Data and Platform Assets Functional Specs and Data Quality Compliance

D5.3

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About OneNet

OneNet will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure.

The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".

While the electrical grid is moving from being a fully centralized to a highly decentralized system, grid operators have to adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. For this reason, the two major associations of grid operators in Europe, ENTSO-E and EDSO, have activated their members to put together a unique consortium.

OneNet will see the participation of a consortium of over 70 partners. Key partners in the consortium include: already mentioned ENTSO-E and EDSO, Elering, E-REDES, RWTH Aachen University, University of Comillas, VITO, European Dynamics, Ubitech, Engineering, and the EUI's Florence School of Regulation (Energy).

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers;
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.

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Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

List of Tables

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List of Abbreviations and Acronyms

Acronym	Meaning
API	Application Programming Interface
ASVS	Application Security Verification Standard
CRUD	Create Read Update Delete
BUC	Business Use Case
DEP	Data Exchange Platform
DER	Distributed Energy Resource
DQ	Data Quality
DSL	Domain Specific Language
DSO	Distribution System Operator
ENISA	European Union Agency for Cybersecurity
ESO	European Standardization Organization
FR	Functional Requirement
FSP	Flexibility Service Provider
HEMRM	Harmonized Electricity Market Role Model
IDS	International Data Space
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LV	Low Voltage
MOL	Merit Order List
MV	Medium Voltage
NISTIR	National Institute of Standards and Technology Interagency or Internal Report
OHL	Overhead Line
OWASP	Open Web Application Security Project
PLC	Power Line Communication
RES	Renewable Energy Resources
SG-CG	Smart Grid Coordination Group
SGAM	Smart Grid Architecture Model
SGIS	Smart Grid Information Security
SQL	Structured Query Language
SUC	System use case
TC	Test Case
TSO	Transmission System Operator

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Executive Summary

This document has two purposes: First, it provides the **functional specifications** for smart grid interoperability and a seamless integration of all actors in the electricity sector that shall be enabled by the OneNet System. These requirements are based upon core use cases for flexibility products and services of smart grid applications. They are not intended to provide a detailed information model or API specification but serve as a description of the functional layer supporting specifications of the information layer in other Tasks of OneNet WP5. Furthermore, they are the basis for the implementation of the OneNet API and other components of the OneNet System in WP6. The functional specifications of the OneNet System are described here with the intent of not precluding their extension based on additional valid applications and use cases for the smart grid that may arise in the future.

Second, this document provides an insight into the **data quality requirements** of the interoperability functions enabled by the OneNet System and further it can be used in the development phase of project in WP6.

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1 Introduction

The smart grid exhibits a high complexity regarding organisational and technological issues. The key challenge is the integration of different technologies and stakeholders into one jointly operating power system. This affects all the components, systems, applications and information involved. Telecommunications play an important role in the realisation of the smart grid since they enable data exchange between components. There are a plethora of telecommunication technologies that can be utilized for the smart grid depending on the application, either wireless or wired [1][2].

In general, there are three main domains of applications for the smart grid network: the High Voltage (HV) network used for the electricity transmission, the Medium Voltage (MV) network used for the electricity distribution, and the Low Voltage (LV) network used to provide electricity to end-users [3]. Within all three domains, the smart grid network is used to connect renewable energy sources (RES). Functionalities and interfaces of a smart grid should enable interaction to execute all the necessary processes within the system. Thus, interoperability is an essential requirement for the smart grid, a technical imperative, and the enabler of an open market where innovation can flourish.

Interoperability refers to the ability of two or more devices from the same vendor, or different vendors, to exchange information and use that information for correct co-operation [2]. As stated by the CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG) [4], this definition is extended to "The ability of two or more networks, systems, devices, applications, or components to interwork, to exchange and use information in order to perform required functions." In addition, "Interoperability between systems in a smart grid must be considered and well specified in use cases, in order to develop interoperable Smart Grid systems by design. Use cases provide a basis for the specification of functional requirements, non-functional requirements, Test Cases (TC) and test profiles".

A framework that has been used for interoperability purposes is the Smart Grid Architecture Model (SGAM), which is the main outcome of Reference Architecture working group mandated by the EU's 490 Mandate [5] entitled "Smart Grid Mandate–Standardization Mandate to European Standardization Organizations (ESOs) to support European Smart Grid deployment". The additions made clarify the field regarding the different types of interoperability available and their connection to different interoperability layers.

Based on the SGAM framework there are five different layers of interoperability [6]:

- Business layer, which represents the business view on the information (business models, market structures, business portfolios etc.)
- Functional layer specifying the functions and services

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- Information layer which is the data model and data semantics to be used to ensure a common understanding of the data exchanged
- Communication layer which is the communication mechanism (e.g. PLC or Ethernet) and the communication protocol for data transmission
- Component layer which is the physical distribution of all participating components to connect systems or devices

This means that all interactions (i.e., physical, information-based and process-based) should satisfy the interoperability principle. This includes the field level (e.g., substation automation, distribution automation, distributed energy resources), to remote operations (e.g., remote grid management), market management, service management, customer management, and others. A major challenge for interoperability is the integration across different domains.

1.1 WP5 objective

Work Package 5 (WP5) in OneNet is titled "Open IT architecture for OneNet". The main objective of this WP is to design an open conceptual architecture for effective yet seamless operation of a smarter pan-European electricity system where market and grid technologies are coordinated in real-time and across countries. Moreover, this WP provides requirements, functional and technical specifications, together with interoperable and standardisable interfaces for an open scalable decentralized interconnection of platforms through a technology agnostic, adoptable, and flexible IT reference architecture which fully supports the OneNet concept and provides the necessary backbone for the subsequent implementation of the OneNet data sovereignty working space in WP6.

1.2 Objective of Deliverable 5.3

For this deliverable, interactions with other WPs and Tasks in the OneNet project are considered. The main interactions are summarized in Figure 1. Within WP5, Deliverable 5.3 provides a detailed data quality assessment for the OneNet Connector as well as functional specifications of the OneNet System components and their interfaces. It analyses the interoperability requirements and System Use Cases of the OneNet project (Deliverable 5.1 [28]) as well as interoperability requirements of use cases and applications identified in other Horizon 2020 projects such as CoordiNet or PlatOne (see WP4, T4.1, T4.2, T4.3) [19-27].

Furthermore, D5.3 harmonized the given information from a different aspect. D5.1 [28] is used as a reference for harmonizing use cases and synchronizing functional specifications of cross-platform services. D5.2 [29] has been taken into account for the harmonization of interoperability components based on OneNet system reference architecture. D2.5 [31], D2.4 [32] have served for role harmonization assigned to cross-platform

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services. To verify the alignment of the cross-platform services with the security requirements, the services linked with relevant requirements are described in D5.8 [30]. In addition, for the functional specifications of the OneNet Connector, the data exchanges that determine the different components' interaction in the OneNet System are defined and documented, taking into account the desired extensibility and independence and the possible reusability of existing solutions and infrastructures.

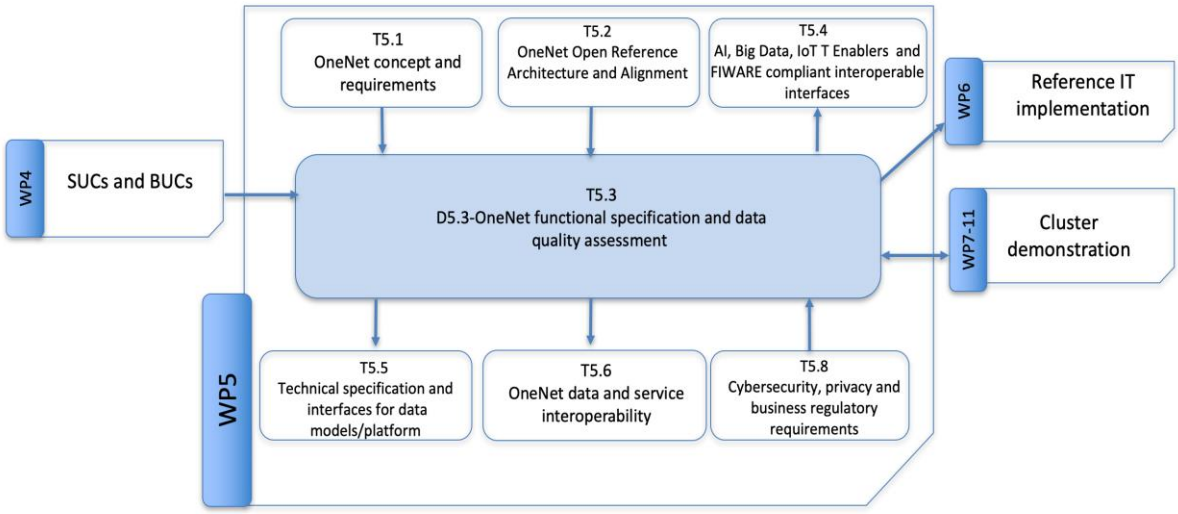

Figure 1: T5.3 relation with work packages and tasks

Task 5.3 is also in charge of analysing the methods, procedures and tools that assess data quality to be accepted for taking part in the OneNet System. The focus is on supporting data providers and service developers to define the minimum requirements in terms of data quality elements such as format, latency and continuity to not compromise the data delivered by other participants in the OneNet System. Furthermore, the data sources are pre-processed to apply the defined profiling and access control rules, evaluate profiling routines, define cleaning rules, auditing the cleaning rules, and check data standards and formats. This work is closely related to Task 5.6 to keep the rules related to data formats, the requirements of the OneNet System, and ongoing work in interoperability and homogenization synchronized. The tasks run in parallel and their output should be consistent. Deliverable 5.3 will be considered within the development of the IT solution in WP6, which aims to analyse and implement the interoperability components of the OneNet System which are being used by the different demonstrators.

1.3 Structure of deliverable

This deliverable focuses on functional specification and data quality requirements for the OneNet System. Chapter 2 describes the components of the OneNet System and their functions as well as their relations. Chapter

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3 identifies the cross-platform interoperability services to be enabled by the OneNet System. This identification is based on the inputs from WP4 and Task 5.1 and Task 5.2. Chapter 4 describes the functional specifications and Chapter 5 elaborates on data quality compliance for these cross-platform services. In Chapter 6, a summary and outlook are provided.

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2 OneNet System – Architecture and Functionalities

This section provides the fundamental elements and the functionalities of the OneNet System. We refer the reader to Deliverable 5.2 [29] "OneNet Reference Architecture" for more details on the design and foundations. Here, the goal is to provide a brief definition of each element and outline its anticipated function(s) and its interplay with other elements for the overall OneNet System.

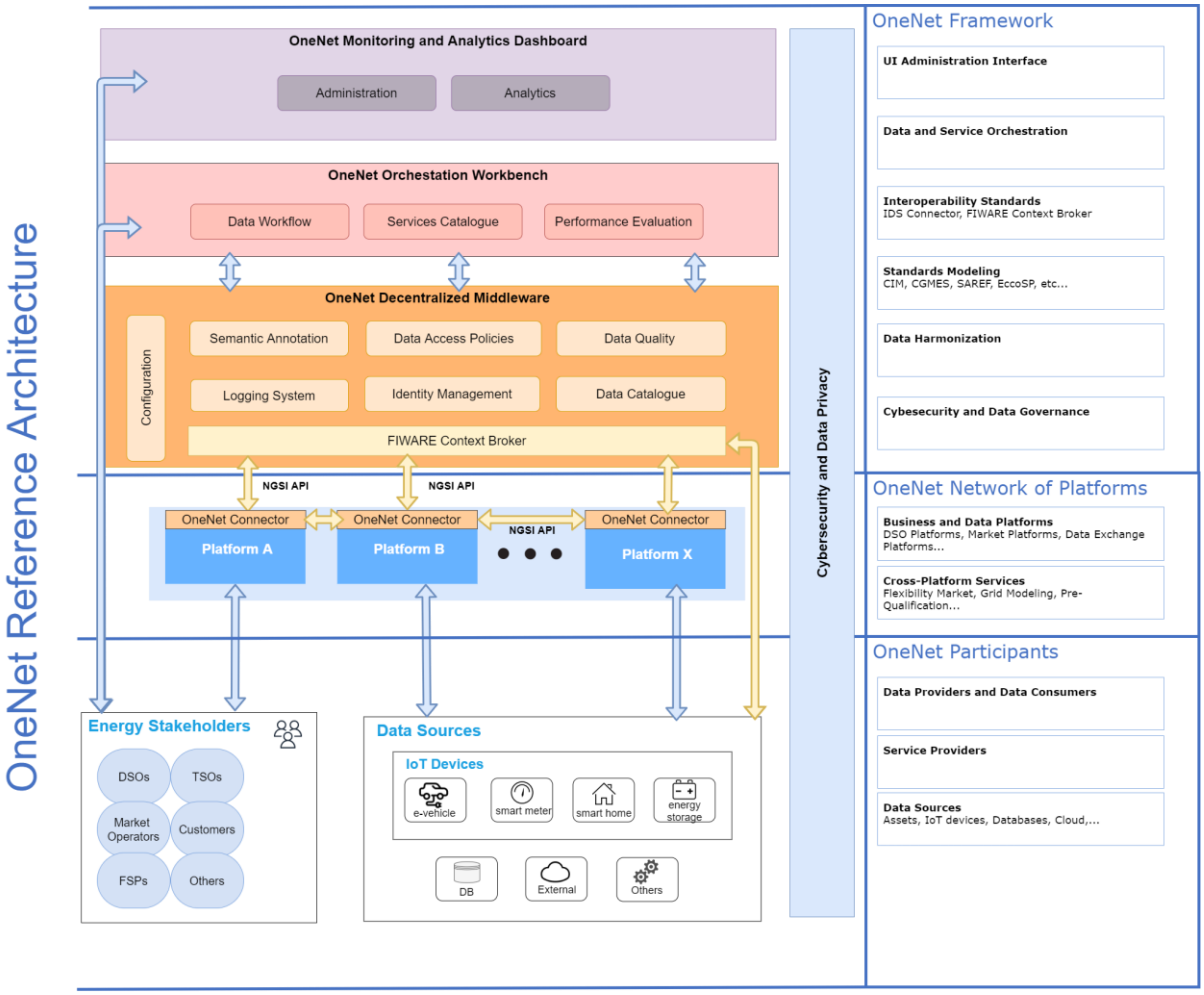

Figure 2: OneNet architecture adapted from D5.2 [29]

2.1 OneNet System

The OneNet System includes all the three horizontal layers described in the OneNet Architecture (see Figure 2) as well as the Cybersecurity and Data Privacy vertical layer. The three layers are:

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- OneNet Framework;
- OneNet Network of Platforms;
- OneNet Participants;

The OneNet Framework is the core of the OneNet System and includes several components and functionalities that will be described in the next paragraph. The OneNet Decentralised Middleware, in particular, enables the data exchange in a peer-to-peer communication. Each Participant of the OneNet System is able to interact with the OneNet Framework and the other OneNet participants through an OneNet Connector, which handles connectivity and data services. The OneNet Connector is an instance of the OneNet Decentralised Middleware and the key component to establish decentralized peer-to-peer connectivity between participants and perform actual data transfer between data providers and data receivers.

