European (energy) data exchange reference architecture 3.0

Ignacio Abad, Jose; Lambert, Eric; Bak-Jensen, Birgitte; Lampathaki, Fenareti; Bosco, Ferdinando; Maqueda, Erik; Coelho, Fabio; Papadopoulos,, Giorgos; Dognini, Alberto; Piotrowski, Krzysztof; Farré, Marjolaine; Radziszewska, Weronika; Gonzalez, Javier Ferreira; Sebilleau, Dune; Genest, Oliver; Siksnys, Deividas; Kokos, Isidoros; Tosic, Milenko; Korjus, Greete; Yang, Guangya

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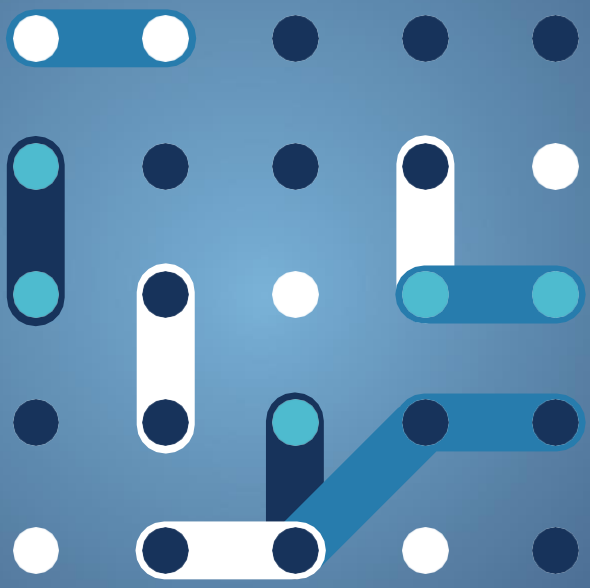
Data Management Working Group



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AUTHORS

J Mário Couto, EPRI
Konstantinos Kotsalos, European Dynamics SA
Kalle Kukk, Elering
Antonello Monti, RWTH Aachen University and Fraunhofer FIT
Javier Valiño, Atos

CONTRIBUTORS

Jose Ignacio Abad, CIRCE
Birgitte Bak-Jensen, Aalborg University
Ferdinando Bosco, Engineering
Fábio Coelho, INESC TEC
Alberto Dognini, Fraunhofer FIT
Marjolaine Farré, Trialog
Javier Ferreira Gonzalez, Saxion University of Applied Science
Olivier Genest, Trialog
Isidoros Kokos, Intracom Telecom
Greete Korjus, Elektrilevi
Eric Lambert, EDF
Fenareti Lampathaki, Suite5
Erik Maqueda, Tecnalia
Giorgos Papadopoulos, Suite5
Krzysztof Piotrowski, IHP
Weronika Radziszewska, IMP Pan Gdansk
Dune Sebilleau, Trialog
Deividas Siksnys, Litgrid
Milenko Tosic, VizLore Labs
Guangya Yang, Technical University of Denmark

SUPPORT FROM THE BRIDGE SECRETARIAT

Savvas Symeonidis, ICCS (NTUA), BRIDGE Secretariat
Martin Bracken, CLERENS, BRIDGE Secretariat
Niclette Kampata, ZABALA, BRIDGE Secretariat
Agnieszka Gierej, ZABALA, BRIDGE Secretariat
Marcos Jareño, ZABALA, BRIDGE Secretariat

BRIDGE WG/TF CHAIRMANSHIP

Olivier Genest – *Chair*

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Contact: Mugurel-George Păunescu (DG ENER), Mariana Stantcheva (CINEA)
E-mail: Mugurel-George.PAUNESCU@ec.europa.eu, Mariana.STANTCHEVA@ec.europa.eu;
European Commission
B-1049 Brussels

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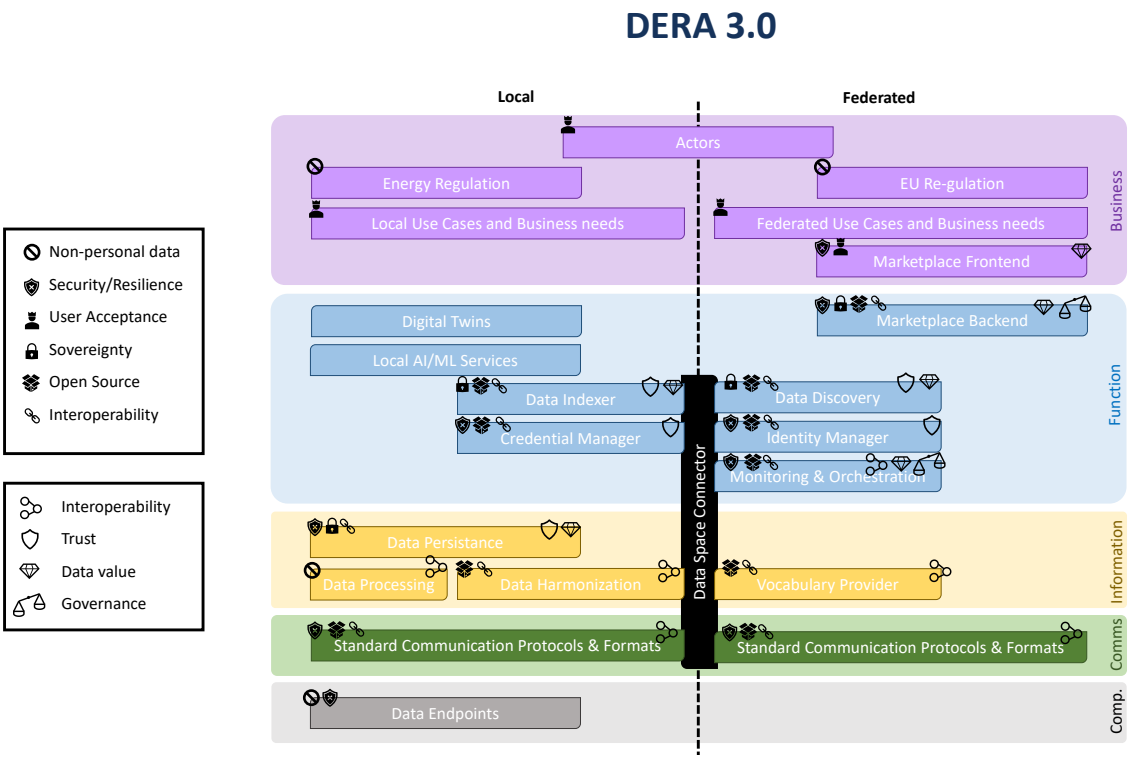
List of Acronyms and Abbreviations

AI	Artificial Intelligence
AIOTI	Alliance for Internet of Things Innovation
AMQP	Advance Message Queuing Protocol
API	Application Programming Interface
BDVA	Big Data Value Association
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CGMES	Common Grid Model Exchange Specification
CIM	Common Information Model
CM	Congestion Management
CPS	Cross-Platform Services
CSV	Comma-Separated Values file
DEP	Data Exchange Platform
DERA	Data Exchange Reference Architecture
DESAP	Digitalising the Energy System - EU Action Plan
DSO	Distribution System Operator
EC	European Commission
ECCo SP	ENTSO-E Communication & Connectivity Service Platform
EG	Expert Group
eIDAS	EU regulation on electronic IDentification, Authentication and trust Services
ENTSO-E	European Network of Transmission System Operators for Electricity
ESMP	European Style Market Profile
ESO	European Standardisation Organisation
ETIP-SNET	European Technology & Innovation Platform - Smart Networks for Energy Transition
ETSI	European Telecommunications Standards Institute
EU	European Union
FAIR	Findability, Accessibility, Interoperability and Reusability
FTP	File Transfer Protocol
GDPR	General Data Protection Regulation
GUI	Graphical User Interface
HDFS	Hadoop Distributed File System
HEMRM	Harmonised Electricity Market Role Model
HERM	Harmonised Energy Role Model
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IaaS	Infrastructure as a Service
ICT	Information and Communications Technology
IDS	International Data Space
IDSA	International Data Spaces Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEGSA	Interoperable pan-European Grid Services Architecture
ISGAN	International Smart Grid Action Network
ISO	International Organisation for Standardisation
IT	Information Technology
JPEG	Joint Photographic Experts Group
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
ML	Machine Learning
MOL	Merit Order List
MQTT	Message Queuing Telemetry Transport

NGSI	Next Generation Service Interfaces
NIS	EU directive on security of Network and Information Systems
OEO	Open Energy Ontology
OPC	Open Platform Communications
PNG	Portable Graphics Format
R&D	Research & Development
RAM	Reference Architecture Model
RAMI	Reference Architecture Model Industrie
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
RDGM	Reference Data Governance Model
REST	REpresentational State Transfer
SaaS	Software as a Service
SAREF	Smart Appliances REFerence ontology
SCADA	Supervisory Control and Data Acquisition
SGAM	Smart Grid Architecture Model
SGTF	European Smart Grids Task Force
SOAP	Simple Object Access Protocol
TCP	Transmission Control Protocol
TSO	Transmission System Operator
UML	Unified Modelling Language
WG	Working Group
XLSX	Microsoft Excel Open XML Spreadsheet
XML	Extensible Markup Language
XMPP	Extensible Messaging and Presence Protocol
XSD	XML Schema Definition

Executive Summary

This is the third version of **D**ata **E**xchange **R**eference **A**rchitecture – DERA 3.0. BRIDGE report on energy data exchange reference architecture aims at contributing to the discussion and practical steps towards truly interoperable and business process agnostic data exchange arrangements on European scale both inside energy domain and across different domains.



Recommendations related to the implementation of DERA:

A. Leverage Smart Grid Architecture Model (SGAM) usage by completing it with data governance requirements, specifically from end-customer perspective, and map it to the reference architectures of other sectors (similar to the RAMI4.0 for industry – Reference Architecture Model Industrie 4.0; and CREATE-IoT 3D RAM for health – Reference Architecture Model of CREATE-IoT project), incl. for basic interoperability vocabulary with non-energy sectors.

B. Facilitate European strategy, regulation (harmonisation of national regulations) and practical tools for cross-sector exchange of any type of both private data and public data, e.g. through reference models for data space, common data governance and data interoperability implementing acts.

C. Ensure cooperation between appropriate associations, countries and sector representatives to work on cross-sector and cross-border data management by establishing European data cooperation agency. This involves ongoing empowering/restructuring of the Data Management WG of the BRIDGE Initiative to engage other sectors and extend cooperation with projects that are not EU-funded and with European Standardisation Organisations (CEN-CENELEC-ETSI).

D. Harmonise the development, content and accessibility of data exchange business use cases for cross-sector domain through BRIDGE use case repository. Track tools that identify common features on use cases, e.g. interfaces between sectors, and enable the alignment with any potential peer repositories for other domains. Also, the use case repository must rely on the HEMRM with additional roles created by some projects or roles coming from other associations (related to another sector than the electricity/energy sector).

E. Use BRIDGE use case repository for aligning the role selection. Harmonise data roles across electricity and other energy domains by developing HERM – Harmonised Energy Role Model and ensure access to model files. Look for consistency with other domains outside energy based on this HERM – cross-sectoral roles. Harmonised Energy

Role Model shall have clear implications and connections with data (space) roles such as data provider/consumer, service provider etc.

