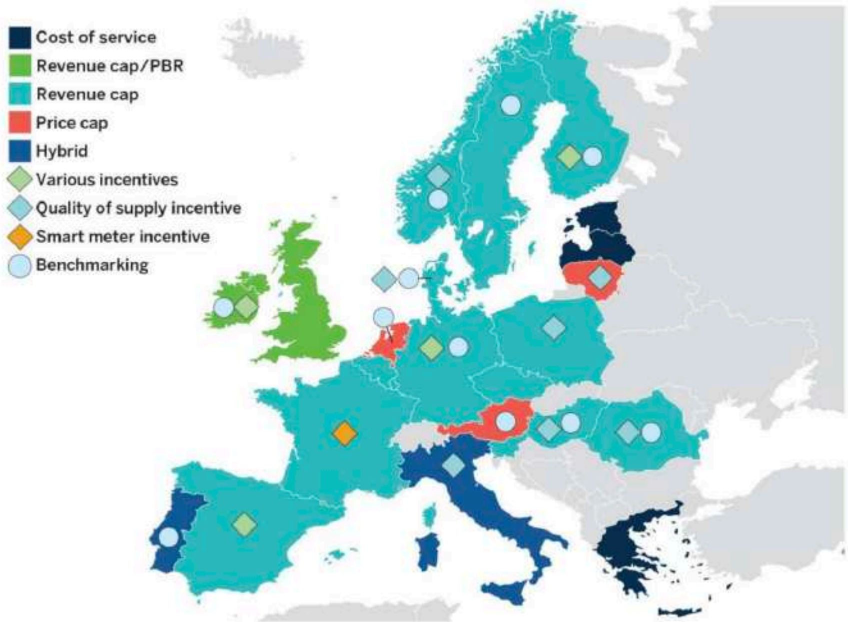


Figure 20 Regulatory models for DSOs in Europe [34]

An important aspect of PBR is the definition of baselines. In general, there are two approaches for determining standard Continuity of Supply baselines to compare the measured outcome as Grahn et al describe in their paper. The first is to consider performance over time (history), like the method used in Italy and the method used in Sweden from 2012 to 2015. The other method is to use a mathematical model, like the one used in Norway. A third approach is a mix of both, like it is done in Sweden since 2016 [30]. From these baselines, countries at the forefront of customer-centric policies implement incentives or penalties for the DSOs. Sweden for instance, uses a complex method illustrated in Figure 21 to define financial incentives described by Grahn et al [30].

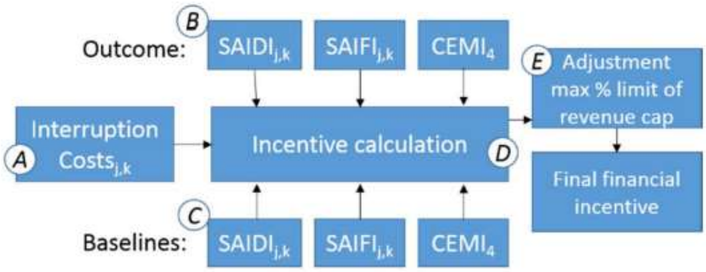


Figure 21. Schematic of Swedish Incentive Calculation [30]

Understanding the complexities of the European grid is a hard task to achieve. For this reason, one of the most relevant actors at a European level in terms of power supply quality and reliability was created and evolved to become the Council of European Energy Regulators (CEER). Among the tasks undergone by the CEER, the organisation oversees the regulation specifics for each member and unifies the main indicators of Continuity of Supply across Europe in their benchmarking report. The following section describes the CEER and their reporting concerning the CoS indicators.

3.1.1 CEER

First formed in the year 2000 and then established in the year 2003, the Council of European Energy Regulators (CEER) is a non-profit organisation which primary objective is to facilitate the creation of a single, competitive, efficient, and sustainable internal market for gas and electricity in Europe. Within this body, Europe's national energy regulators cooperate to protect consumer interests. One of the contributions from the CEER is the periodic benchmarking report on the continuity of electricity and gas, in which the organisation unifies the main indicators of Continuity of Supply across Europe. The indicators include:

- System Average Interruption Duration Index (SAIDI),
- System Average Interruption Frequency Index (SAIFI) and
- Customer Average Interruption Duration Index (CAIDI)

The specifics on which indicators each member tracks, can be found in the charts of the latest CEER Benchmarking Report [14]. On the same note, the benchmarking report also sheds light over the development of the indicators across time. Perhaps the most significant observations can be summarized in the charts representing the SAIDI and SAIFI without exceptional events in Figure 22 and Figure 23, where it is noticeable from both charts, that both unplanned SAIDI and SAIFI have decreased over time.

However, while these reporting shows how indicators overall tend to go down, which mean the reliability of the grid increases, the European network is undergoing a shift towards renewable energy sources. This shift adds complexity and variability, which must be compensated by new policies and strategies hand by hand with technology advancements.

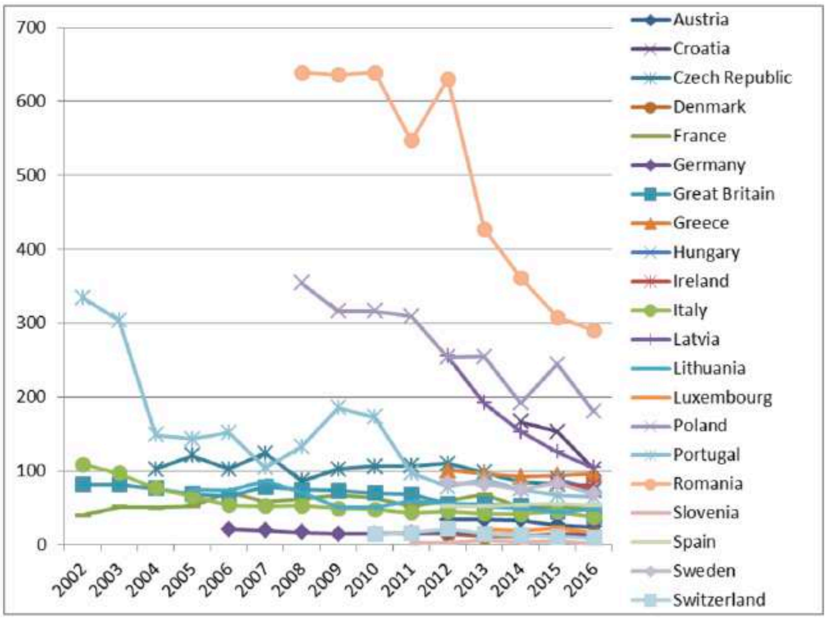


Figure 22: unplanned SAIDI, without exceptional events (minutes per customer)

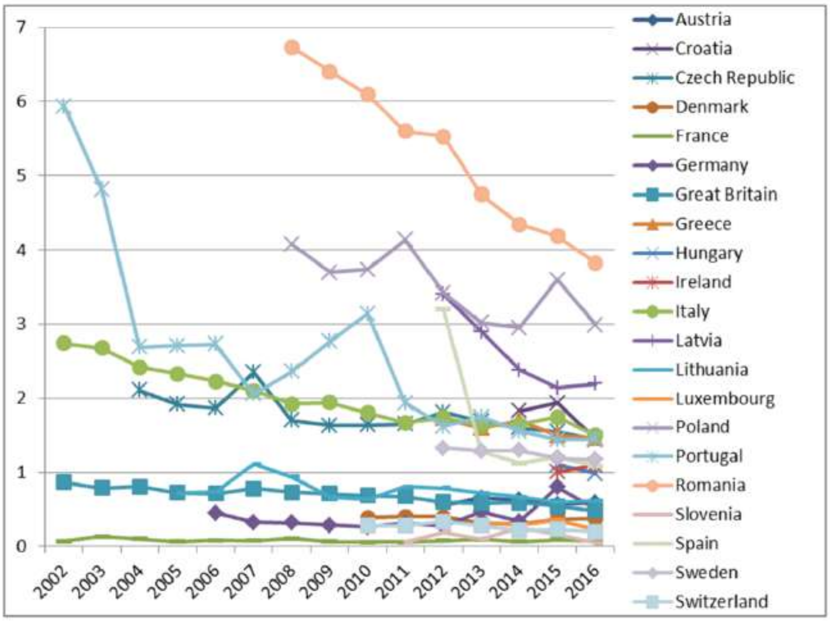


Figure 23: unplanned SAIFI, without exceptional events (interruptions per customer)

3.2 EU directives – Directives concerning green transformation of the grid

Figure 24 portrays an aggressive change of the European grid mix in the years to come. To achieve the decarbonisation plans, and the energy requirements for 2050, EU's electricity mix is projected to grow to a 50% of wind energy.