2.2 OneNet Framework

The OneNet Framework includes three main components:

- OneNet Monitoring and Analytics Dashboard;
- OneNet Orchestration Workbench;
- OneNet Middleware;

The main goal of the OneNet Framework is to enable the secure and yet flexible interoperability of OneNet Participants. For these purposes, its modules provide the core functionalities for authenticated data access and connection establishment between OneNet Participants as well as a list of the data and services that are offered by participants. Furthermore, data and service discovery are enabled along with a monitoring and management user interface. The OneNet Framework is the management component of the OneNet System. It does not have access to the data sent and shared by the OneNet participants, nor does it forward or process such data. The functions of the framework are purely administrative. Its modules are described in more detail in the following subsections.

2.2.1 OneNet Middleware

The OneNet Middleware is a core mandatory component of the OneNet Framework. It is an “enhanced” instance of the OneNet Connector (see next section) providing additional services to the OneNet System. Its main role is provisioning of authentication for OneNet Participants within the OneNet System so that all rules of data access and privacy are fulfilled. It is the main keyhole to the rest of the OneNet Framework as well as for the connectivity of OneNet Participants. It facilitates the connection establishment between OneNet Participants by supporting the configuration of their respective OneNet Connectors, for example endpoint settings for the context broker.

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As described in OneNet D5.2 [29], the OneNet Connector and the decentralised approach of deploying such Connectors and the OneNet Middleware allow to implement a complete end-to-end communication among one or more OneNet Participants offering a pluggable and configurable solution (see Figure 3) that does not require any technical implementation for the OneNet Participants.

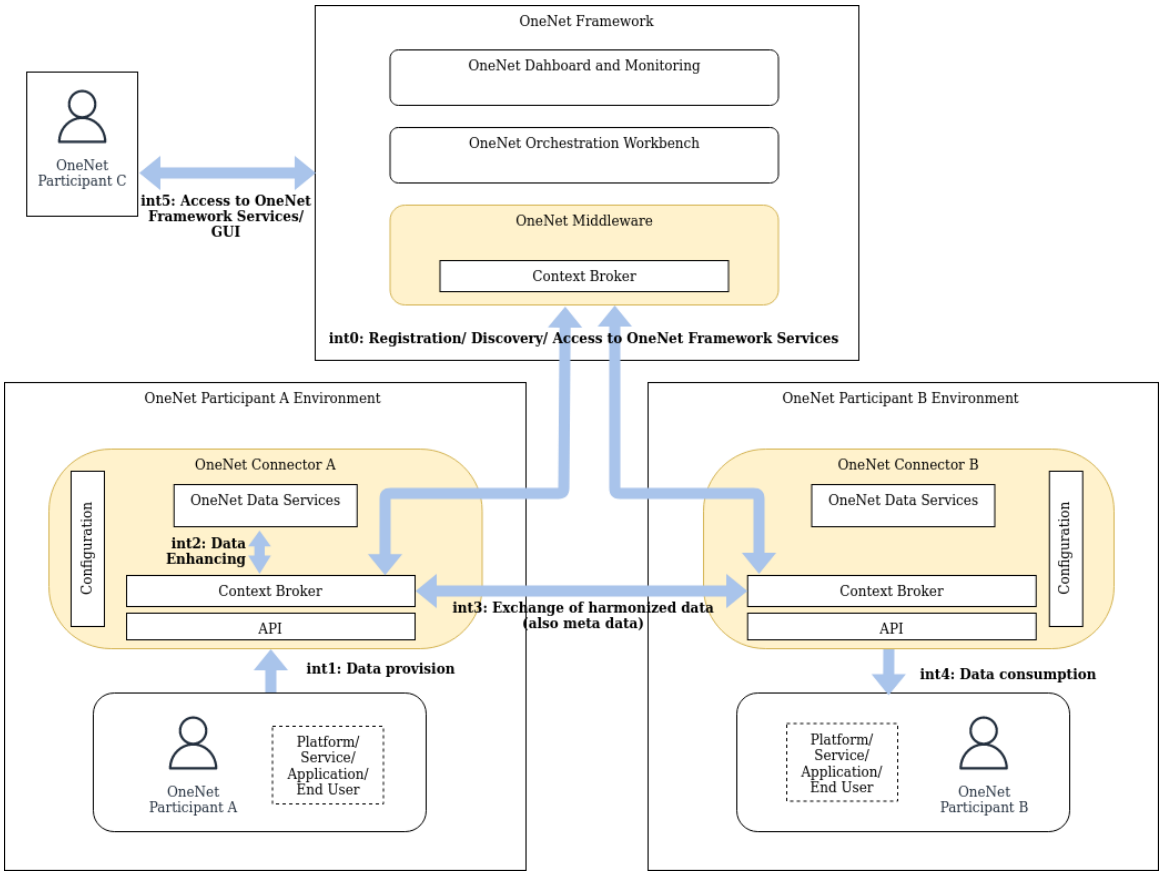

Figure 3: OneNet decentralized approach with Middleware and Connector including interfaces

2.2.2 OneNet Connector

The OneNet Connector is the decentralised interoperability component of the OneNet System. Each OneNet Participant runs one instance of the OneNet Connector. It serves as the gateway to the rest of the OneNet System including the OneNet Framework. The Connector executes data services to ensure secure data access, proper data formatting, semantic annotation and data quality. Furthermore, each OneNet Connector has a Clearing House service to tack all data exchanges locally. Not all data services have to be active to participate in the OneNet System. It depends on the requirements of the OneNet Participants which services are used and

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how they are configured. The only mandatory service is the one for data access and policies to ensure a secure and trusted communication. The list of data services presented in the following chapters may not be complete at the time of submission of this deliverable. In fact, the OneNet Orchestration Workbench will allow providing new additional data services in the future. The OneNet Connector has the following modules and functions:

OneNet Data Services

The OneNet Connector includes a set of OneNet Data Services to pre-process the data to be sent before it is actually transmitted to the receiver(s). The data services operate on the data consecutively – each one for a separate purpose. The following list of data services will be included in the OneNet Connector:

- Data Access and Policies Service: This service is responsible for checking if the data transfer is authenticated and the direction of the data is permitted. The service must be compliant with the IDS specification. It will contact the OneNet Middleware. The data access and policies service does not work directly on the data, but on the related Meta information. It also checks if the minimum required data services are activated and configured at the sending OneNet Connector, so that requirements of the receiving side are met. This service should always be the first service to act upon initialization of a data transmission. Any other data service should only be activated for a set of data if this service yields a positive response. We refer the reader to activities of OneNet Tasks 5.7 and 5.8 [30] for more details about Data Access and Policies.
- Data Harmonization Service: This service checks the format of the data to be sent. If possible, desired, and required it fixes the format. Instead of fixing, the service can return a negative response to the data sender with hints on how to improve data formatting. The Data Harmonization Service enables the fulfilment of format requirements of both data sender and receiver. It ensures that only harmonized data, that means data, which is compatible to the OneNet System and has a certain known format, leaves an OneNet Connector. We refer the reader to activities of OneNet Task 5.6 for more details on Data Harmonization.
- Semantic Annotation Service: If ontology information is available and configured for a certain set of data, the Semantic Annotation Service can tag the data based on the ontology to improve harmonization and understand ability by other OneNet Participants. This service further contributes to data harmonization. We refer the reader to activities of OneNet Task 5.6 for more details on Semantic Annotation.
- Data Quality Service: The Data Quality Service checks the quality of data based on pre-configures requirements. We refer the reader to Chapter 5 of this document for more details on data quality assessment.

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Context Broker

The Context Broker of an OneNet Connector is the core data managing and forwarding component. It is a publish and subscribe broker that stores the latest context (i.e., latest values) as its current status. It interconnects all modules of the OneNet Connector internally and OneNet Connectors among each other. We refer the reader to activities of OneNet Task 5.4 for more details about the role and usage of the FIWARE context broker in the OneNet System.

OneNet Application Programming Interface (API)

Data Providers and Users require an interface to use the OneNet System for interoperability. The OneNet Application Programming Interface (OneNet API) represents this feature. It is the interface between OneNet Connector and Data Providers/ Users. The OneNet API provides the functions that enable interoperability. The interoperability functions, called “cross-platform services”, are categorized and specified in Chapters 3 and 4 of this document.

Configuration

All components of the OneNet Connector require configuration, for example to establish connectivity by setting correct endpoints in the Context Broker. Furthermore, the data and services offered by an OneNet Participant need to be registered in the OneNet Orchestration Workbench and status as well as software updates received from the OneNet Framework need to be processed. The Configuration module of the OneNet Connector takes care of these administrative tasks. It monitors the status of the OneNet Connector and all sub-components and moderates the connectivity inside the OneNet Connector as well as to the OneNet Framework and other OneNet Participants. The Configuration module has a user interface for activating and configuring OneNet data services and for updating and downloading additional services from the OneNet Orchestration Workbench. The user interface can also be used for monitoring the health status of the OneNet Connector from the user side so that measures can be taken in case of problems.

2.2.3 OneNet Dashboard and Monitoring

The OneNet Dashboard and Monitoring is an element of the OneNet Framework that provides a graphical user interface to monitor the health status of OneNet participants, OneNet Middleware, OneNet Orchestration Workbench and all connections. It alerts OneNet system managers and/ or participants if any unexpected status is detected. This component is not mandatory for establishing the interoperability within the OneNet System but it is crucial to identify the current status and problems. For problem detection and anticipation, artificial intelligence techniques may be used.

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2.2.4 OneNet Orchestration Workbench

The OneNet Orchestration Workbench is a mandatory component of the OneNet Framework. Its purpose is to provide service and data discovery for services and data provided by OneNet Participants. The discovery can be potentially based on artificial intelligence techniques. Furthermore, the OneNet Orchestration Workbench provides software updates for data services or other modules of the OneNet Connector and ships new modules and data services for the OneNet Connector to the OneNet Participants to enhance and maintain their connectivity in the OneNet System. It can also be used to test new services for their performance, correctness etc. prior to practical use. We refer the reader to activities of OneNet Task 5.4 for more details about the Orchestration Workbench design.

2.3 Functionalities and Interfaces of the OneNet System

This section will list the functionalities and interfaces of the OneNet Decentralised Middleware and the OneNet Connector, including internal and external integration of the components. More detail in the OneNet Orchestration Workbench, OneNet Monitoring and Analytics Dashboard and FIWARE Broker, will be provided in D5.4.

OneNet Connector and OneNet Decentralized Middleware will implement many interfaces (internals and externals) for the integration of the external platforms and components as well as the provisioning of the OneNet Data services. The Figure 3 represents the interfaces schema of the OneNet Connector and Middleware and Table 1 provides the list of interfaces and their description. A list of functionalities of the OneNet Connector and Middleware is provided in Table 2.

Table 1: List of interfaces in the OneNet System

Interface ID	From	To	Bidirectional	Description
int0	OneNet Connector (NGSI broker)	OneNet Middleware (NGSI broker)	Yes	Interface between OneNet Middleware and the OneNet Participant's connector for data and meta-data exchange e.g., register data information availability, contact with Certification Body, Evaluation facilities, Dynamic Attribute Provisioning Service, or access to OneNet Framework Services (optional)
int1	OneNet Participant (data source/ data provider)	OneNet Connector (NGSI broker)	No	Interface between data provider platform and local OneNet Connector: OneNet network of platforms access for data provision (OneNet API)

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int2	OneNet Connector broker (NGSI broker)	OneNet Data Services	Yes	Interface between OneNet Connector broker and OneNet Data Services
int3	OneNet Connector (NGSI broker)	OneNet Connector (NGSI broker)	Yes	Interface between local OneNet Connectors (data consumer's – data provider's) for data exchange and meta-data exchange
int4	OneNet Connector (NGSI broker)	OneNet Participant (data exchange/ consuming data)	No	Interface between OneNet Participant's local OneNet Connector (broker) and data consumer platform: OneNet network of platforms access for data exchange/ consuming data
int5	OneNet Participant (User)	OneNet Framework	Yes	Interface between OneNet Participant (user account) and OneNet Framework through OneNet Middleware: OneNet network of platforms access for non-automated data exchanges and graphical user interface

Table 2: List of functionalities of the OneNet Connector and Middleware

Functionality ID	Title	Description
FCON_API_1	Connector Registration	The OneNet Connector is able to register an external platform using REST APIs.
FCON_API_2	Connector Identification	The OneNet Connector is able to identify an external platform using REST APIs.
FCON_API_3	Data Provisioning	OneNet participant is able to publish any kind of data source using the OneNet Connector APIs.
FCON_API_4	Data Consuming	OneNet participant is able to receive any kind of data using the OneNet Connector APIs.
FCON_DS_1	Clearing House	All the data exchanged in the connector are tracked in the Clearing House service
FCON_DS_2	Data Quality	All the data exchanged are assessed form a quality perspective, based on the data quality requirements.
FCON_DS_3	Data Access Management	The OneNet Connector provides the possibility to configure data access policies for each data source.
FCON_DS_4	Semantic Annotation	Techniques to create metadata and put machine-understandable data on the web. It will transfer the raw data to OWL/RDF/JSON-LD based on the data model and ontology that will be described in T5.6.
FCON_UI_1	URIs Configuration	The OneNet Connector must provide a UI for the configuration of the URIs.

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FCON_UI_2	Data Model Selection	The OneNet Connector should provide a UI for the selection and usage of the standard data models.
FCON_UI_3	Data Model Update/Creation	The OneNet Connector should provide a UI for the creation and updates of customised data models.
FCON_BROK_1	Data Exchange	The OneNet Connector is able to manage the entire data exchange process, including data and metadata.
FMID_MID_1	Participant Registration	The OneNet Middleware is able to manage the OneNet Participants registration and provide a list of the already registered participants.
FMID_CON_2	Identity Management	The OneNet Middleware is able to manage the identities, the access and the authorization of all the OneNet Participants.
FCON_DS_1	Data Catalogue	The OneNet Middleware must provide a data source catalogue.
FCON_DS_2	Vocabularies Explorer	The OneNet Middleware should provide an explorer for all the standard vocabularies.

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3 Cross-platform interoperability services for the OneNet System

The goal of the OneNet System is to facilitate data exchanges among existing platforms, services, applications, and devices by the power of interoperability techniques. To ensure that system requirements are technically - implementable and widely adopted, internationally standardized file formats, metadata, vocabularies and identifiers - are required.