F. Define and harmonise functional data processes for cross-sector domain, using common vocabulary, template and repository for respective use cases' descriptions. Harmonisation of functional data processes for cross-sector data ecosystems including Vocabulary provider, Federated catalogue, Data quality, Data accounting processes, Clearing process (audit, logging, etc.) and Data tracking and provenance.

G. Define and maintain a common reference semantic data model, and ensure access to its model files facilitating cross-sector data exchange, by leveraging existing data models like Common Information Model (CIM) of International Electrotechnical Commission (IEC) and ontologies like Smart Appliances Reference Ontology (SAREF).

H. Develop cross-sector data models and profiles, with specific focus on private data exchange. Enable open access to model files whenever possible.

I. Ensure protocol agnostic approach to cross-sector data exchange by selecting standardised and open ones.

J. Ensure data format agnostic approach to cross-sector data exchange. The work done by projects like TDX-ASSIST and EU-SysFlex (using IEC CIM), and PLATOON (using SAREF) must be shared and made known to consolidate the approach in order to reach semantic interoperability. Metadata must also be taken into account.

K. Promote business process agnostic DEPs (Data Exchange Platforms) and make these interoperable by developing APIs (Application Programming Interfaces) which enable for data providers and data users easy connection to any European DEP but also create the possibility whereby connecting to one DEP ensures data exchange with any other stakeholder in Europe. DEPs shall explore the integration of data space connectors towards their connectivity with other DEPs including cross-sector ones.

L. Develop universal data applications which can serve any domain. Develop open data driven services that promote also cross-sector integration collectively available in application repositories.

Possible next steps ("sub-actions") for 2023/2024:

- Release BRIDGE Federated Service Catalogue tool and associated process.
- Release DERA interactive visualisation tool.
- Follow up the implementation of DERA 3.0 in BRIDGE projects (mapping to DERA)
- Update recommendations to comply with DERA 3.0.
- Develop / enhance the "data role model".

1. Introduction

The Data Management Working Group (WG) aims to cover a wide range of aspects ranging from the technical means for exchanging and processing data between interested stakeholders to the definition of rules for exchange, including security issues and responsibility distribution in data handling. Accordingly, the WG has identified 3 areas of collaboration around which mutual exchange of views and discussions have been set:

- **Communication Infrastructure**, embracing the technical and non-technical aspects of the communication infrastructure needed to exchange data and the related requirements;
- **Cybersecurity and Data Privacy**, entailing data integrity, customer privacy and protection;
- **Data Handling**, including the framework for data exchange and related roles and responsibilities, together with the technical issues supporting the exchange of data in a secure and interoperable manner, and the data analytics techniques for data processing.

BRIDGE Data Management WG is continuously willing to contribute to the ongoing activities of European Commission (EC) to deliver 'data interoperability implementing acts' as mandated in articles 23 and 24 of electricity market directive [2019/944] [1] and Common Energy Data Space as foreseen in DESAP (Digitalising the Energy System - EU Action Plan) [2].

The objective of this report is to continue working on issues related to organising energy data exchanges on European level. The first version of EU data exchange reference architecture was defined in BRIDGE Data Management WG report in 2021 [3] and the second version in the report of 2022 [4]. The latter is presented in Figure 1.

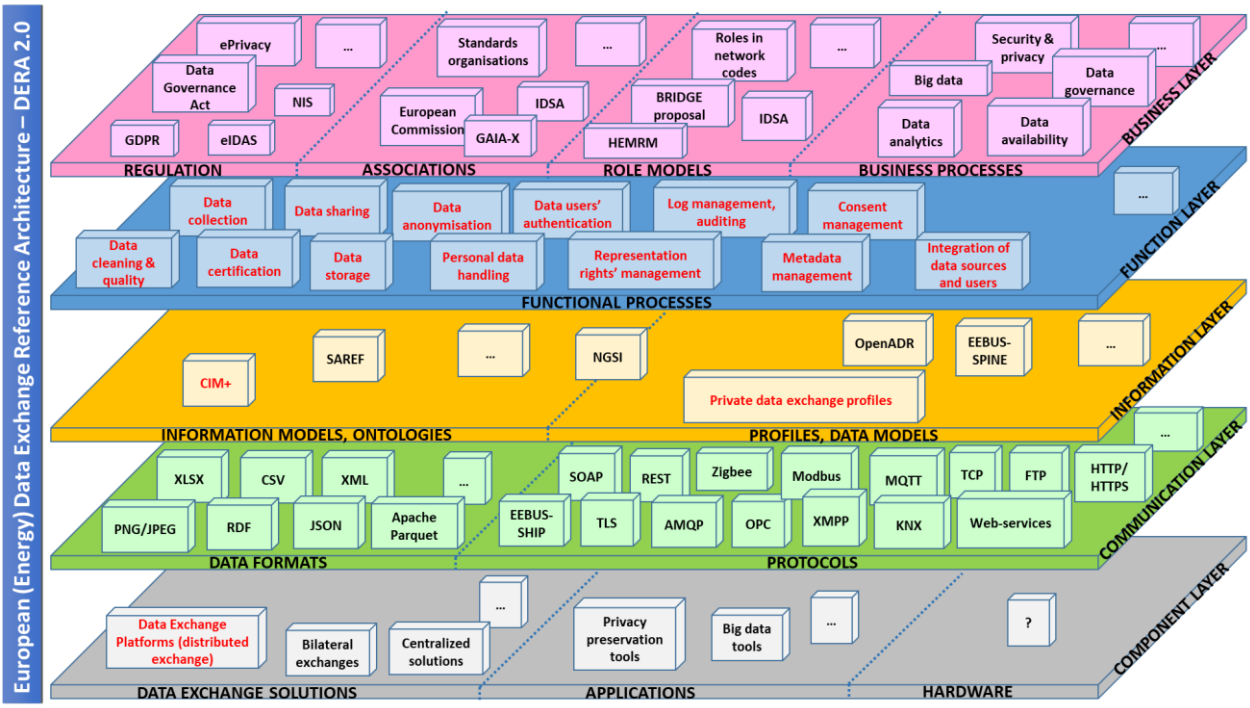


Figure 1. Second version of European energy data exchange reference architecture [4]

In 2022 General Assembly it was concluded that while the reference architecture is quite mature (though probably can never be "ready") its practical usability should be considered. Also, it was recognised that DERA is a useful building block of the Data Space and should be therefore considered in DESAP.

Link with other BRIDGE activities related to use case repository, smart energy standards user group and asset interoperability framework is required. The methodology for describing Generic Business Processes and the repository for storing use cases can be leveraged by using the same approach for other electricity sector (i.e. not only flexibility market processes related) data exchanges as well as for cross-sector data exchanges.

General Assembly identified possible activities related to data exchange reference architecture for 2022/2023:

1. Continue pilot implementation of the reference architecture, including the steps like:
   a. Mapping to SGAM (e.g. using SGAM Toolbox);
   b. Data modelling, profiling;
   c. Implementation/development.
2. For improved visualisation model the reference architecture, e.g. by applying Unified Modelling Language (UML).
3. Follow the implementation of individual recommendations related to reference architecture.
4. Add data governance layer to the reference architecture.
5. Engage closely new projects funded through Horizon Europe call on Energy Data Spaces.
6. Contribute to Digitalisation of Energy Action Plan:
   a. On strategic level – ensure the inclusion of cross-sector perspective, interoperability of sectorial data spaces and governance aspects;
   b. On operational level – benefit from BRIDGE data exchange reference architecture.

This report is based on the contributions of five sub-actions:

1. Pilot implementation of the reference architecture
2. Visualisation and usability of the reference architecture
3. Implementation of individual recommendations related to reference architecture
4. Data governance layer of the reference architecture
5. Improvements to reference architecture, incl. its contribution to DESAP

In Chapter 5, sub-action 1 discusses the pilot implementation of the reference architecture, detailing the BRIDGE federated catalogue implementation as well as the use case story of a cross-project linkage implementation.

Sub-action 2, included in Chapter 2, deals with the visualisation and usability of the reference architecture. The team has identified that a similar work has been performed in GAIA-X and main idea is to take a very similar approach. In a nutshell the visualisation will be performed by implementing a web-based dashboard. Technical implementation details have been already agreed and now that DERA 3.0 is available, the online dashboard will be shortly implemented. A couple of reference use cases will be used to test the approach and to provide users with guidelines.

Sub-action 3 aimed to track how the projects from Horizon programmes follow the recommendations formulated in the scope of the DERA 2.0. For that purpose, a survey was created and disseminated throughout the projects of Horizon 2020 and Horizon Europe. The questions for the survey were created according to the DERA 2.0 recommendations for each layer of the SGAM: business layer (regulation, cooperation, processes and data roles), function layer, information layer (canonical data model, data models and profiles), communication layer (protocols, data formats) and component layer (data exchange platforms and data applications). In addition, the survey also asked the participants to provide recommendations and identify gaps in the recommendations of DERA 2.0. The survey involved 16 projects from Horizon 2020 and Horizon Europe. Based on the feedback provided by the projects, an upgraded version of the recommendations is presented in Chapter 4 towards implementing the DERA 3.0.

Sub-action 4 focuses on data governance in Chapter 3, proposing to add the governance layer to DERA. It starts with summarising the data governance elements and requirements, originally developed in OneNet project, but now put into the context of DERA. A survey was conducted also for this sub-action in which Data Management WG members were asked to assess per each governance requirement the relevance, feasibility and actual implementation in their projects.

Sub-action 5 elaborates the new version of reference architecture – DERA 3.0. This being the major deliverable of this report, Chapter 2 right after the introduction describes the architecture and explains all the interoperability layers of it.

Finally, Chapter 6 outlines possible next steps.