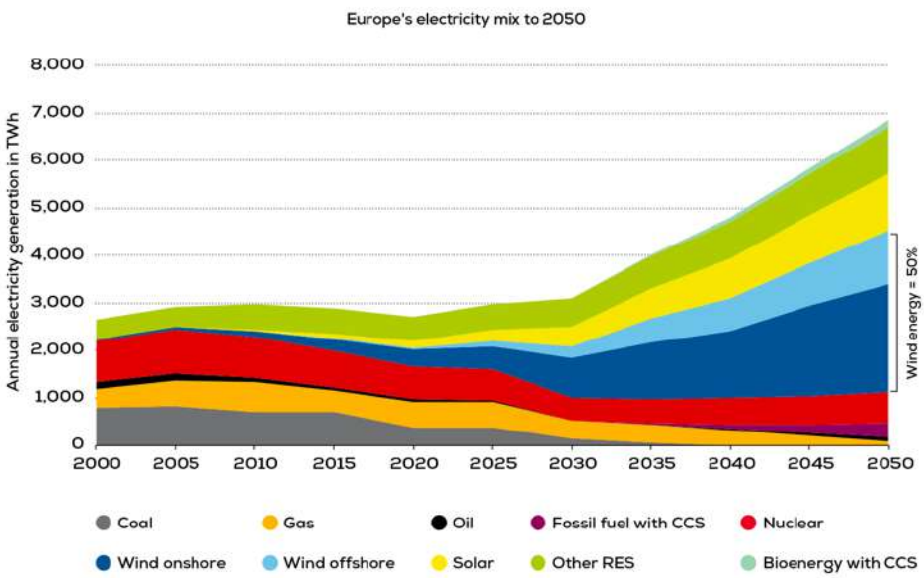


Figure 24. European grid mix projection [18]

This paradigm shift implicates further changes in the grid and big data techniques to compensate for the increase in variations of the sources of the grid. In fact, the same report from ETIP wind accounts for advance forecast techniques to reliably predict the daily PV generation [18]. This subchapter explores the different mandates that define the strategy behind the shift in the grid mix.

3.2.1 The European Green Deal

The European green deal outlines initiatives across all policy sectors to achieve a climate neutral EU by 2050. Energy efficiency and renewable energy are fundamental pillars to reach the proposed targets. The European Commission is constantly evaluating and presenting new measures through policy making, aimed at embracing technological advance across all sectors of the energy system [19]. The EU strategy on energy system integration [20], the EU strategy on offshore renewable energy [21] and the Digitalisation of the energy system [22] are some of the policies elaborated on the context of the European green deal.

3.2.1.1 Fit for 55

In the context of the European green deal, the Fit for 55 package aligns and modernizes legislation with the EU's 2030 climate targets. Fit for 55 includes directives like Carbon border mechanisms, Revision of the Energy Tax Directive, new CO2 emission standards for vehicles, and an amendment to the Renewable Energy Directive to accelerate the energy transition and achieve the new 2030 targets [23]. Another recent example of the initiatives within the Fit for 55 package is the REPowerEU Plan. The aggressive plan would bring the total renewable energy generation capacities to 1,236 GW by 2030, in comparison to the 1,067 GW by 2030, envisaged under Fit for 55 for 2030, to ensure Europe's independence from the Russian fossil fuels, given its unreliability and volatility [24].

3.3 EU directives – Directives concerning Digital transformation of the grid

Data analytics play a key role in the modern electricity transmission and distribution network for data collection, storage and analysis with the help of wide installation of smart meters and sensors [25]. The digitalisation of the energy system is being deployed with the help of various policies in the last two decades, promoting strategies for data, cloud and edge, and cybersecurity.

3.3.1 European Strategy for Data

Many new players involved in generation, supply, distribution, or consumption bring another important asset: their data. importance of handling and sharing data in accordance with the EU values. To ensure a unified strategy for data, several actions have been taken and are being developed by the European Commission. Amongst them, the Data Act proposed in 2022, the Clean Energy Package, the Digitalisation of Energy Action Plan and the development of the common European Data Spaces in 9 domains, including Energy.

3.3.1.1 Data act

On February 2022, the Commission proposed a Regulation for harmonised rules on fair access to and use of data, also known as the Data Act. The purpose of the Act is to set up rules regarding the use of data generated by Internet of Things (IoT) devices, like the Smart Meters and other devices implemented in the energy domain [26]. EU also announced the development of common European data spaces in nine domains and sectors of strategic importance, including energy. However, actors like Euroelectric in the energy field have signalled improvements in terms of data exchanges between businesses, consumers and public authorities [27].

3.3.1.2 Digitalisation of Energy Action Plan

To help integrate renewable energy sources and ensure energy quality and reliability, the EU adopted in October 2022 the Action plan for the digitalization of energy [22]. Among other actions, the goal is to build a common Energy data space to support the energy transition. This will be achieved with the focus on 5 research areas: an European data-sharing infrastructure, Climate neutrality in the IT sector, empowering citizens to participate in the energy market, cybersecurity in the energy sector, and enhancing the uptake of technologies [28].

4 Big Data Analytical Techniques

Big data is essential for improving grid reliability and efficiency while reducing the cost energy use [1]. The following section takes initial data gathered through the study of relevant research papers and case studies together with the input from the Bilbao Workshop with the pilot experts, as a starting point to determine the big data approaches to different areas of the Smart Energy Network. Each of the areas within this section explore the applications of these initiatives and ideas to improve the regulatory framework and incentives towards grid reliability, aiming to give recommendations to the involved stakeholders.

Predictive maintenance: The energy sector is adopting predictive maintenance at all levels. Although Transmission System Operators (TSO) are already using it to quickly identify faults, Distribution System Operators (DSO) have already started strategic plans for the digitization and automation of networks [2].

Predictive maintenance uses signals from smart meters and data analysis tools to distinguish, detect, and find the deficiency in the smart grid before a total breakdown occurs [3]. The applied methods can be classified as conventional and Machine Learning methods. Conventional methods include "*Infrared Thermography-Based Technique with Multi-layered Perceptron (MLP)", "Traveling Wave Fault Location", "Impedance-Based Method", "Current Measurement and Synchronize", "Voltage Relay Protection System",* and *"Monitoring and Sensors Infrastructure*". While Machine Learning methods include *"Support Vector Machine (SVM)"*, "*Artificial Neural Network (ANN)", "Random Forest", "Recurrent Neural Networks (RNN)"* [2]. Although they differ in their execution, all can essentially benefit from big data adoption and innovation.

Improved supervision of the LV grid: the increase of distributed power generation at consumer level is a challenge for DSOs, but thanks to the deployment of smart metering, some of the traditional limitations of the LV grid, like near-real-time supervision can be solved, while also reducing the operational costs [4]. The monitoring at the edge of the grid, allows for various big data big data practical applications and benefits for the DSOs and the end-customers, amongst the following [5]:

- **Efficient fault detection through real-time alarms**: grid monitoring allows for automated countermeasures and reduced downtime caused by problems like frequency-caused blackouts, a blown fuse, overcurrent, overvoltage, undervoltage, and others.
- **Technical loss detection**: improved understanding of grid losses from generation to the LV feeder to evaluate improvements in the DSOs technical and economical operations
- **Efficient diagnostics and power quality monitoring**: improved understanding of electrical switching lifecycle. New customer metrics permit to go beyond "Interruptions" and improve quality for events like voltage sags or swell that do not count as SAIFI but affect operations.

- **Transformer health monitoring:** data can improve transformer stability, lifetime extension and avoid unplanned interruptions with predictive maintenance. Platoon's pilots 1a and 2b use big data for transformer health monitoring.
- **NTL detection**: direct connections and meter tampering affect DSOs permanently and are traditionally identified through specialized technicians, which is a time-consuming work. Algorithms to identify tampering and significant losses can help identify these problems remotely. Pilot 2b is implementing NTL detection with big data methods [6].

Energy production and demand forecasting: better planning and management of the electricity grid is now possible thanks to the developments of forecasting models, which now integrate various methods for big data use, together with artificial intelligence (AI) and machine learning (ML) techniques. Forecasting applications not only should focus on the demand, or on the consumption side, but also help the TSO-DSO dynamic. Some of the applied techniques include:

- **Improve energy consumption forecasting**: Consumption forecasting and report of foreseeable electricity demands help optimize grid balance and plan for periodical operations like planned maintenance. The analysis of the big data from sensor networks across buildings and industry is also being used to manage consumption patterns and generate savings [7].
- **Renewable energy forecasting**: wind and solar energy are the fastest growing renewable energy sources. However, both rely on factors such as radiation, wind speed, temperature, rain and other weather variables. Forecasting helps plan for backup capacity, maintenance, and future investments. Although traditional models are used nowadays, they miss non-linearity of data and have long-term dependencies [8]. Direct forecasting is being emphasised, with many methods being applied in different areas. For instance, Extreme Machine Learning being used for wind speed forecasting and daily global solar radiation, Shark smell optimization and fuzzy clustering for day-ahead wind power and short term PV forecasting and many other applications [8]. In this category, Pilot 4a is implementing PV nowcasting.
- **Interoperability and integration of supply chain**: the energy quality depends on the balance between supply and demand. Both previously mentioned applications concern utility providers. Forecasting and a good TSO-DSO dynamic is mandatory for the proper functioning of utilities. Techniques like the Jelly-fish optimizer, with square support vector regression allows for multi-step energy consumption forecasting and is used to keep the energy supply and demand balance [8].