As presented in Figure 4, the "Cross-Platform Access" pattern is the fundamental characteristic of an interoperable ecosystem. The pattern entails that an application accesses services or resources (information or functions) from multiple platforms through the same interface. For example, a "grid monitoring" application gathers information on different grid indicators provided by different platforms that conduct measurements or state estimations. The challenge of realizing this pattern lies in allowing applications or services within one platform to interact with other platforms (eventually from different providers) with relevant services or applications via the same interface and data formats. Thereby, reuse and composition of services as well as easy integration of data from different platforms are enabled.

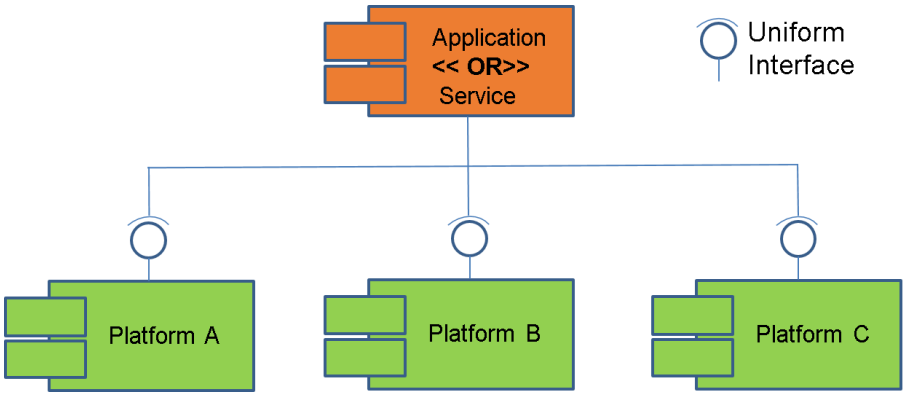

Figure 4: Cross-platform services pattern

According to the aforementioned concept, Deliverable 5.3 starts by defining the list of cross-platform interoperability services based on the input from WP4 and Task 5.1 [28].

3.1 Analysis of input from WP4 and T5.1

The main objective of WP4 is to link the market activities with grid operation and target to maximize the integration of flexibility service providers (FSP) e.g., RES. The goal is to achieve both at TSO and DSO level while

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also the customer perspective is considered. WP4 takes its references from activities performed in ongoing and completed H2020 projects in defining the interfaces between market and grid operations [19-27].

Hence, the review of available solutions is performed and state of art of technical requirements to enable the flexibility services and products of projects are summarized.

Based on the defined concept for cross-platform services, we start analysing inputs from WP4 regarding data exchange patterns and roles involved for system use cases (SUCs) from other H2020 projects and the OneNet demo clusters (WP7 – WP11). As a result, a first list of cross-platform services was gathered. This initial list was categorized into 10 categories of cross-platform services that are listed in Table 3. Within the categories, we detected redundancy in the cross-platform services within and across projects and demo clusters. To reduce redundancy, all categories were filtered and merged, resulting in a list of generic cross-platform services per category, including the associated actors (their roles), data senders (producers), and receivers (consumers) as a basis for the following steps in this task. Figure 5 illustrates the identified service categories (bottom of the figure) empowered by the OneNet System Services and products identified in WP2 (top part of the figure).

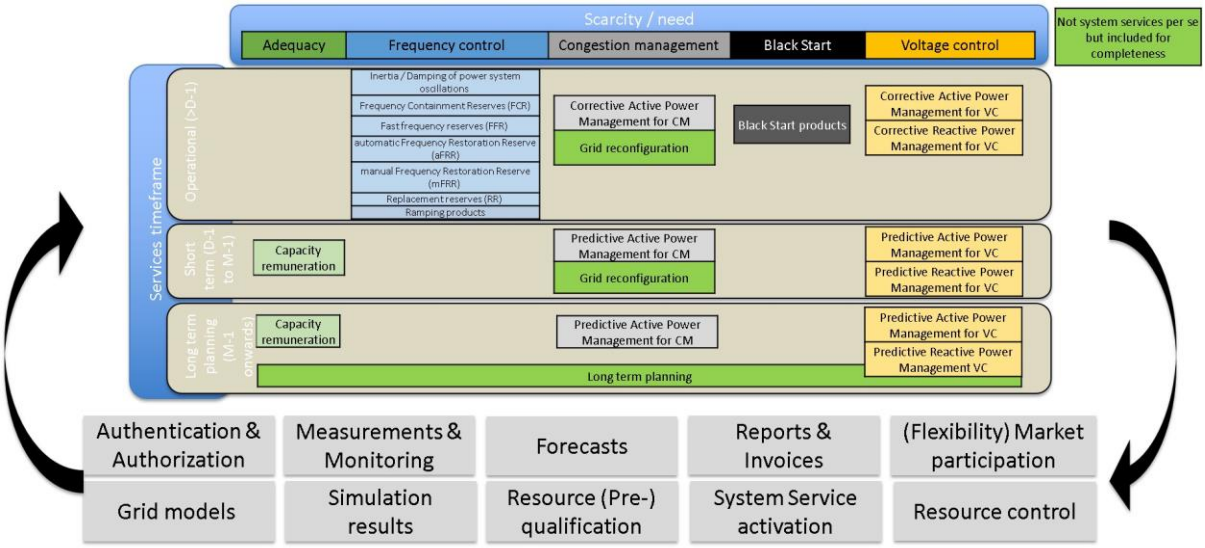

Figure 5: Cross-platform service categories enable the OneNet System Services identified in WP2

3.2 Categories of cross-platform services in the OneNet System

Table 3 provides the categories of cross-platform services and a short description for each category. Functional specs and data quality requirements for the cross-platform services in each category follow in Chapters 4 and 5 respectively.

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Table 3: Categories of cross-platform services in OneNet

No	Category Name	Description	Details
1	Authentication & Authorization	Activities related to cross-platform authentication and authorization. This category is different from the other categories of cross-platform services, since it specifies cross-domain services for authentication and data access policies.	See Table 6
2	Measurements & Monitoring	Exchanging measurements or other data related to monitoring, e.g., state estimation results	See Table 7
3	Forecasts	Exchanging forecast of any kind	See Table 8
4	Reports & invoices	Activities related to reporting or invoicing of system or other services, incl. Reporting energy/flexibility settlement	See Table 9
5	(Flexibility) Market participation	Activities related to participation in market, e.g., sending bids, market clearing etc.	See Table 10
6	Grid models	Exchange of grid models, for example for grid reconfiguration	See Table 11
7	Simulation results	Exchange of simulation results, for example power flow results	See Table 12
8	Resource (pre-) qualification	Activities related to the (pre-) qualification of resources, incl. qualification of product's/ service's technical parameters	See Table 13
9	System service activation	Ask system operator to activate/ start certain system service	See Table 14
10	Resource control	Sending set points to assets/ flexibility sources etc.	See Table 15

3.3 Harmonization of cross-platform services in the OneNet System

3.3.1 SUCs' harmonization

According to the OneNet concept and requirements described in D5.1 [28]possible data exchanges for each OneNet demonstration have been detailed. To verify the alignment of activities within task 5.3 regarding functional specifications and OneNet SUCs described in D5.1, the services were checked and harmonized.

In this process, data exchanges for OneNet SUCs have been aligned with the list of cross-platform services in Task 5.3, and adaptions and extensions of these services were made if required. The functional specifications described in this deliverable can be further extended by getting new features of the OneNet demo clusters in the future.

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3.3.2 Security requirements' harmonization

In order to verify the alignment of the cross-platform services at the category level with the security requirements, the service categories were linked with the relevant requirements described in D5.8 [30]. The most relevant standards used to assure compliance with cyber security requirements are the NISTIR 7628 Smart Grid Cyber Security standard, SGIS Report, Open Web Application Security Project (OWASP), and Application Security Verification Standard (ASVS). A full list of cyber security requirements can be taken from these. These requirements were assigned according to the relevance to each of the cross-platform service categories. These can be observed in Table 4:

Table 4: Relevant security requirements for each of the cross-platform service categories.

Cross-platform service categories	NISTIR 7628, OWASP, ASVS and SGIS Requirements
Authentication & Authorization	SG.AC Access Control; SG.CA Security assessment and authorization; SG.IA Identification and authentication; SG.ID Information and document management; SG.MA Smart grid information system development and maintenance; SG.MP Media protection;
Measurements & Monitoring	SG.CA Security assessment and authorization;
Forecasts	-
Reports & Invoices	SG.AU Audit and accountability;
(Flexibility) Market participation	-
Grid models	SG.CM Configuration management; SG.CP Continuity of operations; SG.IR Incident response; SG.MA Smart grid information system development and maintenance;
Simulation results	-
Resource (Pre-) qualification	SG.CA Security assessment and authorization; SG.SA Smart grid information system and services acquisition;
System Service activation	-
Resource control	SG.CP Continuity of operations; SG.IR Incident response;
Across all categories	SG.SC Smart grid information system and communication protection; SG.SI Smart grid information system and information integrity;

Each requirement of the NISTIR 7628 laid out in the table comes with the recommendations to help with its implementation in the OneNet System (listed in Table 5). There are some requirements that apply across all categories since they are intrinsic to the data exchange process. Some categories end up not having specific requirements while others have more than one, particularly the category "Authentication & Authorization" since this one is specially connected with cybersecurity requirements.

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Table 5: Recommendations for each relevant security requirement

Requirements	Recommendations
SG.AC Access Control	• Separation of duties should be enforced to eliminate conflicts of interests. (NISTIR 7628 SG.AC-6); • Principle of least privilege should be implemented. (NISTIR 7628 SG.AC-7); • For critical systems with higher security levels consider using of multi-factor authentication, cryptographic devices, or client-side certificates for higher impersonation resistance. (OWASP ASVS 2.2.4);
SG.CA Security assessment and authorization	• Conduct routine self-assessments. (ENISA Smart Grid Threat Landscape and Good Practice Guide 9.1.9);
SG.IA Identification and authentication	• Authentication mechanism should obscure feedback during authentication process. (NISTIR 7628 SG.IA-6);
SG.AU Audit and accountability	• Detect and record security relevant events. (OWASP ASVS 7.1.3); • Non-repudiation measures should be implemented. (NISTIR 7628 SG.AU-16);
SG.ID Information and document management	• Communications with devices outside OneNet system should be limited only to the devices that need to communicate. (NISTIR 7628 SG.ID-4)
SG.CM Configuration management	• System components should be configured to provide only essential functionality with unnecessary functions, ports, protocols and services disabled. (NISTIR 7628 SG.CM-7) ; • Baseline configuration for smart grid information system should be developed, documented and maintained as well as keeping previous baselines for possible rollback (NISTIR 7628 SG.CM-2);
SG.CP Continuity of operations	• OneNet systems should integrate fail-safe response procedures upon the loss of communications with other systems. (NISTIR 7628 SG.CP-11); • Use of backup telecommunication provider(s) (NISTIR 7628 SG.CP-8) and alternate control centre(s) should be considered. (NISTIR 7628 SG.CP-9);
SG.MP Media protection	• Passwords, integrations with databases and third-party systems, API keys should resist offline attacks. (OWASP ASVS 2.10.4)
SG.IR Incident response	• In case of wider adaptation of technologies developed during OneNet need for European Organization similar to US ICS-CERT has been identified. (SGIS Report).
SG.SA Smart grid information system and services acquisition	• Security engineering principles should be applied in specification, design, development, and implementation of all OneNet information systems. (NISTIR 7628 SG.SA-8); • Information system documentation should include guides on how to install, configure and use security features built into the system. (NISTIR 7628 SG.SA-5).
SG.MA Smart grid information system development and maintenance	• Administration and management functions should be limited to authorized administrators. (OWASP ASVS 13.1.2).

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SG.SC Smart grid information system and communication protection	• Industry proven or government approved cryptographic algorithms and libraries should be used. (OWASP ASVS 6.2.2).
SG.SI Smart grid information system and information integrity	• Security functions should be verified on system start-up, restart and at defined frequency when tasked by user with appropriate privileges. (NISTIR 7628 SG.SI-6).

3.3.3 OneNet Architecture

The OneNet Reference Architecture, described in deliverable D5.2 [29], provides a high-level description of the OneNet System: the list of components, actors involved, and related interactions. This information is the main input for the definition of the Functional Specifications, to define for each part of the OneNet System, which are the expected functionalities. These functional specifications are provided in Chapter 4.

For the harmonization between the definition and categorization of cross-platform services and the architecture, it is important to underline that the architecture of OneNet, as described, focuses on a purely platform-agnostic aspect. This made it possible to have a specific implementation of the OneNet System, which for the integration part of the platforms, is agnostic from the platform itself and from its business processes. Obviously, not all components and tools provided in the implementation of the architecture can be implemented without knowing the domain in which they operate. For this reason, the harmonization of T5.3 consists of:

• Analysing which features provided by the OneNet architecture are dependent on the cross-platform service processed

• Verifying that the high-level specifications are sufficient to implement the identified cross-platform services

• Describing the interactions between the components and the functionalities expected for the processing of these services (see Chapter 2 of this document).

3.3.4 Roles' harmonization

Upon the identification of the cross-platform services for OneNet, described in Chapter 3, a multitude of services originated from both previous and ongoing H2020 projects and the OneNet demo clusters. These were mapped in a common manner with the objective to obtain a list of services to be considered within the OneNet framework. The gathered, identified, and merged cross-platform services had as a basis for their development several H2020 projects and OneNet demonstrations, in which different roles and actors designations were considered. Hence, the need arose to harmonise the multiple terminologies being used in order to avoid

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redundancy and ensure the singularity of the roles assigned to cross-platform services, which will serve as an input for the development of the OneNet framework.

The process for harmonising the roles followed the process below:

1. Map all the actors from each cross-platform category
2. Extract unique actors per services from each category
3. Merge all the categories actors into one list
4. Extract unique actors from the previous merge
5. Classification of roles and actors in order to remove entries that are not roles/actors
6. Map roles to HEMRM and BRIDGE Roles [18]
    a. Map exact definitions
    b. Harmonise roles that are named differently but are in fact the same
    c. Identify gaps in the HEMRM and BRIDGE
7. Trace back the results to the original services

When undertaking the process of harmonisation, it is important to ensure traceability between the input data and the result; this was assured during the process of harmonisation. Table 18 in the Appendix shows the final list of harmonised roles that are considered for the OneNet project. However, it is important to note that in some cases harmonization was not possible, as can be seen in Table 18 in yellow highlighted roles and actors.

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4 Functional specification of OneNet cross-platform services

The purpose of this section is specifying the cross-platform data exchanges to be supported by the OneNet System – the OneNet API as part of the OneNet Connector – on a functional level. These data exchanges are the foundation for the technical specification of the interfaces in the OneNet System (see Tasks 5.5, 5.6) and the overall implementation (see WP6). Since APIs are defined at interface boundaries, are intended to mask the need to understand the internal architectures and ease the deployment and integration of the OneNet Connector on either side of the interface, the focus of the functional specifications is to define generic cross-platform data exchanges that are independent of a specific platform implementation or application. Therefore, the functional specification starts from the cross-platform services to be supported by the OneNet System as described in Chapter 3 of this deliverable.