2. DERA 3.0

2.1 Description of reference architecture

BRIDGE data management working group members active in Action #2, Data Exchange Reference Architecture (DERA) agreed to iterate the previous 2.0 version and, therefore, generate the new 3.0 version based on the following objectives:

- The previous version of BRIDGE DERA (v. 2.0) presented a higher granularity and generality per layer. An effort to **aggregate and simplify** the modules, grouping them in terms of similar approach/objective/functionalities, have been done. As a result, fewer and more high-level modules will be presented in DERA 3.0.
- DERA 1.0 originated from the initial traction of BRIDGE DSO-TSO collaboration project identifying a set of vital function to address cross-sector data exchanges and in turn cross-sector coupling, providing specific recommendations to enhance the transversal interoperability in the energy domains. There, the data value and, generally, data exchanges based on interoperable Data Exchange Platforms was identified. This iterated in DERA 2.0 to introduce even more sector-agnostic approach, but still keeping much emphasis on including energy specific modules as starting point. Meanwhile, the **Data Space concept** arose in the research landscape, with very relevant associations and industry clusters pushing for it also from the ICT sector (such as Gaia-X [5], IDSA [6], DBSA [7] etc.). These initiatives are providing new reference architectures, framework, roles. DERA 3.0 will try to match also these new inputs, while keeping the essence of energy-related requirements as described in DERA 1.0 and 2.0.
- Additionally, the European Commission also published the **Digitalising the energy system - EU action plan** [4] (DESAP) in October 2022. This Action Plan includes several sections, namely “Fostering the exchange of energy data”, “Increasing investments”, “Empowering citizens”, “Cybersecurity and resilience”, “Energy consumption of the ICT sector” and “An EU-wide coordinated approach”. The first one (“Fostering the exchange of energy data”) is especially relevant for this analysis. DERA 3.0 will also provide the link towards DESAP, by identifying reference modules to deliver requirements presented by the European Commission in this DESAP. The requirements listed in the document are the following:
    - **Non-personal data**. Availability of non-personal/anonymised energy data (including protection, confidentiality and sovereignty requirements)
    - **Security/Resilience.** Cybersecurity and data protection
    - **User Acceptance.** Reach consumer acceptance and empowerment
    - **Sovereignty.** EU data sovereignty principles:
        - Data to flow within EU across sectors.
        - Access/es fair, practical and clear.
        - Trustworthy data governance.
        - Open approach to international data flows, based on EU values.
        - Data shared focused and containing essential elements for services.
        - Non-essential data stored and processed locally
    - **Open Source.** Open-source solutions, open standards and data models. APIs
    - **Interoperability.** Interoperable cross-sectoral solutions

In the following sections, the new DERA 3.0 is presented. As in DERA 1.0 and DERA 2.0, the approach of clustering modules based on SGAM [8] interoperability layers are maintained. Each layer is presented, with individual modules’ description based on the following template:

- **Module description**. Why is it placed in the layer and what are the objectives.
- **Aggregation reasoning**. The new modules are grouping legacy modules from DERA 1.0 and 2.0. Here is where the motivation for grouping those modules together is provided.

- **Link with DESAP** [2]. Each of the new modules should identify the relevance with respect to DESAP requirements for data sharing. For those identified, a description regarding how the usage of appropriate technologies there can contribute to achieving the DESAP requirement is provided.
- **Link with OpenDEI Data Space building blocks** [9]. In order to leverage the work done in previous with Data Space related H2020 projects, it would be also very beneficial for DERA 3.0 to align with these building blocks, as ideally the new architecture should include them all.

Last but not least, it is important to stress the DERA 3.0 (in line with what was included also in DERA 1.0) differentiates between Local platforms and Federated Data Space stacks. They are both connected through a piece of software named **Data Space Connector**, allowing the interconnection and data exchange.

A Data Space Connector allows different IT systems/platforms and data using applications to connect and share data with each other. This can be useful for integrating data from different sources, or for allowing multiple applications to access the same data without having to duplicate it in multiple places. Data space connectors typically use standardised protocols to facilitate the transfer of data between different systems. This can help to ensure that the data remains consistent and accurate across all of the connected systems. Beyond trustworthy and interoperable data exchanges, it can provide a seamless services utilization

The Local side of the architecture refers to (most likely already existing) data platforms, either from individual actors (e.g., the data platform from a Retailer) or groups of actors (e.g., the data platform of an Energy Community) or energy market/system as whole (e.g., the Data Hub of metering data, the Flexibility Register, the SCADA, the ECCo SP platform from ENTSO-E and Transparency Platform from ENTSO-E). Those platforms are already capturing and persisting own data, which is usually inputted to local services for tailored applications. The data space connector should be incorporated to these (pre-existing) platforms to enable identification, data harmonisation and brokerage towards Data Spaces.

The Federated Data Space part of the architecture refers to where data is indexed, making it discoverable and providing a sort of marketplace for trading both data and data services. In order to do so, the Data Space will rely on multiple actors and data platforms (the previously described ones) federating through the Data Space Connectors and offering their data under pre-recorded policies.

Figure 2 shows the new DERA 3.0 layered architecture incorporating the elements that will be defined in the following sections, including their relationship with both the DESAP and the OpenDEI building blocks.

Figure 3 extends the architecture to also link to the data governance modules and functionalities as described in Chapter 3 of this document.

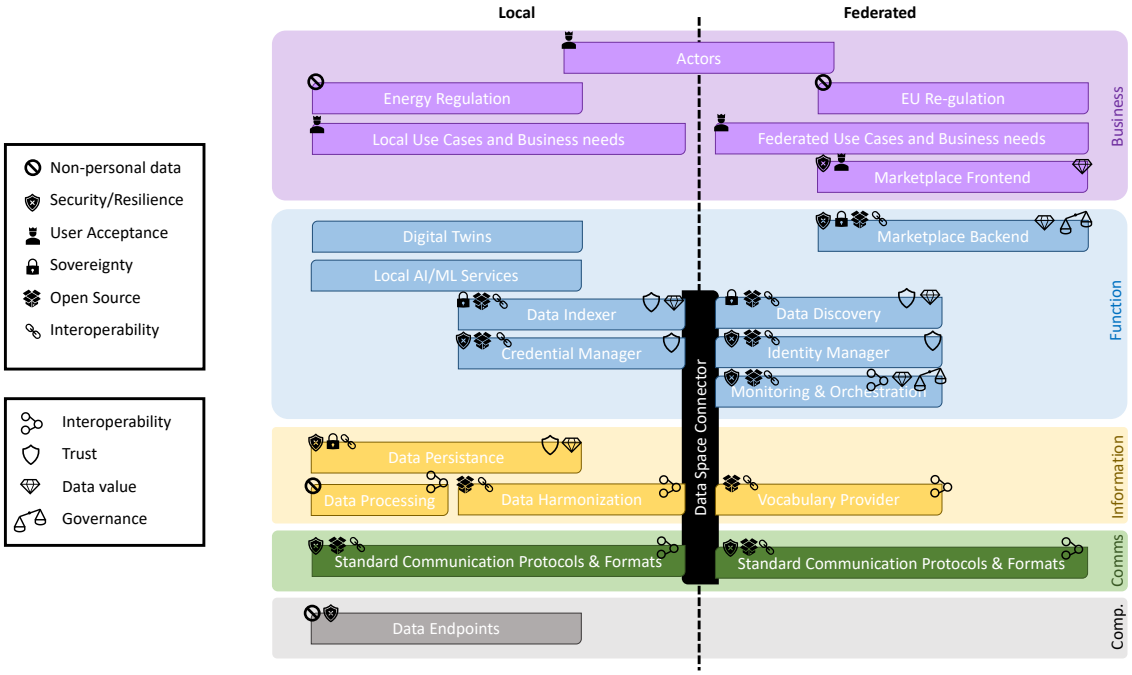


Figure 2. DERA 3.0 layered architecture and link to the DESAP and OpenDEI building blocks

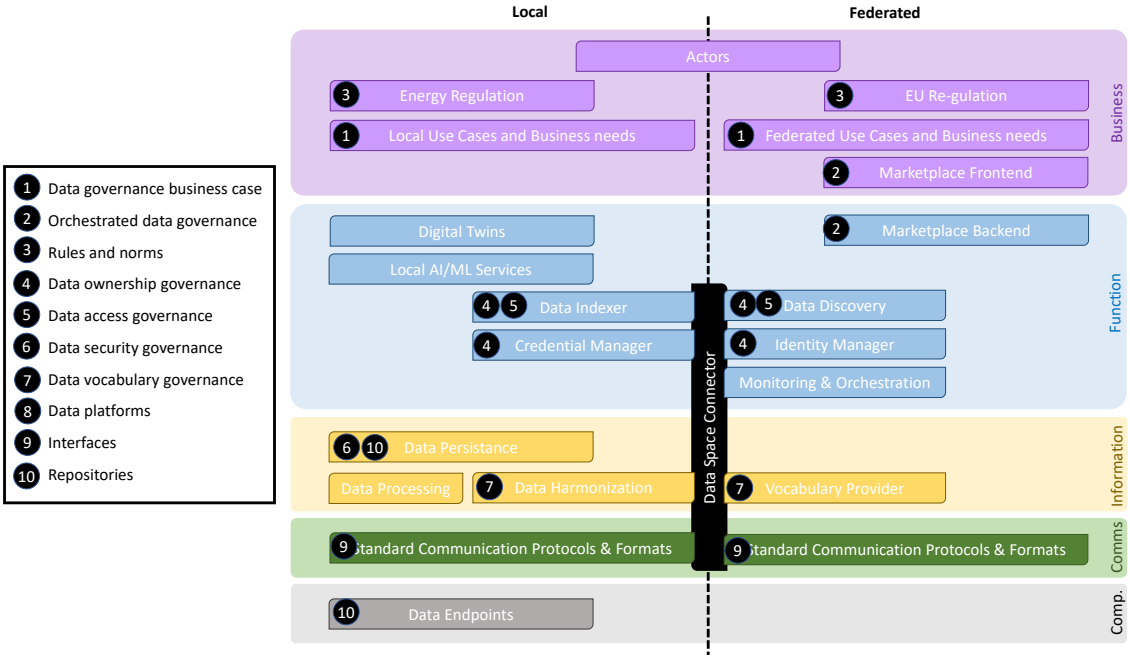


Figure 3. DERA 3.0 link to data governance

In an attempt to clarify and express the potential usage of connectors and interoperability between Local and Federated platforms, Figure 4serves as an extension of Figure 2. This figure includes the cases of (1) data indexing of own data in a data space, (2) data discovery in a data space and (3) bilateral exchange of data.

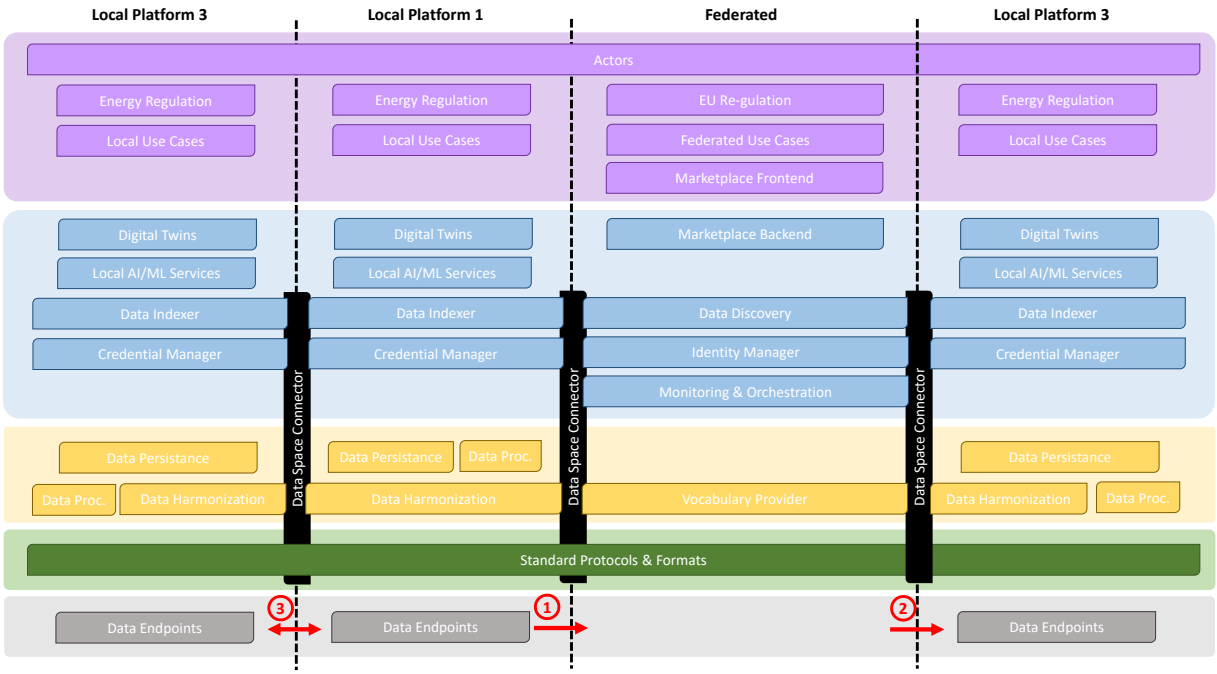


Figure 4. Interactions between Local platforms and the data space

2.2 Interoperability layers of reference architecture

2.2.1 Component Layer

The component layer in the IEC 63200 (SGAM) [8] reference architecture is a logical layer that represents the different components or sub-systems that make up a larger system. It is used to organize and structure the architecture of a system in a way that makes it easier to understand and work with. It helps identifying and understanding the relationships between them. This can be useful for identifying potential areas of reuse or integration, and for designing and implementing the system in a modular and scalable way.