Benchmark and accountability

SAIDI and SAIFI, defined by the IEEE have been the benchmark for reliability measurement for years. They have been useful in evaluating overall reliability, but they fall short in several aspects, like improvement programs or showing great variations when data is aggregated [9]. The generation of outage profiles with big data analysis to characterize outages and understand what happened and why, can be used to create improvement plans and outage prevention opportunities [10]. Lastly, another application of big data includes the modelling of optimal small-scale investments to optimize the current SAIDI and SAIFI indicators. These models promise to significantly improve the indicators, under a strict budget [11].

5 Lessons from the project pilots

Part of the objectives of Task 8.4 is to learn lessons from the pilot projects and the project itself, to generate recommendations to the regulatory bodies on how to improve or update the reliability indicators used by electric power utilities. The two major activities undergone for the task were a co-creation workshop with the representants of all Platoon's partners took place on October 6th, 2022, in Bilbao, and a survey with 2 experts on the domains of Energy and Big Data which was elaborated through the month of November 2022.

The first initiative aimed at presenting the basics of reliability indicators to the partners and exploring the main topics of big data methods to improve or challenge the present metrics and indicators used by regulators to record reliability and end-customer service. The collection of these opinions, together with desktop research, helped design the interview undertaken by experts on the matter to dig deeper into the state-of-the-art applications of big data to improve reliability and generate recommendations for regulation bodies, policy makers and DSOs to go beyond the actual metrics and performance indicators.

5.1 Co-creation Workshop

As the first step to collect lessons from the project, a co-creation workshop has been made with the project partners in a stage that the pilot development has been done and a part of validation was left, in order to collect the knowledge gained from the experience during the project lifetime and from the own expertise of energy digitalisation.

5.1.1 Methodology

The workshop was structured to be a hybrid meeting with exposition and live interaction amongst the expositor and the audience. The event counted with around 40 participants and included an interactive tool that allowed them to access the presentation and provided answers that were anonymously recorded for their analysis. The presentation included 6 questions and the main purpose was to explore the present knowledge of the consortium related to the reliability indicators, their relationship to their work and to the scope of the project. The following section presents the conclusions of the workshop, and how Platoon may contribute to include big data analytics into the reliability indicators across the European power grid.

5.1.2 General results and conclusions

While the full set of the questions of the co-creation workshop are described in Annex AII-1 together with the logic behind each question, and details of the results, this section describes a set of selected core questions and their analysis results.

The workshop began with three general questions to make the audience understand the topic and the first question brought interesting aspect and included in this section.

Question 1, ***What comes to your mind when you think of Continuity of supply?***

This question was presented in a "Word cloud" format and asked at the very beginning of the activity without the audience being presented any hint of the topic. The purpose of the first question was to motivate participants to use the interactive tool and break the ice during the first minutes of the workshop. Therefore, the results from this question were not aimed at providing a direct insight.

The following map was obtained after this first activity:

Figure 25: Word cloud result

The big font indicated that multiple participants gave the word as an answer. Although participants were not informed about the details of the workshop, the most answered word was 'Reliability' when asked about Continuity of Supply. Other related terms that were mentioned more than once include "Quality", "Customer", "Energy Management", "Stability" and "Energy security". It means the participants who answered that they are not familiar with reliability indicators (it is shown from the question 2 and 3 that are included in the Annex, and it is somewhat understandable because most of the participants are on technical domain), the answer clearly shows that reliability was considered the most important aspect of energy continuation, which is well fitting to the scope of the task.

Besides the questions to introduce the topic, the workshop aimed at answering 3 main questions, first "*How can big data strategies improve energy quality and reliability*", second, "*How the Platoon project and the pilots impact energy quality and reliability through the mentioned strategies*", and lastly "*What are the barriers for these strategies*".

For each of these 3 questions, results were consolidated and summarized as follows:

Question 4, ***In your opinion, how can big data solutions help to make the grid more reliable for the end customer?***

Table 4 Question 4 consolidated results

Response	Votes
Predictive analysis avoids interruptions with planned maintenance. Predictive maintenance.	14
Detection of disturbances by grid monitoring allows for automated countermeasures and avoids frequency-caused blackouts	13
Better Energy production and demand forecasting with predictive analysis and real time data	7
Decision making in case of supply interruption	4
Data exchange from different stakeholders to improve insights	2
Better root analysis for decision making	2
More data to detect abnormal cases	1
More flexibility	1

The experts' opinion on the main improvements brought by integrating big data analytics into the grid are based on predictive maintenance, quick response to faults with automated countermeasures, and demand forecasting. Although these are some of the applications described in Section 2, other remain out of the top of mind of the project partners.

Question 5, ***How can Platoon big data analytics solutions help to improve reliability and quality for the customer?***

Table 5 Question 5 consolidated results

Response	Votes
Efficient fault detection and diagnostics improve understanding of electrical switching lifecycle and reduce downtime	9
Forecast and predictive maintenance including renewables facilities	9
Transformer health monitoring and smart metering data can bring insights to improve predictive maintenance . Pilots 1a and 2b	7
Industry costumers can forecast and report foreseeable electricity demands and optimize grid balance. Pilot 2a	6
Edge solutions allow for a dynamic SAIDI and SAIFI instead of waiting every quarter	3
Interoperability and integration of supply chain	3
Make available more specific solutions for distribution companies	2
Creation of general rules and data analytics tools to help the development of specific projects	1
Benchmark and accountability	1
Easily use collected data	1
Transparency	1

From the standpoint of Task 8.4 objectives, these responses bring the most value to the objectives of the workshop. The opinion of the area experts, after a brief explanation of the indicators was presented, shows us the more relevant topics on how the pilot projects developed under the scope of the Platoon project can improve the reliability of the power grid, either through incentives like the SoC indicators, or other ways of contributing to the grid stability and reliability. Further work needs to be done over these findings, but the success of the activity relies on guiding the conversation towards improved fault detection, smarter and quicker forecasting, and monitoring for predictive maintenance. All of them, through a practical approach as described by the pilot owners and other participants.

Question 6, ***For these solutions, do you find barriers for scalability?***

Table 6 Question 6 consolidated results

Response	Votes
Complexity of regulatory frameworks across member states and wide scale adoption	10
Data share policies and willingness to share (Collaborative mindset)	7
Handling big data, platform and data complexity	7
Real time data availability	4
Complex financial justification of major rollouts and time constraints	3
Hardware's and software's (big data analytics, etc) quality still need to be improved	2
Data and services integration costs	2
Customer's capability and specific needs	2
Energy consumption and computational demand of solution	1
Company's accountability	1

Stakeholders	1

Finally, the activity included an effort to generate insights on the possible barriers for the given recommendations. The main worries from the experts include the complexity of the European landscape, the lack of a collaborative mindset in terms of data availability, and complexity of handling the data itself. These barriers can pose a big challenge for unified recommendations that apply to the whole European landscape.

Not only in terms of scalability of a proposed solution, but also in terms of reproducibility of a solution in a different regulatory landscape. For instance, one application can be compliant or useful for a specific country, but not for others, given the variety of regulations in terms of reliability indicators across countries, as there might exist country-specific particularities that make the solution either illegal or irrelevant for that particular country.

As with the other findings, further research must be done to produce and update the relevant regulatory and policy frameworks.

5.2 Interviews with experts

The interviews with experts were elaborated with the goal of expanding the feedback from the consortium experts in relation to the possible applications of big data to reliability indicators and recommendations to regulation bodies.

5.2.1 Methodology

The survey was structured to ask on-point, specific questions to experts in the energy and big data domains. With previously mentioned goal, the collection of opinions from the workshop and the desktop research were used to design the surveys. The survey consisted of 10 questions. The first 6 questions were specifically for big data experts and the last 4 were designed for the experts in the Energy sector. The logic behind each question, and results, are described in Annex 2. The following section presents the conclusions of the surveys, and how PLATOON may contribute to include big data analytics into the reliability indicators across the European power grid.

5.2.2 General results and conclusions

The survey aimed at answering 4 main questions, first "*What are the most promising applications of big data in the energy sector in relation to reliability indicators and which ones are being deployed already*", second, "*What are the ,main barriers for these applications to be scalable, replicable and how to overcome these hurdles*", third "*What are the limitations of the reliability indicators and other regulations used nowadays*" and lastly "*What are their opinions on incentive-based schemes used in some parts of Europe to promote continuity of Supply*". The full set of the answer from the interviewees is included in the Appendix AII-1.

The results for these four topics were consolidated in the following bullet points:

- **Promising applications of big data in relation to reliability indicators**: Among the most promising applications in relation to Grid reliability and continuity of supply, as presented to the experts, include the following:
  - **Fault detection**: use of data-mining and other techniques to detect faults in solar and wind grid-connected microgrids.