4.1 Methodology and State of the Art

We add a constraint to the client-server interaction: Data exchange must be stateless in nature, such that each request from client to server must contain all of the information necessary to understand the request, and cannot take advantage of any stored context on the instance of the OneNet Connector.

This constraint induces the properties of visibility, reliability, and scalability. Visibility is improved because a monitoring system does not have to look beyond a single request datum in order to determine the full nature of the request. Reliability is improved because it eases the task of recovering from partial failures. Scalability is improved because not having to store states between requests allows the server component to quickly free resources, and further simplifies implementation because the server does not have to manage resource usage across requests.

Like most architectural choices, the stateless constraint reflects a design trade-off. The disadvantage is that it may decrease communication network performance by increasing the repetitive data (per-interaction overhead) sent in a series of requests, since that data could not be left on the server in a shared context. In addition, placing the application state on the client-side reduces the server's control over consistent application behaviour, since the application becomes dependent on the correct implementation of semantics across multiple client versions. In the context of OneNet, these disadvantages are acceptable, because the focus of OneNet is on interconnecting participants – not on controlling or monitoring their specific applications.

A Functional Requirement (FR) is a description of a service that a use case must offer. In general, a FR describes a software system or its components. A function is nothing but inputs to the software system, its behaviour, and outputs. It can be a calculation, data manipulation, business process, user interaction, or any other specific functionality that defines what function a system is likely to perform. Functional Requirements in

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Software Engineering are also called Functional Specification. For this deliverable, this means a FR is a description of a cross-platform interoperability service that the OneNet API must offer so that interoperability between participants of the OneNet System is achieved for a large variety of different business and system use cases in the energy sector. A Functional Requirement can range from the high-level abstract statement of the sender's necessity to detailed mathematical functional requirement specifications. This section provides the FR of the OneNet API and includes the following aspects:

- Details of interoperability operations conducted in every cross-platform service including used data modification methods (create, read, update and delete, CRUD) and a functional description of the interoperability operation per cross-platform service and method.

This section does NOT include the following information:

- Data handling logic, compliance to legal aspects per participant in the OneNet System and data access/ protection rules.

We refer to Deliverable D5.8 [30] of the OneNet project for an analysis of cybersecurity, privacy and other relevant business regulatory requirements. Data enforcement policies and design for data sovereignty preserving data access will be discussed in Deliverable D5.7 of the OneNet project. Data models and the technical interface specification of the OneNet System will be reported in Deliverable 5.5 while Deliverable 5.6 will provide details about data, platform and service interoperability in the OneNet System.

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4.2 Functional specification of cross-platform services supported by the OneNet API

Table 6: Cross-platform services for Category 01: Authentication & Authorization

Category 01: Authentication & Authorization					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_01AUTH_0001	Authentication	Create (Post)	Data owners and delegated parties can authenticate themselves using the service of an Authentication Service Provider, for example a Customer Portal or a Local Market Platform; for new parties, an account is created (Create).	Data Delegated Third Party (B), Data Owner (B), Flexibility Services Provider (B)	Customer Portal Operator (B), Market Operator
OneNet_01AUTH_0002	Identity verification	Read (Get)	Request verification of identity or validation of account (of data owner or delegated party such as FSP) through and return result of verification/ validation (Read).	Customer Portal Operator (B), Market Operator	Authentication Service Provider (B), Flexibility Services Provider (B)
OneNet_01AUTH_0003	Delegation of representation rights	Create (Post) Update (Put)	Delegate representation rights of data owner to other party through Authorization Service Provider, for example a Customer Portal (Create, Update).	Data Owner (B)	Customer Portal Operator (B)
OneNet_01AUTH_0004	Consent to data access (data owner)	Create (Post) Read (Get) Update (Put) Delete	Create/ Update/ Delete: Data owner creates, updates or deletes consent to data access for other party through Authorization Service Provider/ Consent Administrator (e.g. Customer Portal) Read: Data owner refuses a requested consent through Authorization Service Provider/ Consent Administrator	Data Owner (B)	Customer Portal Operator (B)

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OneNet_01AUTH_0005	Consent to data access (third party)	Read (Get)	Third party requests consent of data owner for accessing data through Authorization Service Provider/ Consent Administrator (Read).	Consent Administrator	Data Owner (B)
OneNet_01AUTH_0006	Consent information	Read (Get)	Authorization Service Provider/ Consent Administrator returns information about consents (given, modified, withdrawn, refused) related to a specific data source/ owner upon request (Read).	Customer Portal Operator (B)	Data Hub Operator (B), Flexibility Register Operator (B), Market Operator, System Operator
OneNet_01AUTH_0007	Data rectification/ deletion (request)	Update (Put) Delete	Update: Data owner requests rectification of data from data users and data providers. Delete: Data owner requests deletion of data from data users and data providers.	Data Owner (B)	Data Hub Operator (B), Consent Administrator
OneNet_01AUTH_0008	Data rectification/ deletion (status)	Create (Post) Read (Get) Update (Put)	Data users or data provider send status information about data deletion or rectification to data owner upon request (Read) or by initiative (Create, Update).	Data Hub Operator (B), Consent Administrator	Data Owner (B)
OneNet_01AUTH_0009	Data usage information	Read (Get)	Authorization Service Provider (e.g. Customer Portal) returns usage information logs of data-to-data owner upon request (Read).	Customer Portal Operator (B), Data Owner	Customer Portal Operator (B), Data Owner (B)
OneNet_01AUTH_0010	Consent to data access (status)	Read (Get)	Data users / applications check via Authorization Service Provider if consent to data usage from data owner exists upon request (Read).	Data Exchange Platform (DEP) Operator (B)	Customer Portal Operator (B)
OneNet_01AUTH_0011	Data request	Read (Get)	Request (Read) data to be used by the data user (from any kind of data exchange platform and/or through Authorization Service Provider).	Data Delegated Third Party (B), Customer Portal Operator (B)	Customer Portal Operator (B), Data Owner (B), Data Delegated Third Party (B), Data Provider, Consent Administrator

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OneNet_01AUTH_0012	Data provisioning	Create (Post)	Data owners provide (Create) data to be used (to any kind of data exchange platform or third party application and/ or through Authorization Service Provider).	Data Provider	Customer Portal Operator (B), Data Delegated Third Party (B), Data Owner, Data Provider, Consent Administrator

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Table 7: Cross-platform services for Category 02: Measurements & Monitoring

Category 02: Measurements & Monitoring					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_02MEMO_0001	Resource information	Create (Post) Read (Get) Update (Put)	Communicate resources' information upon request (Read) or by initiative (Create, Update)	Resource Aggregator, Data Exchange Platform (DEP) Operator (B), Distributed Energy Resources Operator, Flexibility Register Operator (B), Market Operator, System Operator	Data Exchange Platform (DEP) Operator (B), Resource Aggregator, Market Operator, System Operator
OneNet_02MEMO_0002	Metering data	Create (Post) Read (Get) Update (Put)	Communicate Metering data upon request (Read) or by initiative (Create and Update)	Consumer, Customer's In-House Device, Data Exchange Platform (DEP) Operator (B), Data Hub Operator (B), System Operator, Flexibility Services Provider (B), Meter Operator, Metered Data Collection Tool, Party Connected to the Grid, Service Provider, Significant Grid Users, Sub-meter data collection tool,	Resource Aggregator, Consumer, Data Exchange Platform (DEP) Operator (B), Data Hub Operator (B), System Operator, Energy Supplier, Market Operator, Flexibility Services Provider (B), Meter Operator, Market Operator, Energy Supplier / Energy Trader,
OneNet_02MEMO_0003	Estimation data	Create (Post) Read (Get) Update (Put)	Communicate State Estimation data upon request (Read) or by initiative (Create and Update)	Consumer, Data Exchange Platform (DEP) Operator (B), System Operator, Party Connected to the Grid	Data Exchange Platform (DEP) Operator (B), Resource, System Operator, Flexibility Services Provider (B), System Operator

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OneNet_02MEMO_0004	Grid State	Create (Post) Read (Get) Update (Put)	Communicate grid state information upon request (Read) or by initiative (Create, Update)	Data Exchange Platform (DEP) Operator (B), Market Operator	System Operator

Table 8: Cross-platform services for Category 03: Forecasts

Category 03: Forecasts					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_03FORC_0001	Forecast data (general)	Create (Post) Read (Get) Update (Put)	Communicate forecast data for environmental parameters, load, generation or storage upon request (Read) or by initiative (Create, Update). Power forecasts can be both related with the FSPs baseline or aggregated Load and RES forecast.	Data Exchange Platform (DEP) Operator (B), System Operator, Flexibility Services Provider	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator
OneNet_03FORC_0002	Baselines	Create (Post) Read (Get) Update (Put)	Communicate baselines (e.g. of FSPs) upon request (Read) or by initiative (Create, Update).	Data Exchange Platform (DEP) Operator (B), Flexibility Services Provider (B)	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator
OneNet_03FORC_0003	Capacity bid limits	Create (Post) Update (Put)	Communicate (Create, Update) temporary limits on balancing capacity bids (based on forecast data), according to Art. 182-5 SOGL as 1-Partial, 2-Total, or 3-None.	Data Exchange Platform (DEP) Operator (B), System Operator	Data Exchange Platform (DEP) Operator (B), System Operator
OneNet_03FORC_0004	Maintenance forecast	Create (Post) Read (Get) Update (Put)	Communicate forecast of maintenance periods (optionally including enhanced storm and icing forecast) upon request (Read) or by initiative (Create, Update).	System Operator	System Operator
OneNet_03FORC_0005	Dynamic line rating	Create (Post) Read (Get) Update (Put)	Communicate Dynamic Line rating forecast for overhead lines and capacity calculation input data upon request (Read) or by initiative (Create, Update).	System Operator	System Operator

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OneNet_03FORC_0006	Connection state forecast	Create (Post) Read (Get) Update (Put)	Communicate connection state forecast for grid assets upon request (Read) or by initiative (Create, Update).	System Operator	System Operator

Table 9: Cross-platform services for Category 04: Reports & Invoices

Category 04: Reports & Invoices					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_04REIN_0001	Energy Account Document	Create (Post) Read (Get) Update (Put)	Communicate resource activations (Energy Account Document) upon request (Read) or by initiative (Create, Update).	Data Exchange Platform (DEP) Operator (B), Flexibility Services Provider (B)	System Operator, Data Exchange Platform (DEP) Operator (B)
OneNet_04REIN_0002	Settlement process	Read (Get)	Communicate settlement processes upon request (Read).	Data Exchange Platform (DEP) Operator (B)	Flexibility Services Provider (B)
OneNet_04REIN_0003	Market results	Read (Get)	Communicate day ahead and intraday market results upon request (Read).	Data Exchange Platform (DEP) Operator (B)	System Operator
OneNet_04REIN_0004	Under or over-delivered flexibilities	Create (Post) Update (Put)	Communicate information about under or over-delivered flexibilities in real-time (Create, Update).	Flexibility Register Operator (B)	Flexibility Services Provider (B), System Operator, Data Exchange Platform (DEP) Operator (B)
OneNet_04REIN_0005	Verification process results	Read (Get)	Communicate results of verification process for activated flexibility resources (also failure of verification) upon request (Read).	Flexibility Register Operator (B)	Data Hub Operator (B), Flexibility Services Provider (B), Market Operator, System Operator

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OneNet_ 04REIN_ 0006	Invoicing data	Create (Post) Read (Get) Update (Put)	Communicate invoicing data upon request (Read) or by initiative (Create, Update).	Flexibility Register Operator (B)	System Operator

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Table 10: Cross-platform services for Category 05: (Flexibility) Market Participation

Category 05: (Flexibility) Market Participation					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_05MRKT_0001	Market bid/ offer	Create (Post)	Communicate bids/ offers for available flexibility by initiative (Create).	Data Exchange Platform (DEP) Operator (B), System Operator, Flexibility Services Provider (B), Market Operator	Balance Responsible Party, Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator
OneNet_05MRKT_0002	Market clearing/ results	Create (Post) Read (Get)	Communicate market results/ market clearing upon request (Read) or by initiative (Create).	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator	Data Exchange Platform (DEP) Operator (B), System Operator, Flexibility Services Provider (B), Market Operator,
OneNet_05MRKT_0003	Required resources	Create (Post) Update (Put)	Create: Communicate required capacity and location of flexible resources (including limits/ margins). Update: Update limits/ margins of required capacity and location for another market run	Data Exchange Platform (DEP) Operator (B), System Operator, Flexibility Services Provider (B), Market Operator	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator, Flexibility Services Provider (B)
OneNet_05MRKT_0004	Market information	Read (Get)	Communicate market information including information about registered parties in the market (for example FSPs) upon request (Read).	Data Exchange Platform (DEP) Operator (B), Flexibility Services Provider (B), Market Operator	Data Hub Operator (B), System Operator, Flexibility Services Provider (B), Market Operator
OneNet_05MRKT_0005	Confirmation/ Approval	Create (Post)	Communicate confirmation or approval data by initiative (Create).	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator	Flexibility Services Provider (B), Market Operator, Consumer

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OneNet_05MRKT_0006	Resource optimization	Create (Post) Read (Get)	Communicate information on customer resource optimization on request (Read) or by initiative (Create).	System Operator	Consumer
OneNet_05MRKT_0007	Matching bids and grid needs	Create (Post) Read (Get)	Communicate information on matching of bid and grid needs for market decision support upon request (Read) or by initiative (Create).	Data Exchange Platform (DEP) Operator (B)	System Operator
OneNet_05MRKT_0008	Congestion data	Create (Post) Read (Get)	Communicate grid congestion data upon request (Read) or by initiative (Create).	Data Exchange Platform (DEP) Operator (B)	System Operator
OneNet_05MRKT_0009	Merit Order List	Create (Post)	Communicate Merit Order List (MOL) with optimization, grid impact assessment and creation of aggregated network by initiative (Create).	System Operator, Flexibility Services Provider (B)	System Operator
OneNet_05MRKT_0010	Market opening/ closing	Create (Post)	Communicate opening or closing of a market session by initiative (Create).	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator	System Operator, Market Operator, Flexibility Services Provider (B)
OneNet_05MRKT_0011	Offer assessment result	Create (Post)	Communicate offer assessment result (acceptance, validation, re-definition) by initiative (Create).	Market Operator, Resource Aggregator, System Operator,	Market Operator, Resource Aggregator, System Operator, Balancing Service Provider
OneNet_05MRKT_0012	Flexibility awarding	Create (Post)	Market awards the provision of flexibility services to the FSPs and Aggregators according to the market bids by initiative (Create).	Market Operator	Resource Aggregator, System Operator, Flexibility Services Provider (B)

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Table 11: Cross-platform services for Category 06: Grid Models