For the purposes of data exchange realisation, this layer can be abstracted as the origin of the data being handled by the system. This way, whereas theoretically the layer should incorporate the physical components producing data and the ICT infrastructure for enabling its processing and transfer, for the sake of simplicity, DERA 3.0 will record here just a generic module for (Energy) Data Sources.

2.2.1.1 Data Endpoint component

As DERA 3.0 is looking from the Energy perspective, the data endpoints being considered are Energy related, but this component would be identical in functionality regardless of the vertical considered. This layer could equally consider any data source susceptible to be incorporated to the exchange.

It is important to note that these data sources are just available on the Local (left hand side) of the architecture, as data sources and sinks are just considered in local data platforms. The Federated part of the Data Space should just index these data sets, but never persist them.

With respect to DERA 2.0, this component is aggregating the following ones:

- Data Exchange Platforms (distributed exchange), as those are the ones covered by the previous definition and certainly are considered as data sinks, data providers or consumers.
- Centralized solutions, being those also a form of Local data gathering frameworks.

This component is relevant for the following DESAP requirements:

- **Non-personal data**. Even though DESAP describes non-personal data only, the DERA should focus on personal data as well. As this is the entry point of data to the system, it is important to evaluate whether there is a critical need for using personal data or not. In case it is critical, the data should be kept that way just on the Local data gathering platform for concrete and agreed purposes and following all the special GDPR regulation for this kind of data. For this data to be exchanged in a Data Space, a form of consent and anonymization or aggregation, or consent management mechanism should be incorporated prior to their availability on the data space ecosystem.
- **Security/Resilience**. It is very important to identify directly at the origin potential business or operation critical elements. The data from those should be carefully handled and replicated just where and when is strictly needed.

There is no direct link with OpenDEI building blocks, although the data provided here is the raw material used in all of them.

2.2.2 Communication Layer

The purpose of the communication layer in the SGAM [8] reference architecture is to provide a means for different components of the system to communicate with each other. This layer enables the different components to exchange information and coordinate their actions in order to achieve the overall goals of the system. It is an essential part of the architecture, as it allows the various components to work together and function as a cohesive whole.

As in the previous layer, here the previous DERA 2.0 components have been aggregated into a generic protocol and format component, assuring they are open and standard, as both Local data platforms and data spaces should be protocol agnostic for communication purposes.

2.2.2.1 Standard communication protocols and formats component

As anticipated, this layer is unifying the DERA 2.0 components for communication protocols (perceived as the means to exchange data, either for local ingestion or for federated data sharing) and formats (meaning the concrete way to represent the data in the transfer).

On the Local side, as the data is expected to be kept for the platform users, the requirements should not be too demanding. Each data platform administrator can select the most convenient option. Nevertheless, aligning with or integrating standard and open protocols/formats and specially those selected in Data Spaces would highly ease the process of federation.

On the other hand, making sure both the protocol and format used for communication are openly available and standard to pave the way to easy federation is critical at Data Space level. The latter can be achieved with the deployment of a data connector which would establish the communication with the data space ecosystem, assuring the interconnectivity across different domains and sectors.

This component is grouping the following modules as in DERA 2.0:

- All data formats (PNG/JPEG, XLSX, RDF, CSV, JSON, XML, Apache Parquet…)
- All communication protocols (AMQP, REST, OPC, ZigBee, SOAP, ModBus, XMPP, MQTT, KNX, TCP, Web-services, FTP, HTTP/HTTPS…)

Regarding DESAP requirements, this module is key for the following recommendations:

- **Security/Resilience**. The selection of the data format and protocol is not a matter of selecting the one which is more easily implementable. It is rather based on guaranteeing the needed security for sensitive data sets being transferred. Therefore, the protocol selected should ensure the highest levels of cybersecurity needed for keeping those data sets sovereign and confidential, if applicable.
- **Open Source and Interoperability**. The usage of open standards, publicly available APIs and open source is key to make sure everybody who might be interested in federating or using the data space can easily do so. Vendor locking, proprietary protocols and logical black boxes should be avoided in data sharing architectures.

This component is very important for the Interoperability set of building blocks outlined from OpenDEI. More specifically, this module is the basis and the essence of the "Data Exchange APIs" one. Selecting appropriate open communication protocols will inherently provide this building block to the architecture.

2.2.3 Information Layer

The purpose of the information layer in the SGAM [8] reference architecture is to provide a defined location for handling, managing and storing data that is used by the various components of the system. This layer acts as a repository for information, allowing it to be accessed and used by different parts of the system as needed. It is an important part of the overall architecture, as it allows for the efficient and effective management of data, ensuring that it is available when and where it is needed.

This layer is very relevant for Local platforms, as this is where data processing and persistence is occurring. Nevertheless, as the purpose of this document is to propose a data sharing architecture, those functionalities will be presented but not with the detail level as in the data sharing related components.

Additionally, this layer contains also the harmonisation part, which is a cornerstone of semantic interoperability. This comes as a duality in terms of modules to be placed both at Local and Federated level.

2.2.3.1 Data Harmonisation (Local) and Vocabulary provider (Federated) components

As anticipated, this pair of modules regulate the way data is presented and understood along the data sharing endpoints. Depending on which side of the architecture it is considered, the functionalities vary:

- Data harmonisation is the module to be placed in the Local side. can be either embedded into the connector or available data harmonisation services can be found available on the Marketplace, and its functionality is meant to assure the sharing format is appropriate. This refers also to Semantic correctness. In order for all data space actors to understand the data itself, a common vocabulary is used, making sure the data formatting is FAIR (Findability, Accessibility, Interoperability and Reusability). In the particular case of this BRIDGE DERA 3.0, this semantic correctness should link to Energy ontologies.
- Vocabulary provider is the counterpart at Federated data space level. This module, on the one hand side, provides information about the ontology/language used for data and, on the other hand, checks that the data being indexed is compliant with the provided vocabulary. Again, being this an Energy oriented approach, IEC (CIM, 61850, COSEM, etc.), ETSI (SAREF, etc.) standards is what this vocabulary module is expected to be reliant on.

These two aforementioned modules take onboard the following set of legacy DERA 2.0 modules (and other standards not appearing here, such as MATTER, etc.):

- IEC CIM
- SAREF
- NGSI
- OpenADR

- EEBUS
- Private Data Exchange Profiles

The functionalities provided by these components are very relevant to the following DESAP requirements:

- **Open Source**. This will be a trend on this kind of dual side functional blocks. It is very important to rely as much as possible in open source modules for this, as it will foster the scalability of the approach, allowing any party interested in connecting and understanding the language being spoken in the data space and performing correct and meaningful data exchanges.
- **Interoperability**. This is also very relevant for interoperability, especially in the semantic side of it. There should be a consensus on the syntactic format for data exchanges and queries to the Data Space, allowing easy connection and even integration of data spaces from different verticals. Semantic interoperability is also crucial at Local level, making sure the relevant data providers and users are aligned in the way data is presented. This includes the following:
  - Structured Data Sets: for these data sets validation of the data sets should exist. For instance, a CIM CGMES data set will be validated against the Certification Scheme associated to a CGMES data set.
  - Unstructured Data Sets
  - Private Data Set & Open Data Sets

As for the link with OpenDEI building blocks, this module is very linked to “Interoperability” group of blocks. There is one specific building block regarding “Data Models and formats” which is precisely the functionality provided with this module.

2.2.3.2 Data Processing module

As anticipated, this is a relevant module at Local level, but not crucial for the data exchange. This module aggregates all those functionalities related to data security, data quality, data provenance, etc. This DERA 3.0 assumes that those functionalities are implemented at Local level, making sure the data being ingested is compliant with all relevant regulations and standards applied to the vertical (in this case Energy), so that data being used here is ready to be shared if needed. The other way around, for potential datasets being acquired/shared from the Federated part of the data space, this module should make sure that they are again secured, with the level of quality needed and traceable before persisting them in the local data base.

The module incorporates the legacy components of DERA 2.0 for:

- Data cleaning and quality
- Data collection
- Data anonymization
- Personal data handling
- Metadata management

Therefore, the functionalities provided by data processing module are linked to the DESAP requirement about **Non-personal data usage**. This module is in charge of providing the needed anonymization or pseudo-anonymization as applicable by the regulation.

The module is also linked to the OpenDEI building blocks in the “Interoperability” family, especially those listed as “Provenance and traceability”.

2.2.3.3 Data Persistance module

Similarly, to the previous module, it is assumed that Local Energy platforms will have their own means of persisting data. They will use this warehousing capabilities to store their own data sets and also potentially store some new data incoming from the exchanges made on the data space.

The way this data persistence module is implemented is up to each Local platform owner/operator. The requirements from the data exchange side are, as anticipated, making sure everything stored here that is to be shared at data space level is compliant with the vocabulary and syntactic rules.

This module is equal to the DERA 2.0 module named Data Storage.

This way, the module is aligned with the DESAP requirements in regards to:

- **Security/Resilience**. The data persistence module must ensure, especially for those datasets received from other data providers in the data space and entailing potential non-disclosure clauses, a secure, trusted and sovereign storing. This can be achieved by deploying cybersecurity mechanisms to protect the data access and usage at local level.
- **Sovereignty**. As partially described in the previous point, sovereignty should be guaranteed at local storage level. This applies to those datasets owned by the Local platform owners/operators but also to those datasets received as part of a data exchange, that might be labelled for internal use but not able to be re-shared or disclosed.
- **Interoperability**. Also in order to be compliant with each other's non-disclosure rules there is a need for interoperability in the definition of how the data accesses are specified.

As for OpenDEI, based on the previous description, the functionality of the data persistence module links to both "Trust" and "Data Value". In the former case, it is linked to the "Access & Usage control/policies". In the latter, particularly to the "Data Usage Accounting" module.

2.2.4 Function Layer

The purpose of the function layer in the SGAM [8] reference architecture is to provide the actual functionality that is needed to support the goals of the system. This layer is associated to System Use Case Definition as described in IEC 62913-1. It can involve Business Roles and System Roles. This layer contains the components that are responsible for carrying out the tasks and operations that are needed to achieve the desired outcomes. This may include functions such as analysis, and decision-making. The function layer is an essential part of the architecture, as it is where the majority of the work is done to support the system's objectives.