- **Predictive maintenance**: several techniques applied like clustering and data-driven models to provide early warnings in maintenance calls ranging from distribution automation to MV grids.
- **Transient stability analysis**: new approaches to Transient Stability Analysis are needed with the integration of renewables in the smart grid
- **Device health monitoring**: failure models for different components to predict potential risk problems and health condition
- **Power quality monitoring**: pattern recognition techniques for Power Quality Events analysis
- **Topology identification**: visualization of Low Voltage (LV) grids with limited metering and data
- **Renewable energy forecasting**: short-term power prediction
- **Load forecasting**: deep-learning and other techniques to avoid volatility
- **Load profiling**: categorisation of clients by profile through clustering
- **Load disaggregation**: non-intrusive load monitoring to identify loads at household level
- **Non-technical Loss detection**: electrical theft or accounting errors

And as expressed by the experts, the applications of big data being developed based on their knowledge include:

- **Fault detection**: data analytics techniques related to fault detection/health monitoring allow to implement a predictive maintenance strategy to prevent unplanned downtimes of different assets that can jeopardize grid stability. PLATOON has developed and validated different data analytics tools for fault detection/health monitoring as part of the large-scale pilots. **Pilot 1A** developed Hybrid Digital Twins and data driven anomaly detection for Wind Turbines. **Pilot 2A** developed load forecasting tools and data driven algorithms for PV monitoring. **Pilot 2B** developed virtual sensors and health monitoring tools for MV-LV distribution electrical transformers.
- **Topology identification and load forecasting:** forecasting is a transversal tool that can work as input for most of the other techniques. Profiling and disaggregation tools offer the necessary flexibility to balance the variability of renewable energy sources. One of the new projects undertaken by one of the experts includes different data analytics tools regarding flexibility provisioning.
- **Predictive maintenance:** a forecasting baseline also allows for an exchange of degradation models with future expected data to infer the time where a maintenance is needed.
- **Non-technical loss: Pilot 2B** is using a load forecasting tool to detect non-technical loses in their pilot grid. It is currently being validated by the DSO and has received positive feedback.

- **Barriers and how to overcome them**: Experts mentioned three main barriers regarding development, scalability and reproducibility:
  - **Availability of data**: although many smart meters are already installed, wide data loses exist in one of the pilot's networks, and it's a small network. A generalized defined strategy of smart meter data gathering, taking care about saving and sharing data easily, would allow for the usage and scalability of optimization and operation tools being tested today.
  - **Legal framework:** the legal aspects of data usage and availability in some cases are still a bit blurred. It is necessary to policy makers to clearly define the legal aspects

around data sovereignty, especially on who owns the data and who can deal with the data, to make the data flow amongst organisations/individuals in a standardised and trustworthy manner. Having a clear landscape across the member states would incentivize the replicability of applications at the EU level.

- **Incentives for DSOs:** DSOs are only remunerated based on hardware investments which makes it hard for them to invest in the development of data analytics. Regulation and policy changes should be updated so DSOs are remunerated for software investments.
- **Heterogeneous regulatory frameworks:** the rules of the game are very different from one country to the other as they are mostly defined by the NRAs. This presents a key barrier in terms of reproducibility of solutions, as one strategy can be very useful under one incentive based regulation but not useful under other frameworks.

- **Limitation of present indicators**: As exposed to the experts, metrics of grid performance (reliability indicators like SAIFI and SAIDI) vary spatially and temporally by orders of magnitude revealing heterogeneity that is not shown in publicly reported data [9]. This creates the issue missing important data or variations in the reliability indicator due to aggregation of data. To avoid this issue, experts signalled that technology nowadays, with the use of big data, allow to increase the granularity of the data so the analysis can be done to smaller segments of the network. By using a cloud distributed database (an example based on Hadoop ecosystem). for its capacity of data compression, a centralized data repository with available historical and live data can be developed.

  Another point towards the limitations of the current indicators included its nature of being past-oriented. Experts suggested the usage of forecasts using deep learning techniques, so previous existing consumption and production can be adapted based on the renewable production forecast to be one step ahead and prevent events based on pattern-recognition.
- **Incentive-based schemes for continuity of supply**: As the energy system transitions to a fully decentralised system, it is relevant to break the current siloes and allow data sharing amongst different actors of the grid showing a win-win situation towards a more efficient and reliable grid. This should include all the actors including the prosumers who should receive part of these benefits as active players in the smart grids.

6 Recommendations

As the pressure to achieve the Sustainable Development Goals increases, so does the shift in the European matrix to integrate renewable energy sources. This shift, together with the increasing complexity of the European grid brings in a major challenge to ensure quality and reliability for the end customer.

Technological advancements and breakthroughs in renewable energy technologies like Photovoltaics, Windfarms, and other technology in adjacent fields like IoT and Big data, create tools to support quality and reliability. However, there are barriers that prevent these technologies to be deployed at scale and at the required speed. Some of these barriers are caused and can be tackled with different mechanisms, from National policy changes to Global commitments. For this reason, the following recommendations for regulation bodies are gathered from the three actions undertaken, related specifically to the application of big data techniques on reliability indicators.

- **Data sharing and data availability:** data from different stakeholders should be readily available to improve insights. There are two gaps in this area that slow down the implementation of many of the applications explained before. First, loss of data from the smart meters is still a problem. And second, the rules of the game in relation to data are not clear.

  In relation to the first problem, the handling of big data is still an issue in terms of scale and replication across the network. Strategies that prove successful at preventing data loss at scale should be identified and replicated. For instance, one expert recommended a generalized defined strategy for smart meter data gathering in charge of saving and sharing data, which would help the usage and reproducibility of many optimizations and operations tools at scale that nowadays find this issue as their greatest hurdle.

  As for the second issue, the development of Data Spaces can bring vast benefits to the energy system, but it should aim at finding a global optimum solution in such decentralised sector, with the ability to process heterogenous data from different actors of the grids (prosumers, DSO, aggregator, etc.). Although all data should not be fully public for several security and privacy reasons, a recommendation is to categorise data at different groups based on criticality to be disclosed to academia and RTOs for research purposes. Data Spaces must enable secure and trustworthy sharing of data and data analytics tools amongst the actors leading to a win-win situation towards a more reliable interconnected grid. On this note, PLATOON added security and interoperability on top of big data analytics.
- **Faster feedback from indicators:** studies show the granularity of data impact the indicators by orders of magnitude, this limitation can be considered in terms of amount of data and frequency of data. The computation of these indicators could be improved by splitting the gathering of data into a fog architecture combing cloud, on-premises server, and edge computing devices to create and visualize the indicators faster.
- **Legal certainty, transparency, and reporting:** PLATOON has developed and validated the technology for data sharing and data analytics tools. Technology exists, but the legal aspects of data usage and availability are still a bit blurred.
  It is necessary for policy makers to clearly define the legal aspects around data sovereignty, especially on who can deal with the data and in which scope, to make the data flow amongst organisations/individuals in a standardised and trustworthy manner, and foster investments on software.
- **Company's accountability and incentives:** Nowadays, DSOs are only remunerated based on hardware investments. This makes it hard for DSOs to justify investments in software applications like the big data analysis strategies exposed in this document. The promotion on software investments should be fostered through regulation. By updating the incentive schemes so DSOs are also remunerated for software investments, they can invest money in the development in the data analytics tools previously mentioned.
- **Involvement of prosumers and Local Energy Communities:** As the energy system transitions to a fully decentralised system, flexibility and stakeholder management start taking a more important role. Therefore, it is relevant to break the current siloes and allow data sharing amongst different actors of the grid, showing a win-win situation towards a more efficient and reliable grid. This should include all the actors including the prosumers who should receive part of these benefits as active players in the smart grids.

7 Conclusion

As the complexity of the grid increases and decentralisation of the energy network takes place, the focus on the end-customer becomes a priority. Reliability indicators like SAIDI and SAIFI, as traditionally measured, fall short with the outskirt of new technologies like big data analytics that have shown a better and more granular understanding of the complexities brought by renewable energy sources.

This deliverable explains the reliability indicators and describes existing regulatory and policy frameworks to refer. It also summarises a set of big data analytics techniques that are relevant to energy reliability. In order to collect lessons from the project experiences, it made a co-creation workshop and experts' interview. With collective results, it suggests several recommendations given by experts in the relevant fields, for these technologies to be embraced by the energy sector, to keep the continuity of supply at the centre.

It would be beneficial to continue the research with collecting more studies and use cases through a collaborative program with diverse experts in order to generate a harmonised policy on the identified gap area.

Annex II-1: Co-Creation Workshop

One of the objectives of Task 8.4 of the Platoon project is to understand the lessons learned from the pilot projects and the project itself, to generate recommendations to the regulatory bodies on how to improve or update the reliability indicators used by electric power utilities. The goal of the co-creation workshop was to first introduce the topic of reliability indicators to the consortium partners, of which the majority are technical experts on the data science field, and then relate their work to the objective in hand to finally derive recommendations based on their experience and group knowledge.

Methodology

The workshop was structured to be a hybrid meeting with exposition and live interaction amongst the expositor and the audience. The event counted with over 30 participants and included an interactive tool that allowed them to access the presentation and provided answers that were anonymously recorded for their analysis. The presentation included 6 questions and the main purpose was to explore the present knowledge of the consortium related to the reliability indicator and their relationship to their work and to the scope of the project. The logic and results are described in the following section and were then used to derive conclusions about the workshop, and how Platoon may contribute to include big data analytics into the reliability indicators across the European power grid.

Questions and Results

Question 1 – Word cloud:

What comes to your mind when you think of Continuity of supply?