Category 06: Grid Models					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_06GRMO_0001	Network reconfiguration	Create (Post) Read (Get) Update (Put)	Communicate network reconfiguration to be validated upon request (Read) or by initiative (Create). If overall process is iterative, communicate updated network reconfiguration (Update).	System Operator	Data Exchange Platform (DEP) Operator (B), System Operator
OneNet_06GRMO_0002	Network planning (in transmission system)	Create (Post) Read (Get) Update (Put)	Communicate planned changes to transmission system upon request (Read) or by initiative (Create, Update).	System Operator	System Operator
OneNet_06GRMO_0003	Network planning (in distribution system)	Create (Post) Read (Get) Update (Put)	Communicate planned changes to distribution system upon request (Read) or by initiative (Create, Update).	System Operator	System Operator
OneNet_06GRMO_0004	Network model (transmission system)	Read (Get) Update (Put)	Communicate network data of transmission system upon request (Read) or by initiative (Update).	System Operator	System Operator
OneNet_06GRMO_0005	Network model (distribution system)	Read (Get) Update (Put)	Communicate network data of distribution system upon request (Read) or by initiative (Update).	System Operator	System Operator

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Table 12: Cross-platform services for Category 07: Simulation Results

Category 07: Simulation Results					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_07SIRE_0001	Grid power flows data	Create (Post) Read (Get) Update (Put)	Communicate power flow simulation data upon request (Read) or by initiative (Create, Update).	Data Exchange Platform (DEP) Operator (B), System Operator	Data Exchange Platform (DEP) Operator (B), System Operator
OneNet_07SIRE_0002	Grid constraints assessment	Create (Post) Read (Get) Update (Put)	Communicate grid impact assessment upon request (Read) or by initiative (Create, Update).	Data Exchange Platform (DEP) Operator (B), System Operator, Resource Aggregator, Market Operator	Data Exchange Platform (DEP) Operator (B), System Operator, Market Operator,
OneNet_07SIRE_0003	Grid optimization data	Create (Post) Read (Get) Update (Put)	Communicate results of different aggregation level simulations upon request (Read) or by initiative (Create, Update). Simulation results may contain DSO/TSO grid level calculations and/or energy predictions and system state predictions for different aggregation levels of DSO grid and local micro grid: - Unit level: distributed gen. unit, OHL tower/section - Plant level: solar park, wind park, OHL, substation - Local micro grid level: part of the DSO grid	Data Exchange Platform (DEP) Operator (B), System Operator	Data Exchange Platform (DEP) Operator (B), System Operator

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Table 13: Cross-platform services for Category 08: Resource (Pre-) Qualification

Category 08: Resource (Pre-) Qualification					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_08REQU_0001	Certification of a resource	Read (Get)	Communicate upon request (Read) semi-structured information on the certification of a resource have been approved by the responsible SO.	Flexibility Services Provider (B)	System Operator
OneNet_08REQU_0002	Qualification results (for new resource group registration)	Create (Post) Read (Get) Update (Put)	Communicate qualification results for new resource group registration upon request (Read) or by initiative (Create, Update)	Flexibility Services Provider (B), Data Exchange Platform (DEP) Operator (B), Market Operator	Data Exchange Platform (DEP) Operator (B), Flexibility Register Operator (B), Market Operator, System Operator
OneNet_08REQU_0003	Requalification results	Create (Post) Read (Get) Update (Put)	Communicate requalification results for connected resources upon request (Read) or by initiative (Create, Update).	System Operator, Flexibility Register Operator (B), Data Exchange Platform Operator (B), Market Operator	Balance Responsible Party, System Operator, Flexibility Register Operator (B), Resource Aggregator, Flexibility Services Provider (B), Data Exchange Platform (DEP) Operator (B), Market Operator
OneNet_08REQU_0004	Admissible resources	Read (Get)	Communicate admissible (prequalified for participation in portfolio) resources upon request (Read).	System Operator, Flexibility Services Provider (B)	System Operator, Data Exchange Platform (DEP) Operator (B)

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OneNet_08REQU_0005	Congestion management needs	Create (Post) Read (Get) Update (Put)	Communicate congestion management needs and effective local resources (determined based on forecast) upon request (Read) or by initiative (Create, Update).	System Operator	Data Exchange Platform (DEP) Operator (B)
OneNet_08REQU_0006	Request for qualification	Create (Post) Read (Get) Update (Put)	Communicate request for qualification or additional information required for qualification (automated grid qualification algorithm or manual process) upon request (Read) or by initiative (Create, Update).	Data Exchange Platform (DEP) Operator (B), Market Operator, Flexibility Services Provider (B)	System Operator, Flexibility Services Provider (B), Market Operator, Data Exchange Platform (DEP) Operator (B)

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Table 14: Cross-platform services for Category 09: System Service Activation

Category 09: System Service Activation					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_ 09SSAC_ 0001	Activation document	Create (Post) Read (Get) Update (Put)	Communicate activation document for System Service upon request (Read) or by initiative (Create, Update). System Service activation document may include communication of baselines, flexibility and which resources are to be activated/ deactivated for the System Service. After activation, monitoring of activation performance can be done.	Data Exchange Platform (DEP) Operator (B), System Operator, Resource Aggregator	Balance Responsible Party, Data Exchange Platform (DEP) Operator (B), Resource, System Operator, Resource Aggregator, Market Operator, Balancing Service Provider
OneNet_ 09SSAC_ 0002	Activation document (including corrections/ counter action)	Create (Post) Update (Put)	Communicate activation document for System Service including corrections/ counter action by initiative (Create, Update). Counter action can be: - Initiated by system operator responsible for balancing. If there is a lack of time for the counter action, emergency plan is activated by the responsible system operator. - Automatically triggered without direct involvement of system operator. In this case, technical limits of the involved network have to be checked.	Data Exchange Platform (DEP) Operator (B), Resource Aggregator, Market Operator, System Operator	Data Exchange Platform (DEP) Operator (B), Resource, Resource Aggregator, System Operator

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Table 15: Cross-platform services for Category 10: Resource Control

Category 10: Resource Control					
ID	**Name**	**Methods**	**Description**	**Data Sender/ Producer**	**Data Receiver/ Consumer**
OneNet_ 10RECO_ 0001	Activation of assets	Create (Post) Update (Put)	Communicate activation signals for a specific asset or group of assets by initiative (Create, Update).	Resource Aggregator, Balance Responsible Party, Data Exchange Platform (DEP) Operator (B), Consumer, Market Operator, Flexibility Services Provider (B), System Operator	Data Exchange Platform (DEP) Operator (B), Data Hub Operator (B), Market Operator, Resource Aggregator, Flexibility Services Provider (B), Consumer, Scheduling Agent, System Operator
OneNet_ 10RECO_ 0002	Execution orders	Create (Post) Update (Put)	Communicate execution orders to achieve a specific objective such as islanding operation, balancing, energy efficiency enablement or flexibility services by initiative (Create, Update).	Balance Responsible Party, Consumer, Data Exchange Platform (DEP) Operator (B), System Operator, Energy Supplier, Party Connected to the Grid, Energy Trader	Resource Aggregator, Data Exchange Platform (DEP) Operator (B), System Operator, Energy Manager / Metered Data Collector, Flexibility Services Provider (B)
OneNet_ 10RECO_ 0003	Regulation, instruction and control schema	Create (Post) Update (Put)	Communicate instructions/control scheme for regulation of a system parameter by initiative (Create, Update).	Data Exchange Platform (DEP) Operator (B), System Operator	System Operator, Flexibility Services Provider (B), Balancing Service Provider / Resource Aggregator

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5 Data quality assessment

In the latest years, data is increasingly considered a valuable asset, almost equal to or even more than physical assets. Considerable costs are involved in collecting, storing, and acting upon the data. As with physical assets, the quality of the data is a prerequisite for ensuring reliable operations. Additionally, high data quality must be ensured to enable reuse of data and to enable analytics on historical data.

In order to ensure both reliable operations and valid analytics, data quality assessment and continuous monitoring is important for all critical systems and services. Organizations should define data quality policies and processes should be in place to support these policies. The requirements for data quality and dataset definitions must be clearly stated and KPIs should be implemented in order to verify compliance with requirements. Ideally, the measures should be in effect across the entire organization to ensure optimization and to avoid data quality assessment being performed in silos [7].

In the context of OneNet, the **Data Quality assessment** takes on even more importance, as data exchange is the core of the system. The Data Quality assessment is the process of finding and exposing all the business and technical issues related to data so that data cleansing and data enrichment processes can be executed across the organizational data using appropriate data quality tools. This process ensures a high data quality level and is maintained for each operation related to the data.

Therefore, the aim of a data quality assessment is to identify incorrect data, to estimate the impact on the business processes, and to implement corrective action [8]. To achieve good data quality, it is necessary for each organization to determine, in a structured way, exactly what 'good data' means to them, as well as finding a way to ensure that the quality of the data remains 'good'.

Data experts suggest different combinations of data aspects and features to assess for data quality evaluation. These measurable categories are called **data quality dimensions**. In 1996, professors Richard Wang and Diane Strong described their conceptual framework for data quality in Beyond Accuracy: What Data Quality Means to Data Consumers [9]. The research authors consider four data quality categories: intrinsic, contextual, representational, and accessibility (see Figure 6). Each category includes several dimensions, 15 in total [9].

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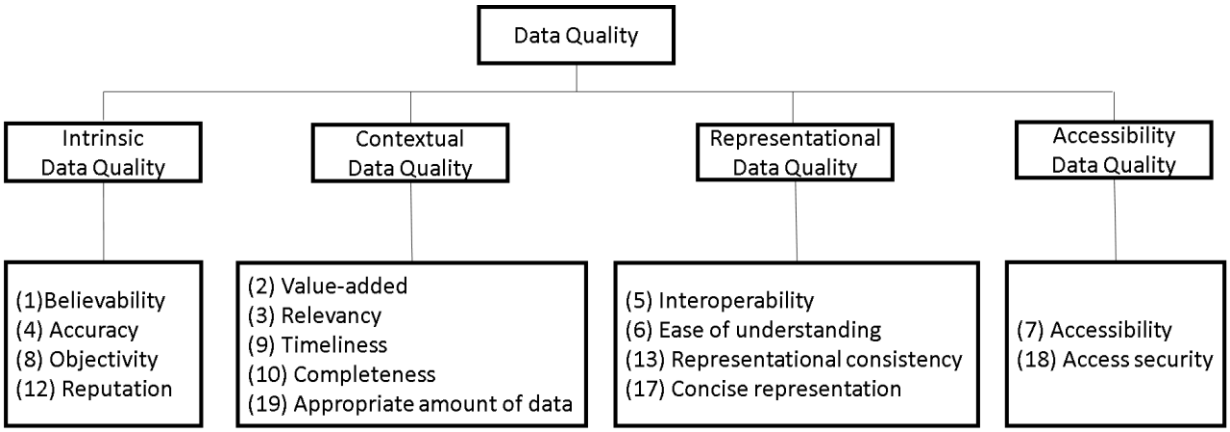

Figure 6: R. Wang e D. Strong Data Quality Conceptual Framework, Figure adapted from [9]

Based on this conceptual framework it is possible to define a specific Data Quality Framework, more suited to the characteristics of the data to be analysed and specifically to the domain of use. In the OneNet context, the analysed data exchanges are related to the Flexibility Market systems. Thus, a domain-specific framework that includes a tailored methodology and approach is described on section 5.4.

5.1 Data quality standards

In addition to a methodological approach, based on the extension and adaptation of a conceptual framework, also more structured approaches try to identify standard approaches for data quality management.

In particular, two ISO standards are relevant:

- ISO 8000:8 – the global standard for Data quality [10]
- ISO/IEC 25012 – data quality model and characteristics [11]

ISO 8000:8

ISO 8000 defines characteristics of information and data that determine its quality, and provides methods to manage, measure, and improve the quality of information and data. When assessing the quality of information and data, it is useful to perform the assessment in accordance with documented methods. It is also important to document the tailoring of standardized methods with respect to the expectation and requirements pertinent to the business [10].

In particular, ISO 8000-8 describes fundamental concepts of information and data quality as well as how these concepts apply to quality management processes and quality management systems. It also specifies prerequisites for measuring information and data quality when executed within quality management processes and quality management systems [10].

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ISO/IEC 25012

The Data Quality model (see Figure 7) represents the grounds where the system for assessing the quality of the data products is built on. In a Data Quality model, the main Data Quality characteristics that must be taken into account when assessing the properties of the intended data product are established.

The quality of a data product may be understood as the degree to which data satisfy the requirements defined by the product-owner organization. Specifically, those requirements are the ones that are reflected in the Data Quality model through its characteristics (Accuracy, Completeness, Consistency, Credibility, Correctness, Accessibility...).

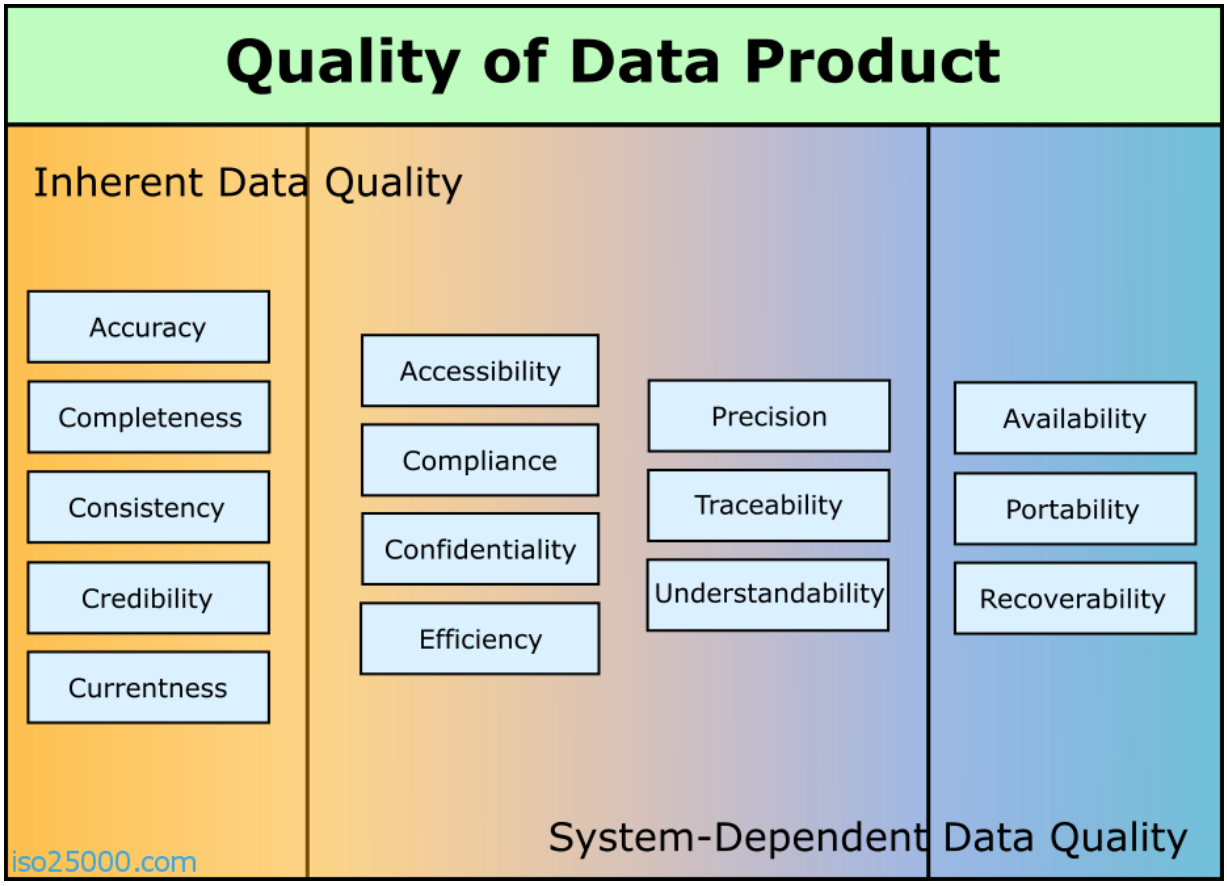

Figure 7: ISO/IEC 25012 Data Quality model [11]

5.2 Assessment Criteria and Techniques

5.2.1 Data Quality Strategies and Techniques

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In their improvement steps, methodologies adopt two general types of strategies, data-driven and process-driven. Data-driven strategies improve the quality of data by directly modifying the value of data. For example, obsolete data values are updated by refreshing a database with data from a more current database. Process-driven strategies improve quality by redesigning the processes that create or modify data. As an example, a process can be redesigned by including an activity that controls the format of data before storage [13].