As in the previous layer, and supported by the figure of the Data Space Connector, this layer has also a lot of dualities, grouping functionalities that should match what is being done in federated infrastructures (the Local data platforms) and the Data Space (the Federated part).

This way, the layer contains the components in charge of managing the identification, allowing data indexing/discovering, monitoring the federation and also potential digital services acting over the data.

2.2.4.1 Credential Manager (Local) and Identity Manager (Federated) modules

These two modules regulate the access to the federation services in the marketplace. Again, the functionality can be split depending on the side of the architecture:

- Credential Manager refers to the modules at the Local part that allows the identification of that data platform as such unequivocally, opening the door for data indexing of own data sets and also potential acquisition of Data Space indexed external resources.
- Identity Manager is the module to be placed at Federated Data Space level to check identities of federated nodes when interacting with the Federated services. This is, therefore, the pre-requisite before starting any data indexing, discovery or transaction.

The two modules incorporate this way the following set of legacy DERA 2.0 modules:

- Data User's authentication
- Integration of data sources and users
- Security and privacy

The functionalities provided by these components are very relevant to the following DESAP requirements:

- **Security/Resilience**. The identity provision and management is per definition one of the critical parts of a cybersecure system.
- **Open Source**. As most modules in this layer, the way to implement identification at any potential interested infrastructure should be kept as simple and as open as possible. Therefore, the usage of open source is highly advised, and specially at Federated level.
- **Interoperability**. It is very important not just to enable easy federation, but also to make sure the identification mechanism proposed is aligned at EU level, maximizing the interoperability with other Data Spaces, either on the same or different sectors, towards the EU data single market.

As for the link with OpenDEI building blocks, this module is very linked to "Trust" group of blocks. There is one specific building block regarding "Identity management" which is precisely the functionality provided with this module.

2.2.4.2 Data Indexer (Local) and Data Discovery (Federated) modules

These are the couple of modules making sure data is discoverable through the data space. For this purpose, the duties are broken down into two parts:

- Data Indexing refers to the ability of Local data platforms to push relevant data into the Data Space, so it can be discoverable. In order to do so, they have to rely on the Data Harmonisation modules of the Information layer, making sure the data is in the format understood at Data Space level. The way to index data is commonly approached as a collection of metadata to be transferred, including self-descriptive pieces of information.
- Data discovery is the counterpart in Data Spaces. It also has a dual functionality. On the one hand side, it should gather and process the data being received from Local data platforms, incorporating them to the catalogue. On the other hand, it should incorporate an engine allowing discovery of the already indexed data sets in the catalogue, allowing users to explore and select potential interesting pieces of information.

These two modules are now grouping the previous DERA 2.0 components:

- Data certification, which is the module in charge of making sure the data indexed in the Data Space is compliant with the standards adopted;
- Metadata management, covering also the part of indexing and brokering at data space level;
- Data availability, in the sense of discoverability;
- Data Governance, making sure the indexing of data sets also incorporated the policies and conditions under which the data owner allows the exchange.

As per the DESAP links, these modules are especially relevant for:

- **Sovereignty**. They should clearly be indexed preventing its misuse or leaking.
- **Open Source**. The technology selected to implement those modules on both ends should be open enough to allow any interested party to federate in the Data Space with no major technical barriers. Open Source is therefore a must on the Federated part and highly recommendable for the Local side.
- **Interoperability**. Linking also with the information layer, the usage of common ontologies and data models to capture and index the data is key to allow understandability and replicability.

This module is also aligned with OpenDEI building blocks, both on “Trust” and “Data Value”. In the former case, it covers the building blocks for “Access and usage control / policies” (together with the previous credential/identity managers). On the latter, this is the core module providing the building blocks for “Metadata and Discovery protocol”.

2.2.4.3 Monitoring and orchestration module

The monitoring and orchestration module comprises the functionalities needed at the Federated part of the Data Space to make sure the federated nodes connected and using the system are performing as expected, together with the needed ICT monitoring of the own resources for a seamless digital operation.

The monitoring functionality of the module should provide transparency to the Data Space users about both the data and services offered on the marketplace and discoverable through the already described discovery module. This alignment relates to requirements such as security, encryption, interoperability or privacy, among others. This module will gather and record evidence proving the alignment of both service/data providers and users, as well as for the transactions made.

The orchestration side of the functionality should allow Data Space users to instantiate and manage potential infrastructure services that are selected through the Data Space portal. This orchestration provides a Life Cycle Management engine, together with standard APIs.

This module inherits the functionality of the following DERA 2.0 modules (in this particular case, most of the functionalities were not recorded in the previous version of DERA, so these modules will be combined with new ones inside the monitoring and orchestration module):

- Data sharing and Bilateral exchanges, so that the transactions can be tracked.

Regarding the alignment with the DESAP, the requirements this module will help coping with are the following:

- **Security/Resilience**. As indicated, especially for the monitoring part, cybersecurity is critical to this module, for guaranteeing privacy and sovereignty in the system.
- **Open Source and Interoperability**. Both the monitoring and orchestration functionalities of the module rely heavily in the openness of the technologies used not directly in this module but also regarding underlying ingestion, communication and formatting modules.

This module is pivotal with respect to OpenDEI building blocks. As described above, the module provides a set of functionalities covering “Interoperability”, “Data Value” and (especially) “Governance”. The interoperability part is covered in the sense that it provides “Provenance and traceability”, as part of the logging system. The Data value side is given by the “Data Usage Accounting” functionality. Finally, the Governance functionalities cover “Operational” and “Continuity model” blocks.

2.2.4.4 Marketplace backend module

The complete offer of the Data Space regarding both data and services available should be somehow prompted to users. The way Data Spaces envisage to do so is through digital marketplaces, indexing the data available and offering data services either as App Stores or using a SaaS (Software as a Service) approach.

In order for these marketplaces to work properly, a number of functionalities should be provided. Those, which are the ones not related to purely visual representation, are the ones covered by this marketplace backend module. These functionalities are, at least, the following:

- **Monetization/payment** engine allowing data or service owners to obtain money/tokens based on what they offer and also users to pay for data or services.

- **Contracting/legal** modules to enforce bilateral contracts between data/service providers and users when certain pre-recorded conditions are made.
- **Clearing house**, for matching offer and demands, asking the previous modules to enforce the needed actions.
- Potential **additional functionalities** helping users and providers to manage their interactions and provide added value functionalities, such as (but not restricted to) Data-as-a-Service, Machine-Learning-as-a-Service, ability to index Models and Libraries, Compliance management, etc.

This module is completely new and, therefore, not considered in DERA 2.0.

As for the DESAP alignment, the marketplace backend will be relevant for achieving the following requirements:

- **Security/Resilience**. Being this the entry gate of both users and providers to the Data Space Ecosystem, the marketplace backend should implement the highest standards of security. For this, it will rely also on certain modules such as the identity Management and the monitoring and orchestration.
- **Sovereignty**. Again, the backend for the marketplace is where the interactions and transactions between different parties are articulated and enforced. It is crucial to carefully implement those to make sure those exchanges will occur just under the circumstances and policies set by data owners.
- **Open Source and Interoperability**. As in previous modules, having the marketplace developer using open source, open standards and open APIs will foster its adoption and ease the interaction with all stakeholders, including not only providers/users, but also the interaction with other Data Spaces and other industries.

This module is also very relevant for OpenDEI alignment on building blocks. As this module regulates the exchange of data (with smart contracts), it is the cornerstone for functionalities related to “Data Value” and “Governance”. In detail, the Data Value here concentrates on “Access and usage control policies” and “Trusted data exchange”, while the Governance part focuses on “Overarching cooperation model”.

2.2.4.5 Digital Twins and Local AI/ML services

This is a generic placeholder for potential Local services that might be hosted on the left hand side of the architecture, that is, the Local data platforms.

Those services could be local/pre-existing (those that were developed to use the own data in the platform) or can be also some additional ones purchased from the App Store of the Data Space Marketplace and then deployed locally.

Those services can be very different, but they are usually related to Artificial Intelligence (AI) and Machine Learning (ML), for data processing and valorisation, or Digital Twins, including system simulation.

There were a number of related modules on DERA 2.0 which are now grouped here, such as:

- Big Data
- Big Data tools
- Analytics

Being these modules oriented directly to data processing and valorisation, instead of being related to data exchange purposes, there are no specific DESAP requirements that they could help achieving.

2.2.5 Business Layer

The purpose of the business interoperability layer in the SGAM [8] reference architecture is to enable different business units and systems to interoperate and exchange data in a consistent and standardised manner, supporting the flow of information across the enterprise and facilitating interoperability between different business processes. This layer is associated to Business Use Case Definition as described in IEC 62913-1. It involves Business Roles as defined in the Harmonized Electricity Market Role Model, or data related roles. The business interoperability layer is designed to be flexible and extensible, allowing organisations to easily integrate new systems and applications into

the architecture and to adapt business processes to new regulatory requirements, for instance impact of network codes and guidelines or data interoperability implementing acts on utilities.

As in the case of the component layer, this layer is populated by a number of very relevant modules, needed to articulate the end-to-end operation of both the Local data platforms and the data space, but not that relevant when it comes to data sharing itself.

This is why the definition of those modules in this DERA 3.0 report might not be as detailed as the previous modules and also the links with both the DESAP and the OpenDEI building blocks for data spaces are not relevant.

2.2.5.1 Marketplace frontend module

The marketplace is broken down into two modules in the architecture. While the functionality is described in the functional layer, including the way data is contractually exchanges, the way services are published, etc.

In this business side of the marketplace, the part related with presentation and actor access is included, which is also relevant.

As in the backend part of the marketplace, this is a new module, so not listed in DERA 2.0.

This frontend part of the marketplace has the following links with respect to the requirements of the DESAP:

- **Security/Resilience**, as in the backend part. In this particular case, the considerations are regarding the way actors are accessing the marketplace frontend.
- **User Acceptance.** Being this the part of the marketplace seen and used by external actors (and potentially not familiar neither with data exchange principles nor Energy insights), making it as simple and as usable as possible is key to maximize its acceptance and engage potential users.

The frontend part of the marketplace is also aligned with the “Data Value” group of building blocks from OpenDEI. It is mapping the functionalities regarding “Publication and Marketplace services”.

2.2.5.2 Local/Federated Use cases and business needs

This module indicates how Local data platforms can make use of a collection of functional layer AI/ML services to build up a concrete use case solving a concrete problem at local level. This is what Local data platforms have been doing so far, collecting or acquiring data, storing it, applying AI/ML or big data analytics and producing a result or a model to be used locally. Those use cases can be, for instance, local energy services such as day ahead optimization of a grid or forecasting of an energy source.

The Federated side of this module is introduced to present one of the big values of the data space and data sharing usage. New Federated use cases can be unlocked, combining both data and services that are not local. This way, combining data from other sources and using services provided by other parties (either in IaaS/SaaS model or downloading the service as an App to be used locally), new use cases such as benchmarking or multi-vector energy grid optimization are enabled.