This question was presented in a "Word cloud" format and asked at the very beginning of the activity without the audience being presented any hint of the topic. The purpose of the first question was to motivate participants to use the interactive tool and break the ice during the first minutes of the workshop. Therefore, the results from this question were not aimed at providing a direct insight.

The following map was obtained after this first activity:

Figure 26: Question 1 - Word cloud result

Although participants were not informed about the details of the workshop, the most answered word was 'reliability' when asked about Continuity of Supply. Other related terms that were mentioned more than once include "Quality", "Customer", "Energy Management", "Stability" and "Energy security".

Question 2

This question was presented in a multiple selection format. The audience could only choose one option. A small explanation of the most know indices was presented beforehand.

How familiar are you with the reliability/quality indicators like SAIDI, SAIFI, or CAIDI?

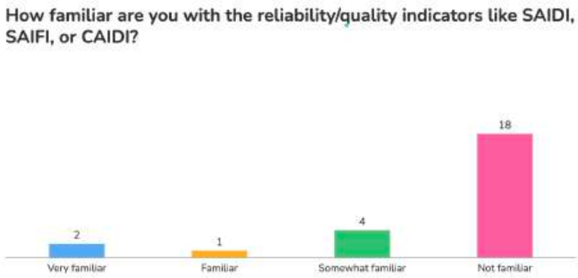
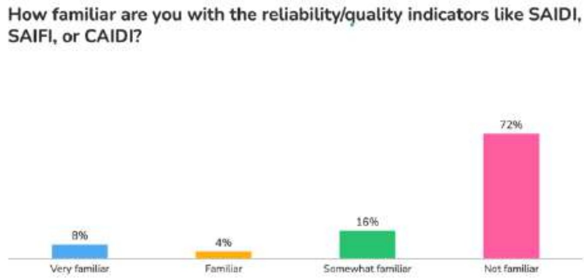
Absolute	***Percentages***
	

Figure 27: Question 2 results

The purpose of the question was to adjust the presenter's expectations about the audience's knowledge of reliability indicators. As the graph shows, only 3 of the participants were familiar or very familiar with the topic in hand, while the majority indicated they were not familiar at all. This mix of participants proposes a good scenario for ideation. While there are technical people familiarized with the concept, there are also technical people from other fields like data science, that could bring out of the box ideas to improve the final recommendations.

Question 3

This question was presented in a multiple selection format. The audience could only choose one option. A detailed explanation of the most know indices was presented beforehand. After showing these results, we presented to the audience the trends of the indices since 2002 as measured by the CEER across Europe presented in section **Error! Reference source not found.**

How useful do you think measuring these indicators is?

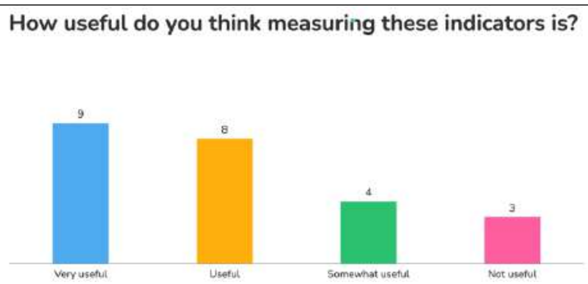
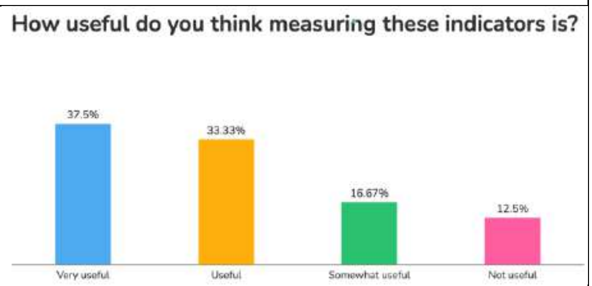
Absolute	***Percentages***
	

Figure 28: Question 3 results

The purpose of the question was to evaluate the perception of usefulness of the indicators in the audience and contrast it with the actual performance of the indicators across the European landscape. A better perception of usefulness from the consortium could be expected to indicate a better attitude towards contributing to improve the tools to generate incentives for a more stable power grid. In general, the majority perceived the indicators as useful or very useful, but more than 25% of the audience marked them as somewhat useful or not useful.

Question 4

This question was presented in a "Brainstorm" and Voting format. The audience was presented three sample answers taken from their project, and then was asked to create new answers and post them for the other to see. Afterwards, a voting process took place to choose the most relevant answers. Participants were able to vote for 2 answers.

In your opinion, how can big data solutions help to make the grid more reliable for the end customer?

The obtained raw data is:

Table 7: Question 4 raw data

Response	Votes
Detection of disturbances allows for automated countermeasures and avoids frequency-caused blackouts	8
Predictive analysis avoids interruptions with planned maintenance	5
Better Energy production and demand forecasting	4
Decision making in case of supply interruption.	4
Predictive maintenance to avoid unexpected stops	4
Predictive Maintenance!	3
Grid monitoring	2
data exchange from different stakeholder	2
Predictive analysis to forecast consumption	2
Predictive maintenance	2
Understand causes	2
More data to detect abnormal case	1
Increased monitoring	1
More flexibility	1
Try to find back-up solution	1
Real-time on demand detection	1
Targeted feedback allows to improve places were problems occur frequently	1
Predicative maintenance	0
Forecasting	0
More options for operations	0
To prevent anomalies	0
Optimisation of actions	0
Grid and electric network fallout cascade forecasting through big data ML forecasting and intervention plans	0
Improved supervision of the LV grid (faster failure detection and solving)	0
Prevention of losses	0

The purpose of the question was twofold. First to identify the views of the audience towards the use of big data into improving the grid reliability. And second, to evaluate the ideas that were more aligned with the audience's expectations on how big data is better used for that purpose.

Before analysing the results, it is important to point out that some answers make reference to the same concept, therefore, the table below shows a categorised group of answers that sums up the votes, ending a more compressed result.

The obtained consolidated results are:

Table 8: Question 4 consolidated results

Response	Votes
Predictive analysis avoids interruptions with planned maintenance. Predictive maintenance.	14
Detection of disturbances by grid monitoring allows for automated countermeasures and avoids frequency-caused blackouts	13
Better Energy production and demand forecasting with predictive analysis and real time data	7
Decision making in case of supply interruption	4
Data exchange from different stakeholders to improve insights	2
Better root analysis for decision making	2
More data to detect abnormal case	1
More flexibility	1
Grid and electric network fallout cascade forecasting through big data ML forecasting and intervention plans	0
Improved supervision of the LV grid (faster failure detection and solving)	0

This first question involves a more general application of big data to improve reliability, a more specific question on what Platoon brings to the table is shown in question 5. The experts' opinion on the main improvements brought by integrating big data analytics are based on predictive maintenance, quick response to faults with automated countermeasures, and demand forecasting. Although these solutions are based on high level opinions, and big data in general, the next step from the T8.4 standpoint is to complement them with further research to generate more specific recommendations.

Question 5

This question was presented in a "Brainstorm" and Voting format. The audience was presented three sample answers taken from their project, and then was asked to create new answers and post them for the other to see. Afterwards, a voting process took place to choose the most relevant answers. Participants were able to vote for 2 answers.

How can Platoon big data analytics solutions help to improve reliability and quality for the customer?

The obtained raw data is:

Table 9: Question 5 raw data

Response	Votes
Efficient fault detection and diagnostics improve understanding of electrical switching lifecycle and reduce downtime	7
Transformer health monitoring and smart metering data can bring insights to improve predictive maintenance	5

Forecast and predictive maintenance	4
Industry costumers can forecast, and report foreseeable electricity demands and optimize grid balance	3
Energy forecasting and energy balance in pilot 2a	3
Forecast and predicative maintenance	3
Edge solutions allow for a dynamic SAIDI and SAIFI instead of waiting every quarter	3
Interoperability	2
Make available more specific solutions for distribution companies	2
Predictive maintenance of renewables and transformers in pilot 1a and 2b	2
More integrated energy supply chain	1
Creation of general rules and data analytics tools to help the development of specific projects	1
Benchmark and accountability	1
Grid monitoring, alerts, fault identification	1
Detection of non-technical losses	1
Easily use	1
Predictive Maintenance of Wind Turbines to Maximize Operability!	1
Predictive maintenance on renewable energy facilities	1
Transparency	1
Energy Forecasting	0
Saving energy consumption but maintaining comfort to end user	0
Predictive analysis	0
Improve energy consumption forecasting	0
Platoon added Security and interoperability on top of big data analytics	0
Clear KPIs	0
NTL detection in pilot 2b	0
PV nowcasting in pilot 4a	0
New customer metrics permit to go beyond "Interruptions" and improve quality for events like voltage sags or swell that do not count as SAIFI but affect operations	0

The purpose of the question was also twofold. First to identify possible new applications of big data into improving the grid reliability, specifically from the Platoon project scope. And second, to evaluate which ideas were more aligned with the audience's expectations.