Both strategies apply a variety of techniques: algorithms, heuristics, and knowledge-based activities, whose goal is to improve data quality. An open-ended list of the improvement techniques applied by data-driven strategies is:

- **Acquisition of new data**, which improves data by acquiring higher-quality data to replace the values that raise quality problems
- **Standardization/normalization**, which replaces or complements nonstandard data values with corresponding values that comply with the standard
- **Record linkage**, which identifies that data representations in two (or multiple) tables that might refer to the same real-world object
- **Data and schema integration**, which define a unified view of the data provided by heterogeneous data sources. Integration has the main purpose of allowing a user to access the data stored by heterogeneous data sources through a unified view of these data. In cooperative, and P2P, information systems, data sources heterogeneities can be largely classified into technological; schema; and instance-level.
- **Source trustworthiness**, which selects data sources based on the quality of their data.
- **Error localization and correction**, which identify and eliminate data quality errors by detecting the records that do not satisfy a given set of quality rules. These techniques are mainly studied in the statistical domain. Compared to elementary data, aggregate statistical data, such as average, sum, max, and so forth are less sensitive to possibly erroneous probabilistic localization and correction of values.
- **Cost optimization**, defines quality improvement actions along a set of dimensions by minimizing costs.

Two main techniques characterize process-driven strategies:

- **Process control** inserts checks and control procedures in the data production process when: new data are created; data sets are updated; or new data sets are accessed by the process. In this way, a reactive strategy is applied to data modification events, thus avoiding data degradation and error propagation.

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- **Process redesign** redesigns processes to remove the causes of poor quality and introduces new activities that produce data of higher quality.

5.2.2 Functional Forms to perform Objective Assessments

When performing objective assessments, a set of principles to develop metrics specific to their needs should be followed [14][15]. Three widespread functional forms are:

- **Simple Ratio**: The simple ratio measures the ratio of required outcomes to actual outcomes. The simple ratio is usually normalized to range between 0 and 1, by assuming that 1 represents the most desirable and 0 the least desirable score.
- **Min or Max:** The minimum or maximum functional form is applied to handle dimensions that require the aggregation of multiple data quality indicators. It is also used to provide an aggregate value of data quality along a single dimension for a set of data. Usually, quality metadata are associated with each record or field; in order to calculate an aggregate value on multiple records or fields, the maximum or the minimum value among the values of different records, fields, or data quality indicators is selected.
- **Weighted Average:** For the multivariate case, an alternative to the minimum or maximum operator is a weighted average of variables. If a company has a good understanding of the importance of each variable in the overall evaluation of a dimension, then a weighted average of variables is appropriate. To obtain a normalized result, weights should range between zero and one and their summation should evaluate to one. A simple average can be used if a single variable must be evaluated for a set of data.

5.3 **Assessment Methodologies**

5.3.1 Reference Methodologies in the Literature

In this chapter, DQ assessments methodologies are presented (see Table 16). These methodologies consist of methods described in the last two chapters, that is, each one uses a combination of data quality dimensions to describe data quality along with different strategies and techniques to improve data quality [13].

Note that these methodologies are well established in the literature, as references to conduct data quality assessments for different dimensions of data quality. Some may be able to apply to modern implementations as theoretical guidelines.

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Table 16: Some DQ Assessment methodologies in the literature, table adapted from [13]

Methodology Acronym	Extended Name	Main Reference
TDQM	Total Data Quality Management	Wang 1998
DWQ	The Datawarehouse Quality Management	Jeusfeld et al. 1998
TIQM	Total Information Quality Management	English 1999
AIMQ	A methodology for information quality assessment	Lee et al. 2002
CIHI	Canadian Institute for Health Information methodology	Long and Seko 2005
DQA	Data Quality Assessment	Pipino et al. 2002
IQM	Information Quality Measurement	Eppler and Münzenmaier 2002
ISTAT	ISTAT methodology	Falorsi et al. 2003
AMEQ	Activity-based Measuring and Evaluating of product information Quality (AMEQ) methodology	Su and Jin 2004
COLDQ	Loshin Methodology (Cost-effect Of Low Data Quality)	Loshin 2004
DaQuinCIS	Data Quality in Cooperative Information Systems	Scannapieco et al. 2004
QAFD	Methodology for the Quality Assessment of Financial Data	De Amicis and Batini 2004
CDQ	Comprehensive methodology for Data Quality management	Batini and Scannapieco 2006

The broad differences in focus across methodologies can be recognized by classifying methodologies into four categories, as shown in Figure 8 [13].

- **Complete methodologies**, which provide support to both the assessment and improvement phases, and address both technical and economic issues
- **Audit methodologies**, which focus on the assessment phase and provide limited support to the improvement phase
- **Operational methodologies**, which focus on the technical issues of both the assessment and improvement phases, but do not address economic issues
- **Economic methodologies**, which focus on the evaluation of costs

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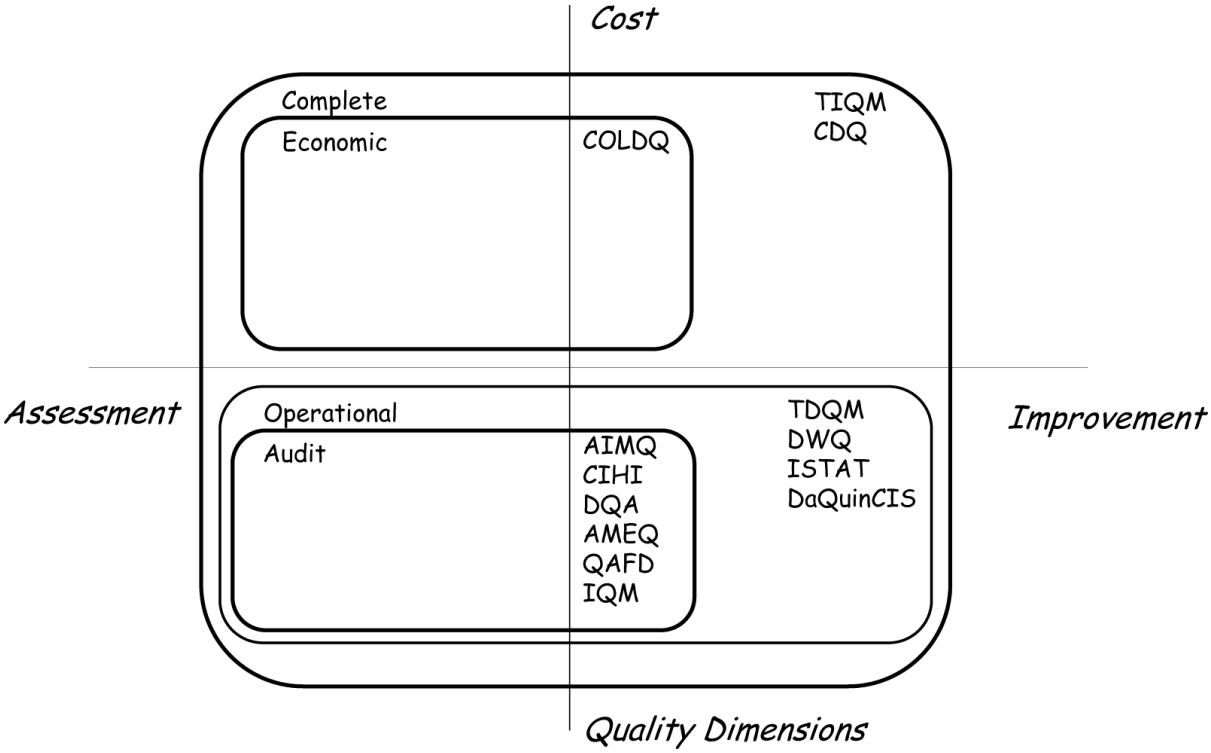

Figure 8: Classification of the previous methodologies [13]

5.3.2 Executable Data Quality Models

In recent years, other methodologies have been proposed, and such is the case of executable data models that make use of a domain specific language (DSL) interpreter. The data quality model, like business processes, is described using some graphical DSL. Since the data quality requirements are different, the used DSLs can also be different [12].

The DSL can be modelled in various platforms and once the DSL is defined and an appropriate editor is created, a data quality model can be designed including the data quality checking parameters for the specific information system. Initially the model can be informal, e.g., the data validations can be described in a textual way. Afterwards, the informal description is substituted by a source code or SQL statements, making the informal model executable. In the next step, the formal data quality model may be translated to software routine or a universal interpreter can be created which is able to execute the data quality model.

This executable data model performs three successive data quality controls (see Figure 9):

1. Syntactic control ensures quality control within one input message: (1) Are all mandatory fields completed? (2) Do the input values have a correct data type? (3) Does the input value fulfil the conditions of the field? This control may be implemented by using external code libraries.
2. Contextual control on interrelated data ensures quality control using attribute values of mutually interconnected data objects: (1) Does the message contain object instances with references to other

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data objects? (2) Are the attribute values of input data in compliance with related data objects? The contextual control on interrelated data can be described by SQL statements. Of course, the statements will be individual for each usage or task.

3. Contextual control on the entire data set checks the compliance with conditions valid for the whole model. The contextual control on the entire data set may also be described using SQL statements although the statements could be rather complicated.

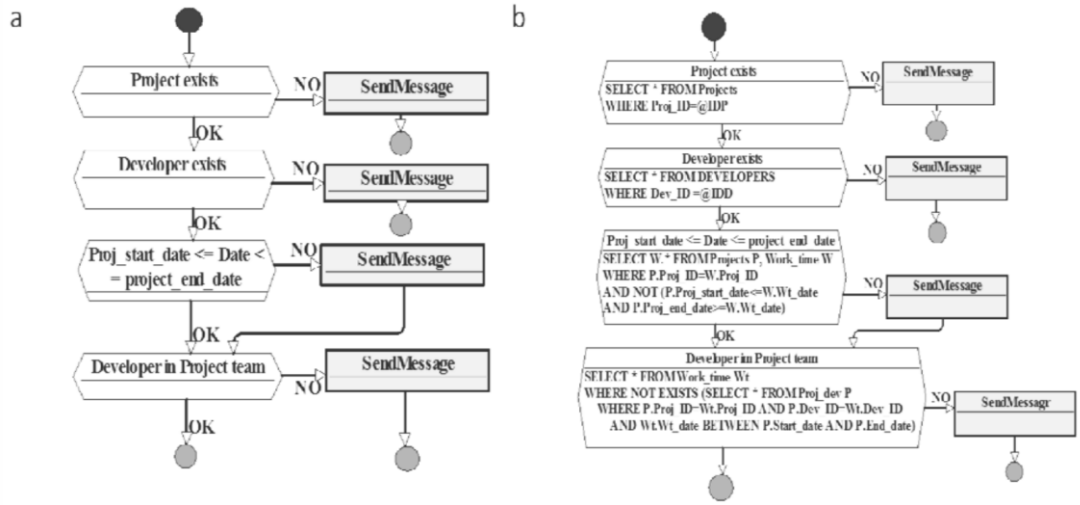

Figure 9: Contextual data quality control: (a) contextual control on interrelated data; (b) implementation of contextual control on interrelated data [12]

In practice, the proposed data quality checking technology is primarily suitable for information systems using relational databases. As the data base structure (ER model) is relatively constant, the data quality model may be used in a very effective way. Before the use of data, the data quality model is executed and all discrepancies with requirements are identified.

The proposed technology is applicable not only for relational databases but also for document-oriented NoSQL databases with XML documents. The main difference: in case of document-oriented databases, the requirements will be described by XQuery statements. One of the advantages of this method is that data quality is checked every time data is entered into the database in contrast to other methods that use static methods and allow for gradual accumulation of data quality defects between assessments.

Note: It is unclear if this method can be further used in other times of data usage (e.g. data exchange, access, processes, etc.) as an additional measure to guarantee data quality in all stages of data usage.

5.3.3 Big Data Quality Assessment

5.3.3.1 The Challenges of Data Quality in the Big Data Era

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Big data presents new features and its data quality also faces many challenges. The characteristics of big data come down to the 4Vs: Volume, Velocity, Variety, and Value. When using and processing big data, extracting high quality and real data from the massive, variable, and complicated data sets becomes an urgent issue. At present, big data quality faces the following challenges [16]:

- The diversity of data sources brings abundant data types and complex data structures and increases the difficulty of data integration.
- Data volume is tremendous, and it is difficult to judge data quality within a reasonable amount of time.
- Data change very fast, and the "timeliness" of data is very short, which necessitates higher requirements for processing technology.
- No unified and approved data quality standards have been formed in China and abroad, and research on the data quality of big data has just begun.

5.3.3.2 Quality Criteria of Big Data

Big data is a new concept, and until 2015 academia had not made a uniform definition of its data quality and quality criteria. The literature differs on a definition of data quality, but one thing is certain: data quality depends not only on its own features but also on the business environment using the data, including business processes and business users. Only the data that conform to the relevant uses and meet requirements can be considered good quality data. In the age of big data, with the diversity of data sources, data users are not necessarily data producers. Thus, it is difficult to measure data quality. Therefore, a hierarchical data quality framework from the user's perspective is proposed (Figure 10) [16].

The data quality dimensions chosen are commonly accepted and widely used as big data quality standards. At the same time, each dimension was divided into many typical elements associated with it, and each element has its own corresponding quality indicators.