As anticipated, this module is not directly linked with any DESAP or OpenDEI requirement/building block by itself, but it is somehow making use of those for its purpose.

2.2.5.3 Energy/EU regulation

These pair of modules are also very relevant for the final operation of both Local and Federated sides of the data space. The functionality to support these regulations have been partially addressed both in Information and Functional layers, making sure the data and usage of data is aligned with relevant regulation both related to Energy and general data usage at EU level (including GDPR).

This module includes the following DERA 2.0 modules:

- Data Governance Act
- GDPR (General Data Protection Regulation)
- eIDAS (EU regulation on electronic IDentification, Authentication and trust Services)
- NIS (EU directive on security of Network and Information Systems)

As anticipated, this module is not directly linked with any DESAP or OpenDEI requirement/building block by itself, but it is somehow making use of those for its purpose.

2.2.5.4 Actors

There are a relevant number of actors expected to use the underlying modules and functionalities in this DERA 3.0 architecture. Those actors are the ones triggering and extracting the information out of both Federated and Local use cases, interacting with multiple of the modules compressed in the layers below.

This module aggregates some DERA 2.0 modules as listed below:

- Standards organisations
- European Commission
- Gaia-X
- IDSA (International Data Spaces Association)
- Roles in Network codes
- BRIDGE proposal
- HEMRM (Harmonised Electricity Market Role Model)

As anticipated, this module is not directly linked with any DESAP or OpenDEI requirement/building block by itself, but it is somehow making use of those for its purpose.

2.3 Visualisation of the architecture

Given the complexity of the architecture it was considered necessary to develop a graphic visualisation that helps the user navigating through DERA. During this year the idea was finalised and the coding is currently under development. It is expected to be ready during summer 2023.

Main inspiration for this implementation is the visualisation approach that also GAIA-X used to present online. The architecture is presented by means of a dashboard as in Figure 5. The dashboard is created using *layoutit!* (https://grid.layoutit.com/) and the plan is to use the same approach for DERA.

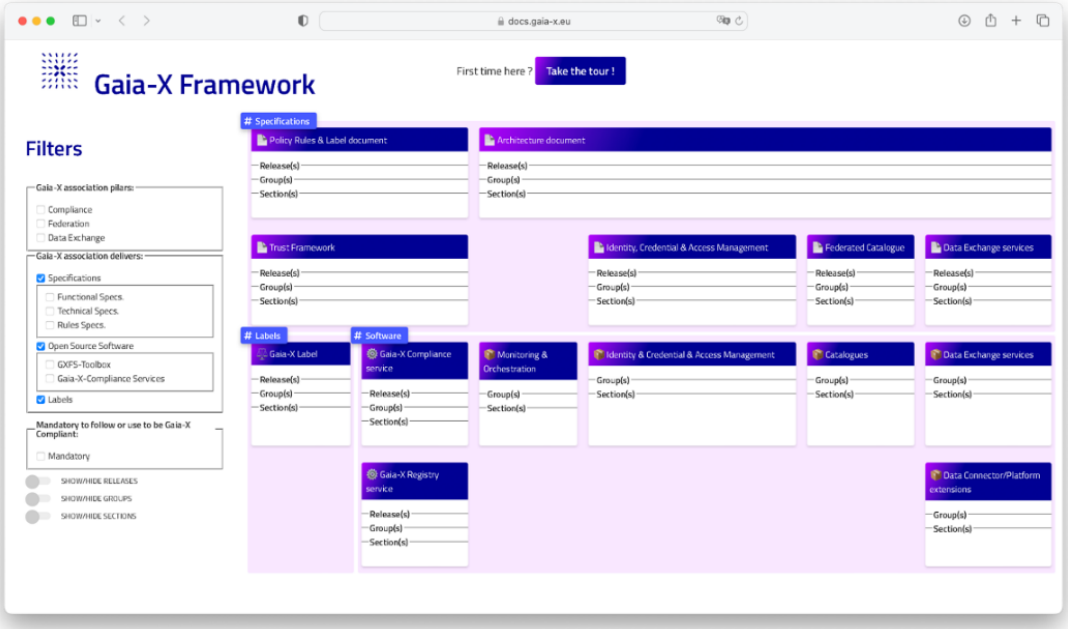


Figure 5. GAIA-X Dashboard

The page will look exactly like the DERA architecture (see for example Figure 2 or 3 in this report) and will be enriched by interactive menus helping the user to follow the details of the architecture.

To make this even more self-explanatory, the plan is to develop a couple of complete use cases with guiding documents to show the users how to apply the dashboard. The examples will be extracted from currently running projects within BRIDGE based on a multi-energy approach.

2.4 Alignment with Gaia-X and IDSA reference architecture and modules

This DERA 3.0 is trying to perform a complex exercise of mapping very different yet relevant baseline architectures and modules coming from different backgrounds.

For starters, this DERA is the third iteration of an architecture coming from the Energy industry, and related to early data exchange projects under the umbrella of BRIDGE. It is therefore inherited here the SGAM layering approach (intrinsically linked to the Energy world) and previous DERA modules and roles.

In this exercise, a more vertical-agnostic and pure data exchange approach is introduced. For this, the most relevant sources of information are Gaia-X and IDSA. They are both issuing their own reference architectures, which are expected to converge in the future (through technical convergence tasks in the Data Space Business Alliance [10]), but are yet separated and different in terms of maturity and component naming/functionality.

Therefore, it is not always easy to know whether one is referring to the same thing or something totally different when it comes to data sharing modules.

Figure 6 makes an attempt to map and group all these names and functionalities considered as equal (or at least covering the same functionality) with respect to DERA 3.0, Gaia-X and IDSA.

For the sake of completeness, Table 1 later summarises the links to Gaia-X, IDSA, DESAP, OpenDEI and previous DERA versions with respect to all listed DERA 3.0 modules. Those DERA 3.0 modules noted with **(C)** are those expected to be provided as part of the Data Space Connector functionality.

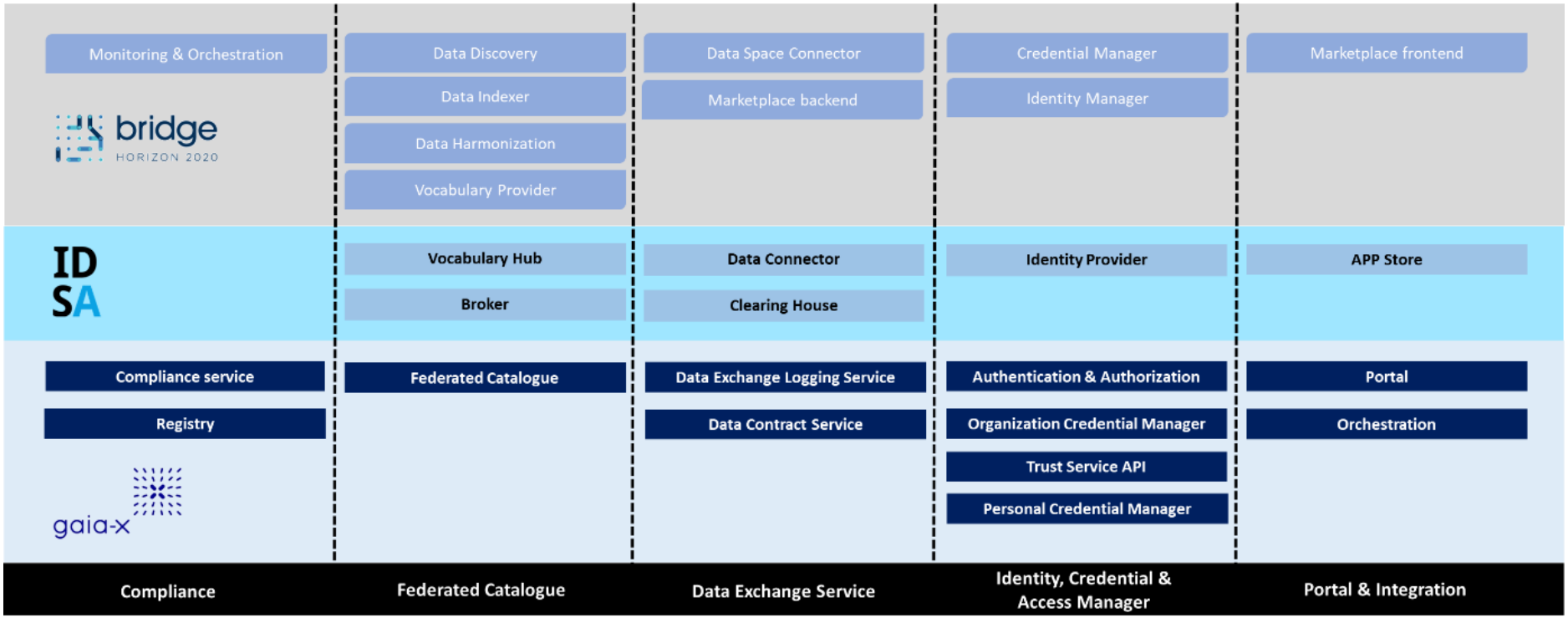


Figure 6. Alignment with Gaia-X and IDSA

Table 1. DERA 3.0 summary table

DERA 3.0	DERA 2.0	DESAP	OpenDEI	Gaia-X	IDSA
Energy Data Sources	Data Exchange Platforms (distributed exchange) Centralized solutions	Non-personal data Security/Resilience	N/A	N/A	N/A
Standard communication protocols and formats	All data formats (PNG/JPEG, XLSX, RDF, CSV, JSON, XML, Apache Parquet…) All communication protocols (AMQP, REST, OPC, ZigBee, SOAP, ModBus, XMPP, MQTT, KNX, TCP, Web-services, FTP, HTTP/HTTPS…)	Security/Resilience Open Source and Interoperability	Data Exchange APIs	N/A	N/A
Data Harmonisation (C) **Vocabulary provider**	IEC CIM, ETSI SAREF, NGSI, OpenADR, EEBUS, Private Data Exchange Profiles ...	Open Source Interoperability	Data Models and formats	Federated Catalogue	Vocabulary Hub
Data Processing	Data cleaning and quality Data collection Data anonymization Personal data handling Metadata management	Non-personal data	Provenance and traceability	N/A	N/A
Data persistence	Data Storage	Security/Resilience Sovereignty	Access & Usage control/policies Data Usage Accounting	N/A	N/A
Credential Manager (C) **Identity Manager**	Data User's authentication Integration of data sources and users Security and privacy	Security/Resilience Open Source Interoperability	Identity management	Authentication and authorization Organisation/Personal Credential manager	Identity Provider
Data Indexer (C) **Data Discovery**	Data certification Metadata management Data availability Data Governance	Sovereignty Open Source Interoperability	Access and usage control / policies Metadata and Discovery protocol	Federated Catalog	Broker

Monitoring and Orchestration	Data sharing and Bilateral exchanges	Security/Resilience Open Source Interoperability	Provenance and traceability Data Usage Accounting Operational Continuity model	Compliance service Registry Orchestration	N/A
Marketplace backend	N/A	Security/Resilience Sovereignty Open Source Interoperability	Access and usage control policies Trusted data exchange Overarching cooperation model	Portal Data Contract Service	APP store Clearing House
Digital Twins **AI/ML services**	Big Data Big Data tools Analytics	N/A	N/A	N/A	N/A
Marketplace frontend	N/A	Security/Resilience User Acceptance	Publication and Marketplace services	Portal	APP store
Local/Federated use cases and business needs	N/A	N/A	N/A	N/A	N/A
EU/Energy Regulation	Data Governance Act, GDPR, eIDAS, NIS	N/A	N/A	N/A	N/A
Actors	Standards organisations, European Commission, Gaia-X, IDSA, Roles in Network codes, BRIDGE proposal, HEMRM	N/A	N/A	N/A	N/A

3. Data governance dimension

3.1 Data governance elements

While data governance is a core dimension of organised pan-European data exchange, including for data spaces, it did not have dedicated attention in previous versions of Data Exchange Reference Architecture. This report reuses the data governance elements and requirements defined in D6.2 of OneNet project [11] in order to include these in DERA 3.0 and to run a survey among BRIDGE projects. OneNet, in turn, used DERA 2.0 as the starting point for landscaping the governance aspects on interoperability layers of SGAM. Table 2 lists the 10 data governance elements.