Before analysing the results, it is important to point out that some answers refer to the same concept, therefore, the table below shows a categorised group of answers that sums up the votes, ending a more compressed result. The obtained consolidated results are:

Table 10: Question 5 consolidated results

Response	Votes
Efficient fault detection and diagnostics improve understanding of electrical switching lifecycle and reduce downtime	9
Forecast and predictive maintenance including renewables facilities	9
Transformer health monitoring and smart metering data can bring insights to improve predictive maintenance. Pilots 1a and 2b	7
Industry costumers can forecast and report foreseeable electricity demands and optimize grid balance. Pilot 2a	6
Edge solutions allow for a dynamic SAIDI and SAIFI instead of waiting every quarter	3
Interoperability and integration of supply chain	3
Make available more specific solutions for distribution companies	2

Creation of general rules and data analytics tools to help the development of specific projects	1
Benchmark and accountability	1
Easily use collected data	1
Transparency	1
Energy Forecasting	0
Saving energy consumption while maintaining comfort to end user	0
Predictive analysis	0
Improve energy consumption forecasting	0
Platoon added Security and interoperability on top of big data analytics	0
Clear KPIs	0
NTL detection pilot 2b	0
PV nowcasting pilot 4a	0
New customer metrics permit to go beyond "Interruptions" and improve quality for events like voltage sags or swell that do not count as SAIFI but affect operations	0

From the standpoint of Task 8.4 objectives, these responses bring the most value to the objectives of the workshop. The opinion of the area experts, after a brief explanation of the indicators was presented, shows us the more relevant topics on how the pilot projects developed under the scope of the Platoon project can improve the reliability of the power grid, either through incentives like the SoC indicators, or other ways of contributing to the grid stability and reliability. Further work needs to be done over these findings, but the success of the activity relies on guiding the conversation towards improved fault detection, smarter and quicker forecasting, and monitoring for predictive maintenance. All of them, through a practical approach as described by the pilot owners and other participants.

Question 6

This question was presented in a "Brainstorm" and Voting format. The audience was presented three sample answers taken from their project, and then was asked to create new answers and post them for the other to see. Afterwards, a voting process took place to choose the most relevant answers. Participants were able to vote for 2 answers.

For these solutions, do you find barriers for scalability?

The obtained raw data is:

Table 11 Questions 6 raw data

Response	Votes
Complexity of regulatory frameworks across member states	9
Real time data availability	4
Data share policies	4
Handling big data	3
Hardware's and software's (big data analytics, etc) quqlity are still need to be improved	2
Platform Complexity	2
Data availability (=willingness to share)	2
Data and services integration costs	2
Complex financial justification of major rollouts	2
Switch to collaborative mindset	1
Data complexity	1
Energy consumption and computational demand of solution	1

Company's accountability	1
Complexity of data	1
Stakeholders	1
Customer's capability	1
Wide scale adoption	1
Specific needs for each client	1
Deployments of hardware take time	1
Regulation	0
Reliable data collection	0
Mindset	0
Customer's awareness	0
Availability of specific tools and methods, especially for small companies	0
Of course, the customers	0

The purpose of the question was also twofold. First to identify barriers of big data applications into improving the grid reliability from the Platoon project scope. And second, to evaluate which barriers were more noticeable from the audience's perceptions.

Before analysing the results, it is important to point out that some answers refer to the same concept, therefore, the table below shows a categorised group of answers that sums up the votes, ending a more compressed result.

The obtained consolidated results are:

Table 12: Question 6 consolidated results

Response	Votes
Complexity of regulatory frameworks across member states and wide scale adoption	10
Data share policies and willingness to share (Collaborative mindset)	7
Handling big data, platform and data complexity	7
Real time data availability	4
Complex financial justification of major rollouts and time constraints	3
Hardware's and software's (big data analytics, etc) quality are still need to be improved	2
Data and services integration costs	2
Customer's capability and specific needs	2
Energy consumption and computational demand of solution	1
Company's accountability	1
Stakeholders	1
Reliable data collection	0
Customer's awareness	0
Availability of specific tools and methods, especially for small companies	0

Finally, the activity included an effort to generate insights on the possible barriers for the given recommendations. The main worries from the experts include the complexity of the European landscape, the lack of a collaborative mindset in terms of data availability, and complexity of handling the data itself. These barriers can pose a big challenge for unified recommendations that apply to the whole European landscape.

Appendix II-1: Targeted survey with matter experts

The survey questions and the received answers are shown below as a reference.

Question 1, 2 & 3 – Big data strategies

Although many big data analytics techniques exist and literature is vast, few applications are deployed in smart grids due to various barriers [25], some of them include:

- **Fault detection**: use of data-mining and other techniques to detect faults in solar and wind grid-connected microgrids.
- **Predictive maintenance**: several techniques applied like clustering and data-driven models to provide early warnings in maintenance calls ranging from distribution automation to MV grids.
- **Transient stability analysis**: new approaches to Transient Stability Analysis are needed with the integration of renewables in the smart grid
- **Device health monitoring**: failure models for different components to predict potential risk problems and health condition
- **Power quality monitoring**: pattern recognition techniques for Power Quality Events analysis
- **Topology identification**: visualization of Low Voltage (LV) grids with limited metering and data
- **Renewable energy forecasting**: short-term power prediction
- **Load forecasting**: deep-learning and other techniques to avoid volatility
- **Load profiling**: categorisation of clients by profile through clustering
- **Load disaggregation**: non-intrusive load monitoring to identify loads at household level
- **Non-technical Loss detection**: electrical theft or accounting errors

Question 1: Which of these techniques do you find more promising to improve overall grid reliability and how? You can choose as many as you want or include others if you know them.

Pilot expert:
Loas forecasting, as it is a transversal tool that can work as input to most of the rest of techniques. It is used in our pilot for both fault detection, using the forecast as a baseline and predictive maintenance, allowing us to exchange degradation models with future expected data and infer the time where a maintenance is needed.

Big data analytics expert:
In my opinion I think that the on the one hand the data analytics techniques related to fault detection/health monitoring are very important to be able to implement a Predictive maintenance strategy to prevent unplanned downtimes of different assets that can jeopardize grid stability. On the other hand, topology identification and load forecasting, profiling and dissagregation tools are very relevant to be able to offer the necessary flexibility to balance the variability of renewable energy sources.

Question 2: Do you know any case of these applications being deployed? Does it impact overall grid reliability? Or how do you see a potential integration of these techniques with the current grid that impacts reliability?

Pilot expert:
Actually, we are using a load forecasting tool to detect non-technical loses in our pilot grid. It is being validated by the DSO and we received positive feedback from them.
Big data analytics expert:
Yes, in PLATOON we have developed and validated different data analytics tools for fault detection/health monitoring in different large-scale pilots. For example, in pilot 1A we have developed Hybrid Digital Twins and data driven anomaly detection for Wind Turbines. In pilot 2A load forecasting tools and data driven algorithms for PV monitoring have been developed. Finally, in Pilot 2B virtual sensors and health monitoring tools for MV-LV distribution electrical transformers have been developed. In addition, as a continuation of PLATOON we are also starting to work in new projects, on different data analytics tools regarding flexibility provisioning.

Question 3: What regulatory changes need to be in place to make these applications widely available?

Pilot expert:
In our pilot the tools developed are not limited by any legal aspect, so there is no necessary change to scale it to bigger networks.
Big data analytics expert:
At the moment the DSOs (Distribution System Operator) are only remunerated based on hardware investments. The regulation should be updated so DSOs are also remunerated for software investments, so, they can invest money in the development in the data analytics tools mentioned above.

Question 4 – Reliability of complex grids

The European power grid is the largest and most complex physical network ever made by humankind. A study of the European power grid concludes that even if more interconnected grids experience a larger number of fault events, their impacts in terms of reliability indicators are significantly lower. These results confirm that more interconnected networks are more reliable, not because of number of occurrences, but because of their overall impact [16].

Question 4: This study implies that larger, more interconnected grids require better tools to handle data. How do you see big data techniques making a larger and more interconnected grid, more reliable?

Pilot expert:
The main problem we found during the project is the availability of data, there exist a lot of data loses in our network, and it's a small network. If a generalized defined strategy about the smart meter data gathering taking care about saving and sharing data easily, a lot of optimization and operation tools can be used and scaled to work with the whole network. With a generalized database network issues can be detected and solved easily.
Big data analytics expert

In this new scenario, I believe that the so-called Data Spaces can bring vast benefits to the energy system. In fact, in order to find a global optimum solution in such decentralise sector it is necessary to process heterogenous data from different actors of the grids (prosumers, DSO, aggregator, etc.). Data Spaces enable secure and trustworthy sharing of data and data analytics tools amongst the actors leading to a win-win situation towards a more reliable interconnected grid.

Questions 5 & 6 – Reliability indicators and implications of aggregating data

An exploratory analysis from the Lawrence Berkeley National Laboratory shows that metrics of grid performance (reliability indicators like SAIFI and SAIDI) vary spatially and temporally by orders of magnitude revealing heterogeneity that is not shown in publicly reported data [9]. This means that limiting access to granular information is a barrier to conducting detailed policy analysis.

Question 5: What recommendations would you give to policy makers to avoid this barrier?