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Dimensions	Elements	Indicators
1) Availability	1) Accessibility	▪ Whether a data access interface is provided ▪ Data can be easily made public or easy to purchase
	2) Timeliness	▪ Within a given time, whether the data arrive on time ▪ Whether data are regularly updated ▪ Whether the time interval from data collection and processing to release meets requirements
2) Usability	1) Credibility	▪ Data come from specialized organizations of a country, field, or industry ▪ Experts or specialists regularly audit and check the correctness of the data content ▪ Data exist in the range of known or acceptable values
3) Reliability	1) Accuracy	▪ Data provided are accurate ▪ Data representation (or value) well reflects the true state of the source information ▪ Information (data) representation will not cause ambiguity
	2) Consistency	▪ After data have been processed, their concepts, value domains, and formats still match as before processing ▪ During a certain time, data remain consistent and verifiable ▪ Data and the data from other data sources are consistent or verifiable
	3) Integrity	▪ Data format is clear and meets the criteria ▪ Data are consistent with structural integrity ▪ Data are consistent with content integrity
	4) Completeness	▪ Whether the deficiency of a component will impact use of the data for data with multi-components ▪ Whether the deficiency of a component will impact data accuracy and integrity
4) Relevance	1) Fitness	▪ The data collected do not completely match the theme, but they expound one aspect ▪ Most datasets retrieved are within the retrieval theme users need ▪ Information theme provides matches with users' retrieval theme
5) Presentation Quality	1) Readability	▪ Data (content, format, etc.) are clear and understandable ▪ It is easy to judge that the data provided meet needs ▪ Data description, classification, and coding content satisfy specification and are easy to understand

Figure 10: Hierarchical data quality Framework [16]

5.3.3.3 Quality Assessment Methodology for Big Data

An appropriate quality assessment method for big data is necessary to draw valid conclusions. In [16], it is proposed an effective data quality assessment process with a dynamic feedback mechanism based on big data's own characteristics, shown in Figure 11.

Determining the goals of data collection is the first step of the whole assessment process. Big data users rationally choose the data to be used according to their strategic objectives or business requirements, such as operations, decision-making, and planning. The data sources, types, volume, quality requirements,

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assessment criteria, and specifications as well as the expected goals need to be determined in advance. In different business environments, the selection of data quality elements will differ.

In order to perform better quality assessment, we need to choose specific assessment indicators for every dimension. These require the data to comply with specific conditions or features. The formulation of assessment indicators also depends on the actual business environment.

Each quality dimension needs different measurement tools, techniques, and processes, which leads to differences in assessment times, costs, and human resources. In a clear understanding of the work required to assess each dimension, choosing those dimensions that meet the needs can well define a project's scope. The preliminary assessment results of data quality dimensions determine the baseline while the remaining assessment as a part of the business process is used for continuous detection and information improvement.

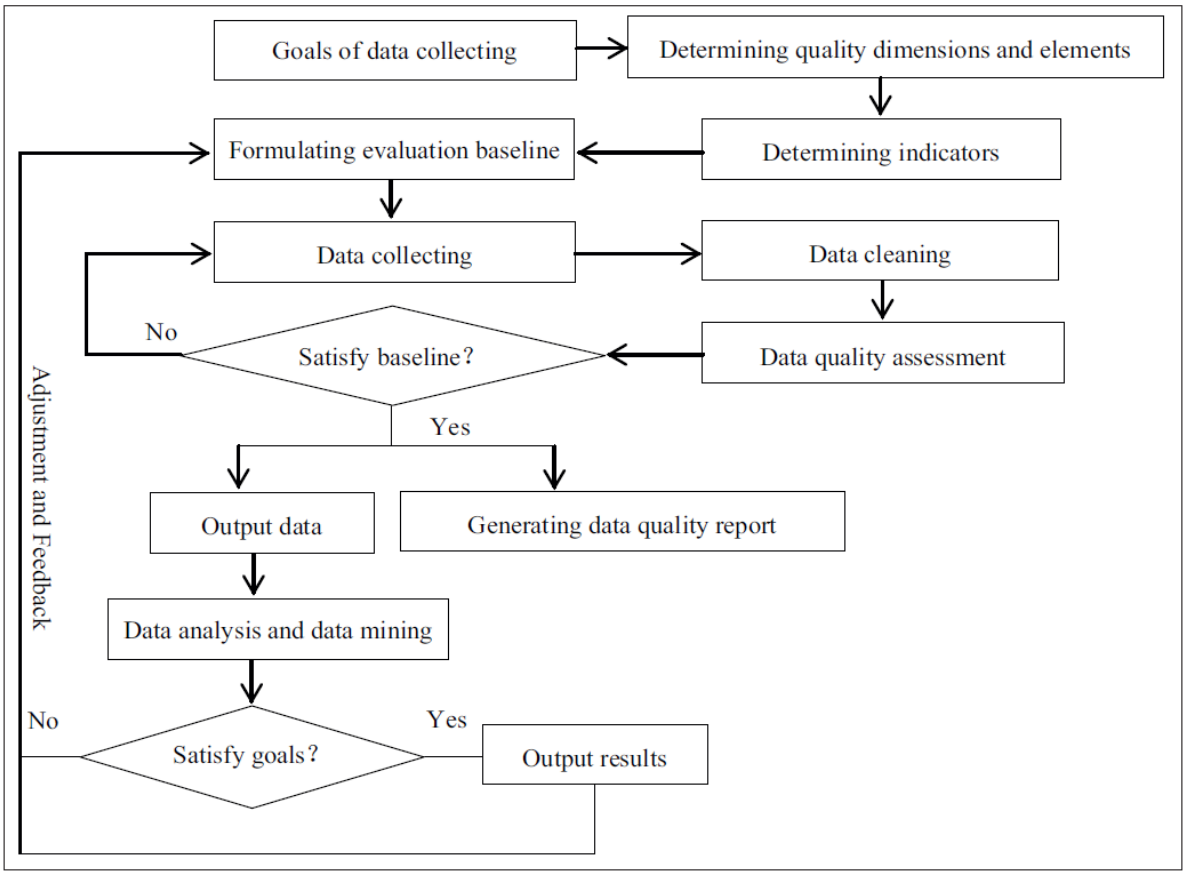

Figure 11: Data quality assessment process based on big data's own characteristics [16]

In the age of big data, data acquisition is relatively easy, but much of the data collected is not always good. We need to improve data quality as far as possible under these conditions without a large increase in acquisition cost.

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Big data sources are very wide and data structures are complex. The data received may have quality problems, such as data errors, missing information, inconsistencies, noise, etc. The purpose of data cleaning (data scrubbing) is to detect and remove errors and inconsistencies from data in order to improve their quality. Data cleaning can be divided into four patterns based on implementation methods and scopes[17]:

- Manual implementation
- Writing of special application programs
- Data cleaning unrelated to specific application fields
- Solving the problem of a type of specific application domain

In these four approaches, the third has good practical value and can be applied successfully. Then, the process enters the data quality assessment and monitoring phases. The core of data quality assessment is how to evaluate each dimension. The current method has two categories: qualitative and quantitative methods. The qualitative evaluation method is based on certain evaluation criteria and requirements, according to assessment purposes and user demands, from the perspective of qualitative analysis to describe and assess data resources. Subject experts or professionals should perform qualitative analysis. The quantitative method is a formal, objective, and systematic process in which numerical data are utilized to obtain information. Therefore, objectivity, generalizability, and numbers are features often associated with this method, whose evaluation results are more intuitive and concrete.

After assessment, the data can be compared with the baseline for the data quality assessment established above. If the data quality accords with the baseline standard, a follow-up data analysis phase can be entered, and a data quality report will be generated. Otherwise, if the data quality fails to satisfy the baseline standard, it is necessary to acquire new data.

5.4 OneNet Data Quality Framework

The analysis reported so far suggests a “one size fits all” set of metrics is not a solution. Rather, assessing data quality is an ongoing effort that requires awareness of the fundamental principles underlying the development of subjective and objective data quality metrics. For this reason, a specific methodology for defining the data quality assessment was set: the OneNet Data Quality Framework.

5.4.1 Data Quality Management: 5-steps approach

Data Quality Management is not only about data quality assessment. It also includes other processes and activities necessary or after the assessment itself. In particular, the Data Quality Management process could be described as a 5-step approach. Figure 12 shows the 5-steps approach which includes preliminary activities and part of the assessment to be conducted in WP5 and subsequent activities in the WP6. In the context of the

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OneNet project, not all these steps are included in the T5.3 activities, which mainly focuses on the data quality assessment and on the definition of the data quality requirements, but it is important to give a complete overview of the entire process and where these activities are foreseen here.

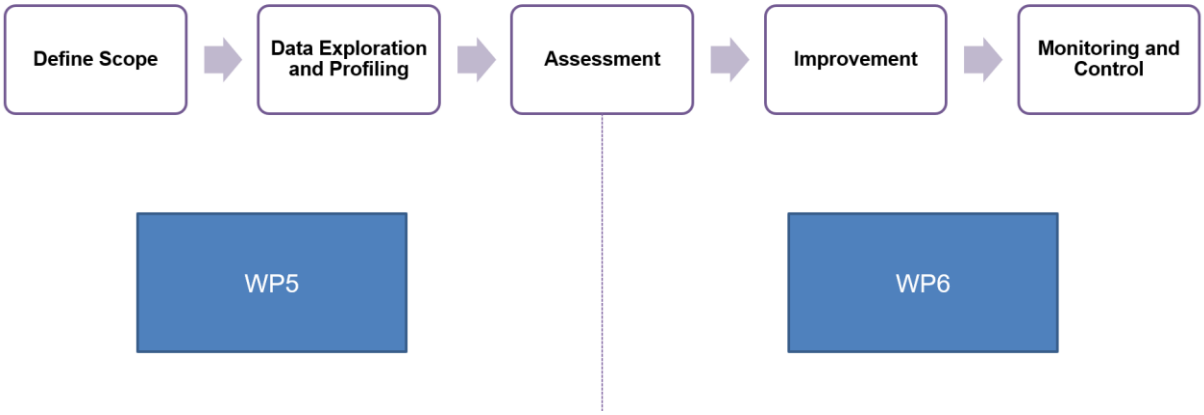

Figure 12: Data Quality Management - 5 Steps approach

More in detail, the 5-steps approach includes:

1. Definition of the Scope
2. Data Exploration and Profiling
3. Data quality assessment
4. Data quality improvement
5. Monitoring and control

Definition of the Scope

Defining the scope for the data quality assessment process consists of finding the context and the domain of the data to be used, making a clear definition of the scope of work. Part of this process is to give a high-level description of the relevant datasets, their criticality related to intended use, the data origin, and the path and steps that the data has been following.

In OneNet context, this process was performed defining the list of cross-platform services to be integrated and addressed in the OneNet system, identifying the actors involved (data sources and data providers) and the data exchanged based on the services categorisation.

Data Exploration and Profiling

Starting from the scope definition, a list of datasets must be identified. Technical users and domain experts should be involved in the identification of these datasets and in the profiling activities. Data quality requirements should focus on those criteria that are relevant for the intended use and be based on schema, metadata, domain

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models, business rules, any relevant policies or governance documents, algorithm requirements, data origins, and life cycles, etc.

In OneNet context, this process was performed in collaboration between task T5.3 and T5.6. This activity brought to the identification of standard Business Objects exchanged in the cross-platform services and for each of these the standard data formats and models to be adopted in the OneNet System. The list of Business Objects will be provided in D5.6.

Data quality assessment

The data quality assessment process is the core of the data quality management process, and it was already described in detail in the previous sections. The scope of this document covers only a part of the data quality assessment: the definition of the data quality dimensions for OneNet and the mapping with the Business Objects identified in the previous step. The result of this activity is described in the section 5.5.

The list of Data Quality Requirements reported does not include information on the specific data exchanged in the different platforms that will be integrated in the OneNet System and evaluated during the demo execution, since at the time this document is drafted, this information has not yet been detailed. A more detailed list of Data Quality Requirements will be provided and enhanced in further activities within this task.

Data quality improvement

Data Quality improvement involves characterizing the value gap attributable to variance in meeting data quality expectations. This process includes two important activities:

- Measuring data quality
- Reporting and tracking data issues

Monitoring and control

Verify at periodic intervals that the data is consistent with the quality requirements specified in the Assessment Step. Communicate the Data Quality metrics and current status to all stakeholders on a regular basis to ensure that Data Quality discipline is maintained. The last two steps (improvement and control) will be implemented during the testing and execution phase in WP6.

5.5 Data quality requirements of cross-platform services in OneNet System

Below the list of the data quality dimensions identified as relevant for the OneNet scope are reported. It was decided to follow the ISO 25012 standard that comprehensively covers the characteristics of the identified dataset.

Accuracy

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The degree to which data has attributes that correctly represent the true value of the intended attribute of a concept or event in a specific context of use.

It has two main aspects:

- Syntactic Accuracy: Syntactic accuracy is defined as the closeness of the data values to a set of values defined in a domain considered syntactically correct.
- Semantic Accuracy: Semantic accuracy is defined as the closeness of the data values to a set of values defined in a domain considered semantically correct.

Completeness

The degree to which subject data associated with an entity has values for all expected attributes and related entity instances in a specific context of use.

Consistency

The degree to which data has attributes that are free from contradiction and are coherent with other data in a specific context of use. It can be either or both among data regarding one entity and across similar data for comparable entities.

Credibility

The degree to which data has attributes that are regarded as true and believable by users in a specific context of use. Credibility includes the concept of authenticity (the truthfulness of origins, attributions, commitments).

Currentness

The degree to which data has attributes that are of the right age in a specific context of use.

Accessibility

The degree to which data can be accessed in a specific context of use, particularly by people who need supporting technology or a special configuration because of disability.

Compliance

The degree to which data has attributes that adhere to standards, conventions or regulations in force and similar rules relating to data quality in a specific context of use.

Confidentiality

The degree to which data has attributes that ensure that it is only accessible and interpretable by authorized users in a specific context of use. Confidentiality is an aspect of information security (together with availability, integrity) as defined in ISO/IEC 13335-1:2004.

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Efficiency

The degree to which data has attributes that can be processed and provide the expected levels of performance by using the appropriate amounts and types of resources in a specific context of use.

Precision

The degree to which data has attributes that are exact or that provide discrimination in a specific context of use.

Traceability

The degree to which data has attributes that provide an audit trail of access to the data and of any changes made to the data in a specific context of use.

Understandability

The degree to which data has attributes that enable it to be read and interpreted by users, and are expressed in appropriate languages, symbols and units in a specific context of use. Some information about data understand ability are provided by metadata.

Availability

The degree to which data has attributes that enable it to be retrieved by authorized users and/or applications in a specific context of use.

Portability

The degree to which data has attributes that enable it to be installed, replaced or moved from one system to another preserving the existing quality in a specific context of use.