Table 2. Data governance elements per SGAM interoperability layers [11]

Business layer	Function layer	Information and Communication layer	Component layer
1. Data governance business case	4. Data ownership governance	7. Data vocabulary governance	8. Data platforms
2. Orchestrated data governance	5. Data access governance		9. Interfaces
3. Rules and norms	6. Data security governance		10. Repositories

OneNet calls this set of elements and requirements Reference Data Governance Model (RDGM). The governance model should recognise the variety of different platforms and systems, fit to different market designs and business processes, enable cross-stakeholder, cross-border and cross-sector data exchanges, ensure easy access to data satisfying GDPR requirements, facilitate TSO-DSO coordination from customer perspective, ensure scalability through open-source principle and agreed rules." [11] Figure 7 depicts the data governance elements in relation to DERA 3.0.

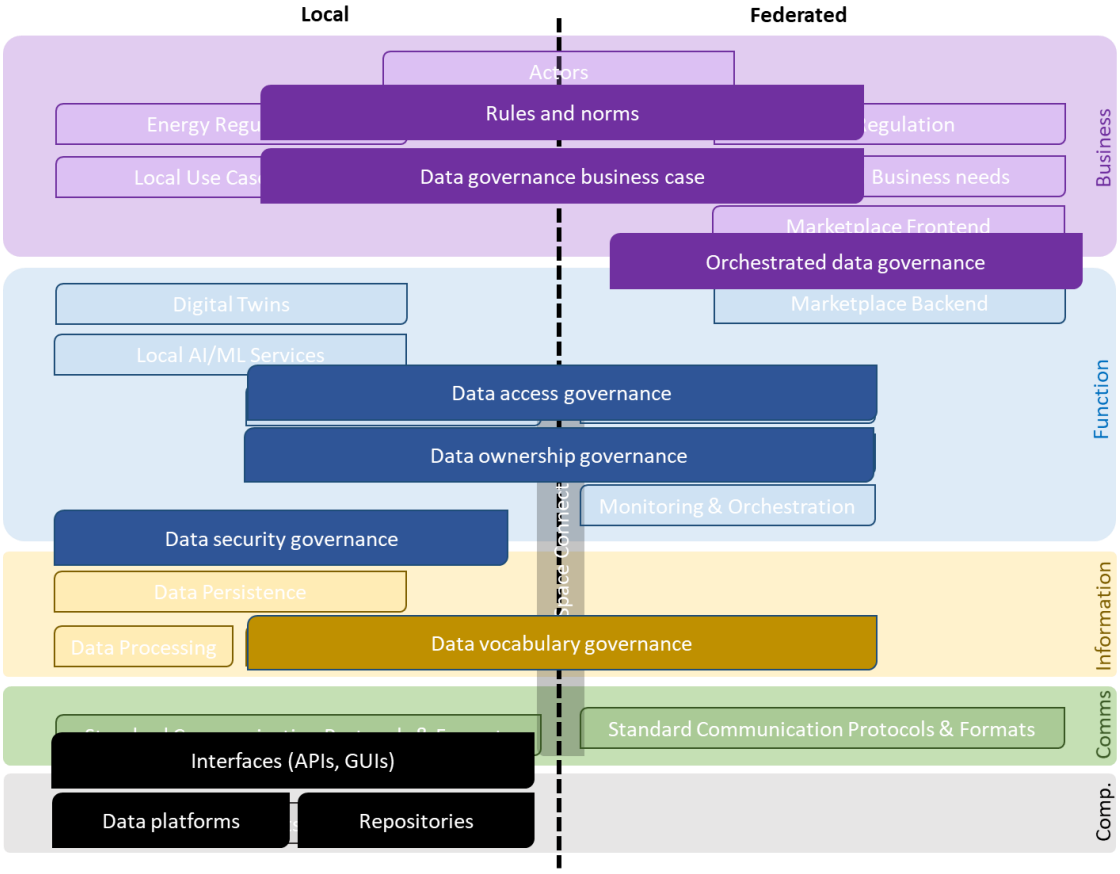


Figure 7. Data governance layer of DERA 3.0

Each element consists of one or more data governance requirements, the numbering of requirements refers to the respective governance element in Table 2. OneNet D6.2 identified 22 governance requirements in total [11], the list of requirements follows and is complemented by the comments from the projects. OneNet deliverable 6.2 provides more insights into each requirement.

1.1. Define **business case** for data governance on relevant level [project / organisation / country / EU], e.g. by means of business model canvas or standardised IEC 62559-2 template.

- *"Enables the coordination of activities and ensures interoperability at business level."*
- *"The business case for data may not be easily defined since same datasets can be used for many business cases."*
- *"It is important from the point of view of documentation, but formal definition is not very relevant to the project."*
- *"The business model driven data governance would be the target. Data governance business case is not described using standardised methods."*

1.2. Evaluate regularly the risks associated to the implementation of data governance program using **risk assessment** methodologies.

- *"Can avoid a lot of cybersecurity and privacy risks, but feasibility depends on the partners' expertise in the domain."*
- *"We are aware of the risks, and they are straightforward. The management of the risks at the level we have is sufficient."*
- *"Risk assessment mostly cover security and privacy."*

1.3. Define and follow the **principles of data-as-an-asset**.

- *"It is hard to define the quality of data in general, depending on the application, measurement system, data collection process, etc."*
- *"This feature is of high importance since it enables the economy of data with the so-called data marketplaces."*
- *"Right data for right decisions. Principles followed but not in a structured way."*

1.4. Define and monitor **KPIs** for data governance program itself and for specific data exchanges.

- *"Difficult to implement: criteria are more qualitative than quantitative."*
- *"Defining a set of KPIs to measure the impact of data is feasible, and also necessary."*

2.1. Establish a **group to steer** the European Energy Data Space, open to European initiatives and stakeholders to participate, and ultimately leading to cooperation between energy and other sectors.

- *"On the level of the project we already do have a nice group of many business and ICT partners contributing to data exchange platform development and implementation. It could even exist after the lifetime of the project, if the critical number of users remains."*

2.2. Define the **responsibilities and accountability** for European data exchange, including European Commission, Member states, data providers, data users, etc.

- *"Data is not so easy to be treated as physical asset where it is easy to define the owner."*
- *"Our project worked on the definition of new roles and semantics models to be used extensively EU-wide."*

3.1. Propose and promote **regulations and standards** facilitating improved data governance.

- *"Difficult to navigate within the range of available standards."*
- *"We might risk over-complicating the process if we regulate. Nevertheless, using standards is a mean to facilitate data governance as semantic interoperability will be easier to reach if standards are used. Governance will be less demanding if standards are used. In Europe some standards (CIM CGMES, CIM ESMP) are already supporting European regulation (grid codes)."*
- *"We do propose extensions to CIM and HEMRM as well as harmonised use cases (for flexibility market). If the regulation and standard is uniform, the usage level is low due to a huge amount of exceptions and local rules. Tailored data governance initiatives are privileged to standards application."*
- *"The UMEI, developed within the project is a good example."*

3.2. Understand regulatory and standards' **requirements** driving the need for proper data governance.

- *"We are aware of the importance of regulatory and standard's requirements, but currently due to current scope these tasks are of a low priority for us."*
- *"We have a dedicated task for cross-sector and cross-border data governance. Very important and costly requirement."*

4.1. Ensure **consent management process** which is accessible to any party willing to provide or use any data and not limited to single country.

- *"A standard method would be good, however not all laws and regulations are harmonised to make this practically possible, especially when collaborating with partners outside the European Union."*
- *"Each use case partner which deals with end users is responsible to manage privacy consents."*

5.1. Ensure the availability of **one-stop-shop** providing information about and access guidance to different types of data.

- *"It is hard to define the access to different kinds of data. I think it is good to have such vision to cover most of the use cases."*
- *"As an end-goal, this one-stop-shop solution may be suitable, but we think regulatory aspects must be clearly stated and defined before such solution can be implemented and used in practice, which at the moment we believe it will be implemented in the far future."*
- *"Theoretically interesting but very difficult to maintain for quite uncertain benefits."*
- *"It shall be clear for the citizen where they can access their data."*

5.2. Make available **single data access points** and ensure everyone's rights to access data.

- *"Information driven from Flexibility Register or TSO/DSO coordination Platform at national level could be interesting information to feed an Data Access Point."*

- *"There are different opinions among project partners about the interpretation of "data access point". Data access processes depend on the data type, the user, their journey, their maturity. Making single access points may prove less useful than tailored access points."*
- *"Single data access points increase cybersecurity risks (single points of failure)."*

5.3. Ensure legislative grounds for sub-meter and other **end-customer related data** governance.

- *"This is already well defined in the Netherlands (e.g. services are offered which have access to 15 minute data)."*
- *"Each use case partner which deals with end users is responsible to ensure the legislative grounds."*
- *"It depends on the usage of the submetering data. For formal processes, such as the ones covered by regulation sub-metering may not provide the necessary certification and reliability as the main meter. However, if that data is used by FSPs to better forecast the available flexibility, it may be useful. Can also be useful for grid operators to gain observability on the behaviour of certain parts of the grid to improve the service."*

6.1. Apply **"know-your-data-user" principle** by making data usage information available to data owners easily and free of charge.

- *"Relevant requirement, but currently difficult to provide such information as well as to track the data usage by authorized 3rd parties. Efforts, which are out of our project scope, should be done to develop such type of support platforms."*

6.2. Harmonise **authentication schemes** across Europe and sectors.

- *"Aligning with data space identity principles will be a good step forward."*
- *"Even though it is a relevant point, currently it is unclear who will be the central authentication authority responsible to coordinate and be responsible of such task."*
- *"eIDAS shall answer/support this requirement. Users having meters in several countries across Europe or moving from one to another are quite rare. Having different authentication schemes across countries is not a hassle."*

7.1. In data modelling, follow the generally recognised **reference models** for roles, information and processes.

- *"We know the importance of unified standards and data models for system interoperability. Our effort is currently set on looking at standard data models as well as protocols for the implementation of our solutions (TRL 6-7)".*
- *"There are too many reference models at the moment and they shall be harmonised in the near future. Important and applied in business cases with many stakeholders."*

7.2. Establish European arrangement for **coordinating reference models** and national mappings.

- *"Enhancing the coverage of CIM profiles in the project. Several extensions are needed such as TSO /DSO profiles, cross-sector coverage."*
- *"ESOs (European Standardisation Organisations) shall be involved / mandated in these activity."*

8.1. Make efforts and demonstrate the **interoperability of a data platform** with other European data platforms.

- *"Even though this an important task, the current maturity of the technical solutions, global coordination and legal frameworks make it almost impractical to be carried out, perhaps in the future."*

8.2. Call the common European (Energy) data space to keep the registry of and to issue **compliance labels** to interoperable data platforms.