Pilot expert:
To increase the granularity of the data so the analysis can be done to smaller segments of the network.
Big data analytics expert:
Over the past decades big investments have been made on the digitalisation of smart grid. In fact, currently there is a big amount of data available that unfortunately is highly under used. We believe this data should be made available ensuring cybersecurity, privacy and sovereignty requirements not only to show transparency but also to unlock new collaboration models than will result in both societal and business impact. The technology to do this is currently ready with the Data Spaces explained above. However, the legal aspect in some cases is still a bit blurred. Thus, I believe it is necessary to policy makers to clearly define the legal aspects around data sovereignty specially on who owns the data and who can deal with the data.

Question 6: What big data techniques could substitute the aggregation of data used nowadays in the indicators like SAIDI and SAIFI, in a progressive and scalable way?

Pilot expert:
Using a cloud distributed database, maybe based on Hadoop ecosystem, for its capacity of data compression.
Big data analytics expert:
There are multiple data analytics techniques specially tailored for dealing with big amounts of streaming data. Additionally, the computation could be split into a fog architecture combing cloud, on-premise server and edge computing devices. As I said before, the technology is ready, the main blocker are the necessary legal aspects around data ownership to make the data flow amongst organisations/individuals in a standardised and trustworthy manner.

Question 7 – Reliability indicators and implications of aggregating data

High resolution data for grid stability and reliability exist nowadays, but it is usually proprietary and not readily available for researchers conducting policy analysis [9]. With the electrification of society, grid performance is mandatory and several big data techniques can be useful to improve it but are currently limited by the above-mentioned barrier.

Question 7: What pathways do you see to ensure power interruption data is available to support policy research, and improve decision-making?

Pilot expert:
A centralized data repository with available historical and live data.
Big data analytics expert:
As explained above Data Spaces can be the solution for this problem. I don´t believe all the data can be make fully public due to several reasons (personal data, critical infrastructures, Intellectual Property Rights, etc.). Nevertheless, data could be categorised at different groups based on its criticality and probably some of the data could be make available to academia and RTOs for research purposes.

Question 8 – Reliability and renewables:

The integration of renewable energy sources to power systems presents new challenges with respect to reliability management. A paradigm shift is needed to efficiently integrate a large amount of renewable energy sources. Indicators are classified into adequacy, security, socio-economic and reliability indicators, and present various short-comings like lagging in time or being deterministic / past oriented [31].

Question 8 : Do you see a potential in the big data techniques mentioned in question 1 to improve the shortcomings of these indicators? Please explain how.

Pilot expert:
Renewable production can be forecasted using deep learning techniques, so previous existing production can be adapted based on the renewable production forecast.
Big data analytics expert:
Yes indeed, at the moment we are working on several projects that somehow are continuation of PLATOON to be able to offer the necessary flexibility to balance the variability of renewable energy sources and result into a more reliable grid. Also, in this sense we believe that Local Energy Communities will play an important role as a relevant new actor with renewable energy production and flexibility provisioning capacity.

Question 9: Incentives based on reliability

In Sweden, a cost of ~140 million euros was estimated in 2013 due to electricity interruptions. Following this cost, a new incentive scheme was implemented, including a revenue cap for DSOs based on the SAIDI, SAIFI and CEMI indicators [30]. Many of these Reward-Penalty Schemes have been used and are proposed as an option internationally, many depend on indicators and include complex factors due to high uncertainty [32]. For instance, in the case of Sweden, the penalty or reward was multiplied by 0.5 in the first years[30].

Question 9: What are, in your opinion, potential contributions of big data granularity and level of analysis to help establish an optimal socioeconomic level of Continuity of Supply and more fair system?

Pilot expert:
N/A
Big data analytics expert:
As explained before as the energy system transitions to a fully decentralised system it is more relevant than ever to break the current siloes and allow data sharing amongst different actors of the grid showing a win-win situation towards a more efficient and reliable grid. This should include all the actors including the prosumers who should receive part of these benefits as active players in the smart grids.

Question 10: Any other recommendations

Do you have any other recommendations or ideas that were not discussed in questions 1 to 9?

Question 10: Please share your thoughts, comments or recommendations for the Platoon project to help public policy research.

Pilot expert:
N/A
Big data analytics expert:
In PLATOON we have developed and validated the technology for data sharing and data analytics tools. Nevertheless, there are still some barriers that need to be overcome. In order to do this public bodies should define a clear legal framework around data ownership and implement policy changes to foster investments on software.

PART III: Standardised assessment for data protection

1 Introduction

PART III summarised the results of the Data Protection-related activities as performed in WP1 and WP3, and the results of the contribution toward a standardized criteria for data protection assessment that were continued under Task 8.4. It particularly showcases the contribution of the PLATOON project to the development of the first European Data Protection Seal (Europrivacy) under Article 42 of the GDPR, a significant milestone not only for PLATOON but also the energy sector. Given that Europrivacy can now be used throughout the entire territory of the European Union (EU) to certify data processing activities' compliance with relevant data protection requirements, it is of high importance that the criteria used for certification can be adapted to various data processing activities in different fields. This is precisely one of the main advantages of Europrivacy that aims at providing an adequate certification framework that can be tailored in accordance with the applicant's field of activities. As will be further analysed below, the participation of PLATOON in the determination of sector-specific criteria is crucial for the energy industry as a whole.

Sections 2 and 3 present a summary of the activities performed under WP1 and WP3, as were further supported through WP8, and the Section 4 indicates the results throughout the whole project time including the continuous compliance activities performed under Task 8.4, targeting to contribute toward a standardized assessment methodology in smart grids, noting a number of recommendations of relevance for the post-project (exploitation, replicability, future research development, etc.) phases.

2 Summary assessment of legal framework developments during the project lifetime

PLATOON prioritised compliance with the legal frameworks that would be applicable to its activities throughout the lifetime of the project. Given the project's innovative activities, extending to multiple sectors, it was necessary to consider and ultimately comply with multiple legal frameworks (whether in force or upcoming), as those were extensively analysed in D1.4, ensuring continuous compliance under Task 8.4, and as they are and indicatively listed below:

- Regional Frameworks of the European Union:
  a. The General Data Protection Regulation (GDPR) [35]
  b. The Directive on Privacy and Electronic Communication (ePrivacy Directive) [36] and the European Union Regulation on Privacy of Electronic Communication (ePrivacy Regulation) [37]
  c. Directive on Security of Network and Information Systems (NIS Directive) [38]
  d. Regulation on Electronic Identification and Trust Services for Electronic Transactions in the Internal Market (eIDAS Regulation) [39]
  e. The Artificial Intelligence Act [40]
  f. The Data Governance Act [41]

- European Data Protection Board (EDPB) Guidelines:
  g. Guidelines 05/2020 on consent under Regulation 2016/679 [42]
  h. Guidelines 2/2019 on the processing of personal data under Article 6(1)(b) GDPR in the context of the provision of online services to data subjects - version adopted after public consultation [43]

i. Guidelines 3/2018 on the territorial scope of the GDPR (Article 3) - version adopted after public consultation [44]
j. Guidelines 1/2018 on certification and identifying certification criteria in accordance with Articles 42 and 43 of the Regulation - version adopted after public consultation [45]
k. Guidelines on transparency under Regulation 2016/679, WP260 rev.01 [46]
l. Guidelines on Automated individual decision-making and Profiling for the purposes of Regulation 2016/679, WP251rev.01 [47]
m. Guidelines on Personal data breach notification under Regulation 2016/679, WP250 rev.01 [48]
n. Guidelines on the right to data portability under Regulation 2016/679, WP242 rev.01 [49]
o. Guidelines on Data Protection Officers ('DPO'), WP243 rev.01 [50]
p. Guidelines on Data Protection Impact Assessment (DPIA) and determining whether processing is "likely to result in a high risk" for the purposes of Regulation 2016/679, WP248 rev.01 [51]

- National Laws of the pilot sites:
  q. Belgium:
    i. Law relating to the protection of individuals with regard to the processing of personal data
    ii. Law establishing the information security committee and amending various laws concerning the implementation of Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of individuals with regard to processing personal data and the free movement of such data, and repealing Directive 95/46 / EC
    iii. Law establishing the Data Protection Authority
    iv. Law regulating the installation and use of surveillance cameras
    v. List of processing operations requiring data protection impact assessment (DPIA) pursuant to Art. 35, paragraph 4 of Regulation (EU) 2016/679
  r. France:
    i. French Data Protection Act
    ii. List of processing operations exempt from data protection impact assessment (DPIA) pursuant to Art. 35, paragraph 4 of Regulation (EU) 2016/679
  s. Italy
    i. Personal Data Protection Code
    ii. List of processing operations requiring data protection impact assessment (DPIA) pursuant to Art. 35, paragraph 4 of Regulation (EU) 2016/679
  t. Serbia:
    i. Personal Data Protection Code
    ii. List of processing operations requiring data protection impact assessment (DPIA) pursuant to Art. 35, paragraph 4 of Regulation (EU) 2016/679
  u. Spain:
    i. Organic Law 3/2018, of December 5, on the Protection of Personal Data and guarantee of digital rights
    ii. Law 34/2002, of July 11, on services of the Information Society and Electronic Commerce
    iii. General Telecommunications Law 9/2014, of May 9
    iv. List of processing operations not requiring data protection impact assessment (DPIA) pursuant to Art. 35, paragraph 4 of Regulation (EU) 2016/679

In addition to the above, PLATOON also considered ethical requirements beyond the H2020 ethics guidelines. In particular, the project complied with the following ethical frameworks:

- Helsinki Declaration of 1964 (revised version 2004)[4]
- European Convention of Human Rights[5]
- Rules of the Convention of the Council of Europe for the protection of individuals (automatic processing of personal data)[6]
- Charter of fundamental human rights (Art. 8, 2000)[7]
- General Data Protection Regulation 2016/679

All of the previously mentioned elements were originally identified and extensively analysed in D1.4, and were used through all WP1 and WP3 activities to guide compliance activities and the inputs provided to associated tasks. Furthermore, this assessment was used throughout the project's lifecycle to examine not only pilot's activities and developed solutions but every partner's activity in relation to PLATOON with the relevant legal and ethical requirements. The activities performed were additionally reviewed taking into consideration the following elements:

- The use of personal data or the possibility thereof,
- The technical and organisational measures implemented to guarantee the security of the data,
- A risk assessment to the rights and freedoms of data subjects.