Recoverability

The degree to which data has attributes that enable it to maintain and preserve a specified level of operations and quality, even in the event of failure, in a specific context of use.

In Table 17, the mapping between these data quality dimensions and the Business Objects identified for OneNet cross-platform services is reported. The list of Data Quality Requirements will be the base for the Data Quality assessment, improving and monitoring, performed on any data exchange in the OneNet Connector and Decentralised Middleware. The Data Quality services will be in fact one of the core data services, as described in Section 2.

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Table 17: Data Quality requirements of cross-platform services in OneNet System

OneNet Service ID	Service Category	Business Object	Accuracy	Completeness	Consistency	Credibility	Currentness	Accessibility	Confidentiality	Efficiency	Compliance	Precision	Traceability	Understandability	Availability	Portability	Recoverability
OneNet_01AUTH_0005	Authentication and Authorization	Consent request	X	X					X			X			X		
OneNet_01AUTH_0007		Data rectification request	X	X	X								X				
OneNet_01AUTH_0008		Data deletion request	X	X	X								X				
OneNet_01AUTH_0009		Data usage information logs	X	X		X							X				
OneNet_01AUTH_0003		Delegated representation rights	X	X	X									X			
OneNet_01AUTH_0003		Details about representing party	X	X	X									X			
OneNet_01AUTH_0002		Identity information of data owner or delegated party	X	X					X			X					
OneNet_01AUTH_0002		Identity verification	X	X					X			X					
OneNet_01AUTH_0004		Consent/Refusal to data access	X	X	X									X			
OneNet_01AUTH_0006		Consent/Refusal to data access	X	X	X									X			
OneNet_01AUTH_0001		Authentication information report	X	X					X			X					
OneNet_02MEMO_0001	Measurements and Monitoring	DER Structural Data	X	X	X				X		X				X		
OneNet_02MEMO_0001		DER structural Data	X	X	X				X		X						
OneNet_02MEMO_0001		Flexibility needs (i.e., balancing, congestion)	X	X	X				X		X						
OneNet_02MEMO_0003		Settlement Data	X	X							X				X		
OneNet_02MEMO_0002		Flexible Resource Metering data	X	X		X			X		X			X	X		
OneNet_02MEMO_0002		Meter Data	X	X		X			X		X			X			

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OneNet_02MEMO_0004		Forecast data (load, generation, FSP)	X	X		X			X		X				X		
OneNet_02MEMO_0004		State Estimation Data	X	X		X			X		X						
OneNet_03FORC_0001	Forecasts	Forecast data (load, generation, FSP)	X	X		X			X		X			X	X		
OneNet_03FORC_0001		weather forecast	X	X		X			X		X			X			
OneNet_03FORC_0001		Hydrological forecast	X	X		X			X		X			X			
OneNet_03FORC_0006		Connection state forecast	X	X		X			X		X			X	X		
OneNet_03FORC_0004		Forecasts of icing and storm conditions	X	X		X			X		X			X	X		
OneNet_03FORC_0004		Prediction of maintenance periods	X	X		X			X		X			X			
OneNet_03FORC_0005		Dynamic Line Rating Forecast for overhead lines	X	X		X			X		X				X		
OneNet_03FORC_0002		Baselines reports	X	X	X				X			X		X	X		
OneNet_03FORC_0003		Possible temporary limits on balancing capacity bids according to Art. 182-5 SOGL classified as 1-Partial, 2-Total, or 3-None	X	X		X			X		X				X		
OneNet_04REIN_0001	Reports and Invoices	Activation signal (Resources to be (de-)activated)	X	X	X				X			X		X	X		
OneNet_04REIN_0001		Energy clearing results	X	X	X				X			X		X			
OneNet_04REIN_0003		*(Day ahead and Intra Day)* Market Results	X	X	X				X			X		X	X		
OneNet_04REIN_0002		Settlement Data	X	X	X				X			X		X	X		
OneNet_04REIN_0006		Invoicing data	X	X	X				X			X		X	X		
OneNet_04REIN_0004		Settlement Data	X	X	X				X			X		X	X		
OneNet_04REIN_0005		Verification process results	X	X	X				X			X		X	X		

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OneNet_05MRKT_0008	Market	Flexibility needs (i.e., balancing, congestion)	X	X	X				X			X		X	X		
OneNet_05MRKT_0010		Energy clearing results	X	X	X				X			X		X			
OneNet_05MRKT_0010		Flexibility needs (i.e., balancing, congestion)	X	X	X				X			X		X	X		
OneNet_05MRKT_0007		Energy clearing results	X	X		X			X		X			X	X		
OneNet_05MRKT_0006		Resource optimization information	X	X					X					X	X		
OneNet_05MRKT_0011		Energy clearing results	X	X	X				X					X	X		
OneNet_05MRKT_0004		Energy clearing results	X	X					X					X	X		
OneNet_05MRKT_0002		Energy clearing results	X	X	X				X					X	X		
OneNet_05MRKT_0003		limits and margins for capacity (by zone)	X	X					X					X	X		
OneNet_06GRMO_0001	Grid Models	network data of transmission system/TSO network information (on specific period and substation aggregate short circuit power-Scc and phase angle-degree)	X	X					X					X	X		
OneNet_06GRMO_0001		Network reconfiguration data	X	X					X						X		
OneNet_06GRMO_0001		Short-Circuit power forecast.	X	X					X						X		
OneNet_06GRMO_0003		Development plans for distribution network	X	X					X			X		X	X		
OneNet_06GRMO_0003		Forecast data (load, generation, FSP)	X	X					X						X		
OneNet_06GRMO_0003		network data of distribution system	X	X					X						X		
OneNet_06GRMO_0003		network data of distribution system/distribution network mode	X	X					X						X		
OneNet_06GRMO_0003		Network demand forecast	X	X					X						X		

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OneNet_06GRMO_0003		Solutions to avoid outage plans incompatibilities	X	X					X					X		
OneNet_06GRMO_0002		Development plans for transmission network	X	X					X			X		X	X	
OneNet_06GRMO_0002		network data of transmission system	X	X					X						X	
OneNet_06GRMO_0002		Transmission network outage plan	X	X					X						X	
OneNet_06GRMO_0004		Network characteristics (internal) information	X	X					X			X		X	X	
OneNet_06GRMO_0004		Network characteristics (internal) information using node-breaker representation	X	X											X	
OneNet_06GRMO_0004		network data of transmission system	X	X											X	
OneNet_06GRMO_0004		Network information	X	X											X	
OneNet_06GRMO_0005		Network characteristics (internal) information	X	X					X			X		X	X	
OneNet_06GRMO_0005		Network characteristics (internal) information using node-breaker representation	X	X											X	
OneNet_06GRMO_0005		network data of distribution system	X	X											X	
OneNet_06GRMO_0005		Network information	X	X											X	
OneNet_07SIRE_0002	Simulation Results	Forecast data (load, generation, FSP)	X	X					X						X	
OneNet_07SIRE_0002		Grid congestions status	X	X											X	
OneNet_07SIRE_0002		Grid constraints Assessment	X	X											X	
OneNet_07SIRE_0001		Power flow simulation	X	X					X						X	
OneNet_08REQU_0002	Pre-Qualification	(Flexibility) Resources	X	X		X			X						X	

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OneNet_09SSAC_0002	Service Activation	Activation signal correction/ counter action (tender reduction)	X	X					X				X	X	X		
OneNet_09SSAC_0001		Activation signal (Resources to be (de-)activated)	X	X					X				X		X		
OneNet_10RECO_0002	Resource Control	Execution order	X	X					X	X		X	X		X		
OneNet_10RECO_0001		(Flexibility) Resources	X	X					X	X		X	X		X		
OneNet_10RECO_0001		(Flexibility) Resources	X	X											X		
OneNet_10RECO_0003		system parameter control schema/ instructions	X	X					X	X		X	X		X		

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6 Summary and Outlook

The main contribution of this document is the identification of cross-platform services that are to be supported in the OneNet System. We have analysed the Business and System Use Cases of several Horizon 2020 projects and the OneNet Demo Clusters to compile a list of currently 58 cross-platform services divided in the following 10 categories.

1. Authentication and Authorization (12 services)
2. Measurements and Monitoring (5 services)
3. Forecasts (6 services)
4. Reports and Invoices (4 services)
5. (Flexibility) Market Participation (12 services)
6. Grid Models (5 services)
7. Simulation Results (3 services)
8. Resource (Pre-) Qualification (6 services)
9. System Service Activation (2 services)
10. Resource Control (3 services)

During this process, we have considered the requirements of the System Use Cases of the OneNet Demo Clusters as much as they are defined and available in D5.1 [27]. Furthermore, we have identified and harmonized the security requirements per service category to align with D5.8 [29]. The components of the OneNet Reference Architecture defined in D5.2 [28] are placed into the context of the identified cross-platform services and their functions and interplay are explained. We have harmonized the roles for the cross-platform services as much as possible with the Harmonized Electricity Market Role Model of ebIX, EFET and ENTSO-E and the new roles suggested by the BRIDGE Regulation Working Group as well as report the roles for which a mapping was not possible at this stage of work. The functional specifications of the OneNet cross-platform services are provided along with a unique identifier, name, list of exchange methods, description, data sender/ producer, and data receiver/ consumer per cross-platform service.

The second big topic of this document is data quality assessment. We report on standards, frameworks and tools for data quality assessment and identify the data quality requirements of the OneNet cross-platform services. This work is the foundation for the implementation of a data quality checking service in the OneNet Connector - the decentralized connectivity enabler in the OneNet System.

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In summary, this deliverable provides the foundation for the technical specification of OneNet interfaces in other tasks of WP5. Furthermore, it will support the implementation process in WP6. In the future until the end of this task, we will monitor the evolution of the OneNet Demo Clusters and - if needed - update the list of cross-platform services and related analyses in this document with additional or new aspects and requirements.

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8 Appendix

Hint: Yellow rows in Table 18 contain actors for which no clear mapping to a HEMRM or BRIDGE role could be made yet. These rows will be reconsidered in an updated version of this deliverable.

Table 18: List of Harmonised Roles

Associated actors (Roles) (T5.3)	Acronym (if any)	Role Model Equivalent (HEMRM and BRIDGE - B)
Energy Manager		
Renewable Energy Community	REC	
Retailer		
Optimisation Operator	OO	
Service Provider		
Significant Grid Users	SGU	
Transmission System Operator (Wide Area Monitoring Protection And Control)	TSO (WAMPAC)	
TSO Ancillary Services market	TSO AS market	
Aggregator		Resource Aggregator
Aggregator (SCADA)		Resource Aggregator
ATC calculator (TSO and RSC)		System Operator
Authentication Service Provider		Authentication Service Provider (B)
balance responsible party	BRP	Balance Responsible Party
Balancing mechanism operator (TSO)		System Operator
CGM manager (RSC)		System Operator
Consent Administrator		Consent Administrator
Consumer		Consumer
Coordinationet Platform		DEP Operator (B)
Coordinet platform		DEP Operator (B)
Customer		Consumer
Customer Portal		Customer Portal Operator (B)
DACF operator (TSO and corresponding expert in DSO)	Day Ahead Congestion Forecast operator	System Operator
Data Delegated Third Party		Data Delegated Third Party (B)
Data Exchange Platform		DEP Operator (B)
Data Exchange Platform (Coordinet)		DEP Operator (B)
Data Hub		Data Hub Operator (B)
Data Hub (for grid data)		Data Hub Operator (B)
Data Hub (for market data)		Data Hub Operator (B)
Data Hub (Metered Data Administrator)		Data Hub Operator (B)
Data Owner		Data Owner (B)
Data Source		Data Provider (B)

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Distributed Energy Resources	DER	Resource
Distributed Energy Resources Operator	DER Operator	Definition Not Found
Distributed Renewable Energy Sources	DRES	Resource
Distribution System Operator	DSO	System Operator
Distribution System Operator/Microgrid operator	DSO/ Microgrid operator	System Operator
Energy Service Provider		Energy Supplier
Energy Supplier		Energy Supplier
Flexibility Operator	FO	Resource Aggregator
Flexibility Operator (VPP)		Resource Aggregator
Flexibility Platform		Market Operator
Flexibility Platform Operator	FPO	Flexibility Register Operator (B)
Flexibility register	FR	Flexibility Register Operator (B)
Flexibility Register Operator	FRO	Flexibility Register Operator (B)
Flexibility Resource		Flexibility Services Provider (B)
Flexibility Service Provider	FSP	Flexibility Services Provider (B)
Frequency Restoration Reserve Providers	FRR Providers	Balancing Service Provider
Grid market hub		System Operator
Home Energy Management System	HEMS	DEP Operator (B)
Individual Grid Model manager	IGM manager (TSO and corresponding expert in DSO)	System Operator
Industrial Customer		Consumer
Integrated pan-European Grid Services Architecture	IEGSA	DEP Operator (B)
Intra Day TSO AS Market		Market Operator
Load Forecasting operator (DSO/Microgrid operator);		System Operator
Load Forecasting operator (TSO/Aggregator)		System Operator
Local Coordinet platform		DEP Operator (B)
Losses calculator (TSO)		System Operator
Maintenance and asset management operator (TSO/DSO)		System Operator
Market Operator		Market Operator
Market platform		Market Operator
Marketplace		Market Operator
Meter Operator		Meter Operator
Metered Data Operator		Meter Operator
Outage scheduler (TSO/DSO)		System Operator
PEM		Resource Provider
Power system control expert (TSO/DSO)		System Operator
Production and Load Forecasting/Scheduling operator (Aggregator)		Balancing Service Provider/Resource Aggregator
Production Forecasting operator (DSO/Microgrid operator)		System Operator
Production Forecasting operator (DSO/Microgrid operator);		System Operator

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Production Forecasting operator (TSO/DSO)		System Operator
Production Forecasting/Scheduling operator (Regional RES coordinator)		Scheduling Agent
Production scheduling operator (market operator)		Market Operator
Prosumer		Party Connected to the Grid
Regional 2DACF operator (RSC)		System Operator
Regional DACF operator (RSC)		System Operator
Regional Operation Centre	ROC	System Operator
Renewable Energy Sources	RES	Resource Provider
Renewable Energy Sources Manager	RES manager	Resource
Renewable Energy Sources Scheduling operator (TSO based)	RES Scheduling operator (TSO based)	Resource Provider
Scheduling Coordinator		Scheduling Agent
System Operator	SO	System Operator
System Operator (SCADA)	SO (SCADA)	System Operator
T&D CP		DEP
Third Party Application		Consent Administrator
Transmission System Operator	TSO	System Operator
TSO or DSO		System Operator
TSO/DSO		System Operator
Two-Days Days Ahead Congestion Forecast operator	2DACF operator (TSO and corresponding expert in DSO)	System Operator
Under-Frequency Reserve provider	UFR provider	Balancing Service Provider/Resource Aggregator
weather data provider		Data Provider (B)
Weather Forecast Information Provider		Data Provider (B)
Weather forecast provider		Data Provider (B)

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