3 Showcase of key outcomes of DPIA activities

In addition to the above, to ensure any risks to the rights and freedoms of data subjects were duly identified and handled, a Data Protection Impact Assessment (DPIA) was performed and maintained throughout the project's course originally under WP3 Task 3.5, in accordance with the continuous legal and ethical evaluation of the project's activities. Given the smart solutions developed by the project in the energy sector, the DPIA was conducted as per Article 35 GDPR.

In particular, the DPIA was performed with a per pilot focus, to better capture the extent and variety of each of their activities and ensure pilot-specific compliance. In order to achieve optimal results, each pilot's use case was separately considered while the collaboration of the pilots' representatives and the partners' DPOs was of utmost importance.

The results of the updated DPIA, as showcased in D3.6, demonstrated that the pilots utilise a wide range of data, mainly historical and live data, as well as data collected by Internet of Things (IoT) devices. Nonetheless, the data collected and processed do not have a high probability of being linked to an identifiable natural person and, therefore, cannot be considered personal data. In view of this conclusion, it was deemed that no further measures needed to be implemented but their activities would be closely monitored to ensure that any new risks are identified and duly addressed. In case additional risks were to arise, an updated DPIA was to take place.

[4] World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects, June 1964.

[5] Council of Europe, European Convention for the Protection of Human Rights and Fundamental Freedoms, as amended by Protocols Nos. 11 and 14, 4 November 1950.

[6] Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data 1981.

[7] European Council, Charter of Fundamental Rights of the European Union (2000/C364/01) 2000.

By the end of the project, no additional risks or compliance concerns were identified by Pilot owners, as no changes related to the potential of personal data processing were made, and thus no further refinements of the DPIA were necessary. The Pilots activities were closely monitored and evaluated against legal requirements throughout the project to ensure their compliance. Constant communication and coordination with Pilot owners were maintained regardless of this situation as an additional trust-generating element and as means to obtain their feedback on the implemented controls and mitigation actions, which was fundamental for the associated research activities performed throughout this process (particularly towards the contribution of smart-grid criteria to the Europrivacy Certification Scheme that will be further analysed below).

4 PLATOON contributions to the Europrivacy Certification Scheme

While the lack of standardized guidance and/or methodologies was identified as a potential problem for research projects, PLATOON put efforts to contribute to build one. Europrivacy (https://www.europrivacy.org/en/ep), was identified as a good candidate as a leading association on data protection ecosystem and certification. In the context of Tasks 3.5 and Task 8.4, PLATOON was able to discuss with relevant stakeholders in the energy sector and privacy to develop and suggest additional extension criteria for the Europrivacy Certification Scheme Data Protection Impact Assessment (DPIA).

In particular, the criteria proposed by the project were incorporated into Europrivacy's Complementary Contextual Checks and Controls (otherwise called C Criteria), providing for additional criteria that can complement the main certification framework depending on the applicant's field of activities. These criteria are thus, more sector and case-specific and can assist in establishing a comprehensive compliance framework. PLATOON's contribution focused on introducing complementary yet essential requirements regarding two main focal points:

1. The use of AI in the Target of Evaluation (ToE), the data processing activity that constitutes the object of certification, ensuring the identification and management of potential risks as well as the inclusion of adequate documentation, case-specific consent requirements and compliance with additional regulations.
2. The use of Smart Grids in the ToE. The criteria proposed were directed at ensuring the special characteristics of Smart Grids are taken into consideration when performing a DPIA, while evolving the security measures that would ensure any personal data collected, processed and stored in the Smart Grid context be duly minimised and protected.

The project's contributions were positively received and validated not only by the scheme owner, i.e., the European Centre for Certification and Privacy (ECCP) and the overviewing Board of Experts, but also the Luxembourgish Data Protection Authority, the competent Data Protection Supervisory Authority as provided in the GDPR in Luxembourg ,and the European Data Protection Board (EDPB), responsible for the overview and monitoring of the consistent application of the GDP, ultimately competent for approving such certification mechanisms in the Union. In the context of Task 8.4, the criteria originally formulated were further refined and adjusted to the EDPB's additional requirements.

In October 2022, Europrivacy, including PLATOON's valuable contributions, was ultimately adopted by the EDPB as the first European-wide certification according to Article 42 GDPR8. As of today, Europrivacy is recognised as the first -and only to this date- certification mechanism which can be used to demonstrate compliance of any data processing activities throughout the European Union's territory, thus showcasing the quality of the conducted work and the relevance of the contributions. Beyond the provision of certifications, Europrivacy has been developed to enable data controllers and processors to: assess and document GDPR compliance; reduce risks; certify and communicate compliance; and maintain and enhance compliance.

As is evident, the participation in the evolution of the certification scheme is a milestone not only for PLATOON, but also the energy sector which is becoming more and more important. With the focus shifting towards Smart Energy solutions that would facilitate the consumers' everyday lives while optimising energy expenditure, the consideration of the sector's needs when evaluating data protection compliance is of utmost importance. As a result, the project's contribution goes beyond the limits of PLATOON and extends to the entire energy industry providing a more personalised solution to comply with personal data protection regulations and requirements. Similarly, future projects in the field when in search of a concrete and domain-specific compliance methodology can benefit from the criteria emerging through Platoon.

Some additional information on this key milestone can be found in the following references:

- Euronews article on Europrivacy: https://www.euronews.com/next/2022/10/13/gdpr-could-be-about-to-get-a-lot-easier-to-understand-with-a-new-certification-scheme
- Europrivacy website: https://europrivacy.com
- Europrivacy Online Academy[9] : https://academy.europrivacy.com

5 Final recommendations

As previously noted, the PLATOON project has sought to ensure compliance by design and by default is maintained throughout the project's lifecycle. This has been performed through constant coordination between the technical and legal activities performed in the diverse work packages of the project and through extensive discussions with relevant data protection authorities. This approach led to the achievement of important milestones, including the inclusion of specific project-developed criteria into the first European Data Protection Seal.

Pursuing these activities, however, was not always simple. Coordination amongst multiple organizations, their DPOs, research teams and representatives can be challenging in any large research project, and information gathering can be slow. Additionally, the varying and sometimes fragmented information sources, guidance, templates and solutions made available in different languages by the relevant authorities (including, but not limited to national data protection and cybersecurity authorities) can lead to conflicting compliance and documentation approaches amongst partner organizations, which can lead to an over complexification of the support and compliance validation activities in any H2020 and Horizon Europe project.

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[8] European Data Protection Board, 'Opinion 28/2022 on the Europrivacy Criteria of Certification Regarding Their Approval by the Board as European Data Protection Seal Pursuant to Article 42.5 (GDPR)' <https://edpb.europa.eu/our-work-tools/our-documents/opinion-board-art-64/opinion-282022-europrivacy-criteria-certification_en> accessed 7 December 2022.

[9] All Platoon partners have been granted access to the Europrivacy Academy's Implementer Training to ease potential impact of the scheme in the scope of the Platoon project and to enhance the exploitability potential of the project's solutions.

In this context, we believe that the key lesson learned building on previous relevant tasks fundamentally was the need to facilitate the range of ethical and data protection compliance activities to be undertaken by any research project through the adoption of unified methodologies. While the lack of standardized guidance and/or methodologies was identified as a potential problem for research projects, the approach followed by PLATOON demonstrates that it is possible to find solutions through cooperation with relevant initiatives, and that these actions can lead to meaningful changes.

The recently adopted adoption of Europrivacy as an official Art. 42 GDPR certification brings forth an interesting opportunity for future research projects to simplify their compliance assessment activities (since the Scheme can be used as a standardized compliance assessment methodology regardless of whether the organizations finally pursue a certification of the solutions and/or enablers generated). Furthermore, given its roots in the European research programme, the scheme is very much open to receive recommendations and contributions (e.g.: as performed by PLATOON, the generation of sector-specific compliance assessment criteria).

This opens the possibility to have a dialogue between stakeholders, which in turn facilitates the move from compliance as a necessary (and sometimes burdensome) action under the terms of the Grant Agreement, towards (enhanced) compliance and a revision of its role as value-generating proposition: better positioning a project's solutions during the post-project exploitation phases.