- *"Not sure if this will be possible, as the issuers for certification should be horizontal data space alliances (e.g. GAIA-X or IDSA which have a certification scheme) or governments."*
- *"We agree with the aim of having a well-defined entity (i.e. European energy data space) to handle these type of issues and standardisation tasks."*

9.1. Make available **interfaces** – Application Programming Interfaces and Graphical User Interfaces – of the data platform.

- *"Data exchanges for all necessary processes can be performed either via APIs or GUI."*

- *"With proper definition for the data governance scope, it seems naturally to provide API interfaces for other systems, for the visualisation or management of solutions. This seems very well possible with current technology and frameworks within our project."*

9.2. Provide unified European wide **guidance for integrating** with any of the European data platform for developers, data intermediaries, data providers and data users, regardless of their physical location and data type.

- *"The level of complexity from each one of the domains, and within the domains might be a serious barrier."*

10.1. Create common **European data repositories** at least for cross-sector data roles, data types (objects, profiles) and processes (use cases).

- *"The concept of data spaces relies on the assumption that there are multiple data repositories. The idea is then federate them allowing discovery of data regardless where it is stored, enabling access based on data owner policies."*

10.2. Make the common European data repositories available **free of charge**.

- *"Access will be free of charge, but datasets can be just available purchasing them or exchanging them with similar value data."*

3.2 Data governance survey results

In the survey the BRIDGE Data Management WG members were asked to assess per each governance requirement the relevance, (i.e., positive impact), feasibility, (i.e., risks) and actual implementation in project/demo. Ranking from 1 to 5 from these three perspectives was requested. 18 projects answered to the survey.

Figures 8-11 present the detailed analysis of answers for most and least relevant as well as for most and least feasible requirements. Consent management was assessed to be the most relevant data governance requirement (the score 4,61) and common repositories least relevant (3,44). Feasibility to follow data reference models was the highest according to the answers (3,82) while the availability of one-stop-shop would be least feasible (2,87). Left part of each figure explains how every project answered individually (score 0 means that no answer was provided). Lower right part illustrates the implementation of the respective requirement – score 1 means that it is not implemented by the project at all and 5 means that it is fully implemented.

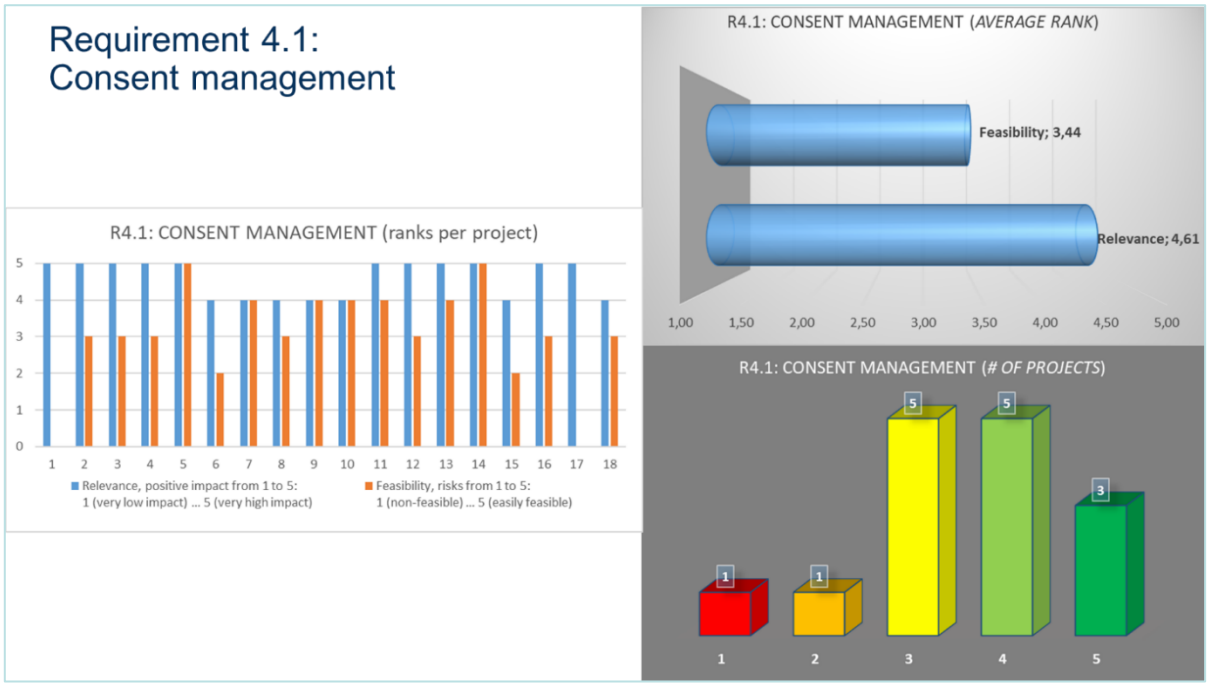


Figure 8. Consent management – most relevant governance requirement according to the survey

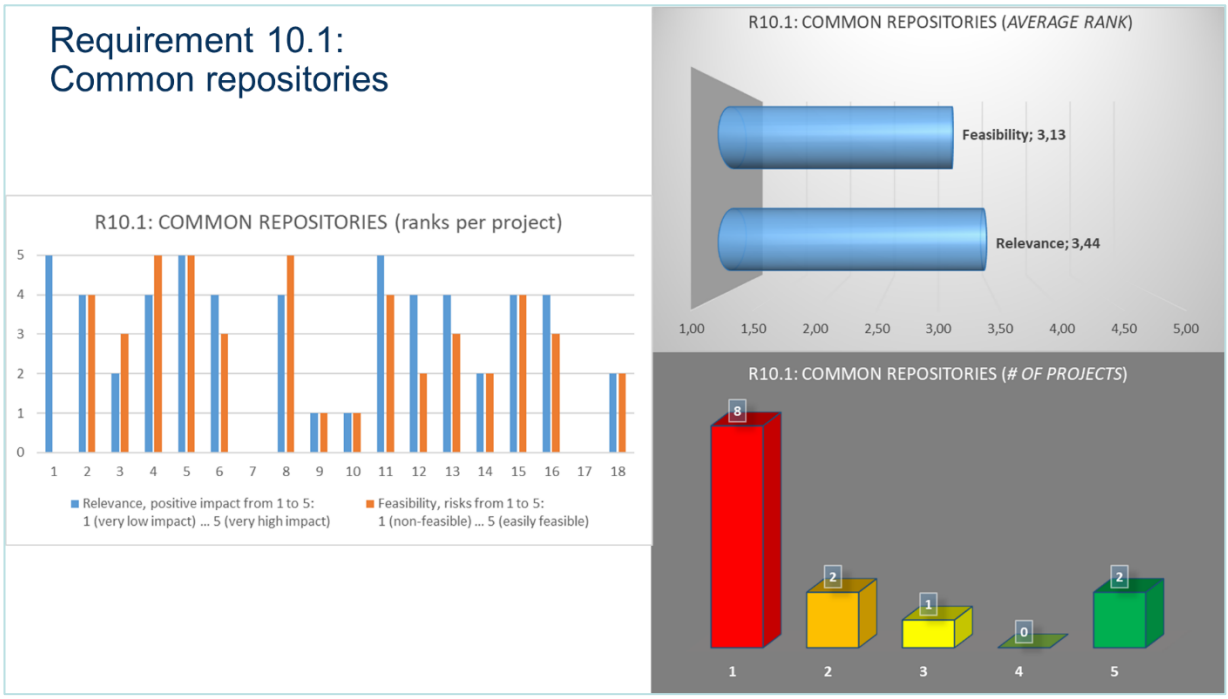


Figure 9. Common repositories – least relevant governance requirement according to the survey

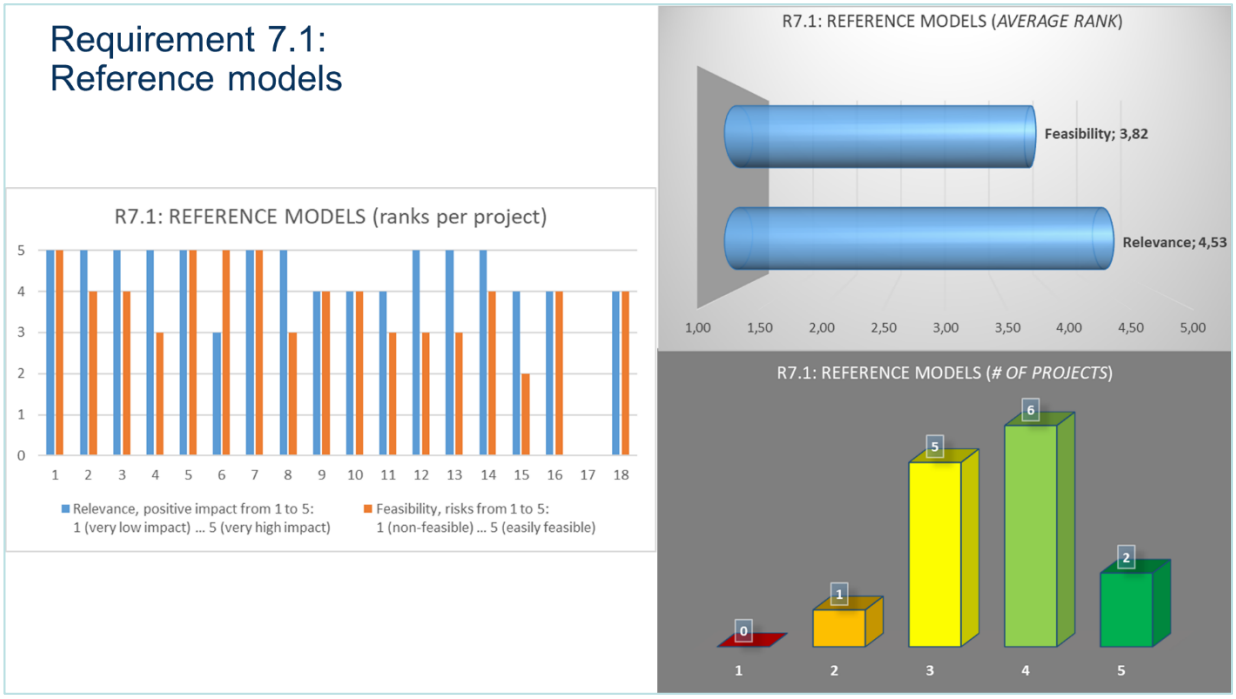


Figure 10. Reference models – most feasible governance requirement according to the survey

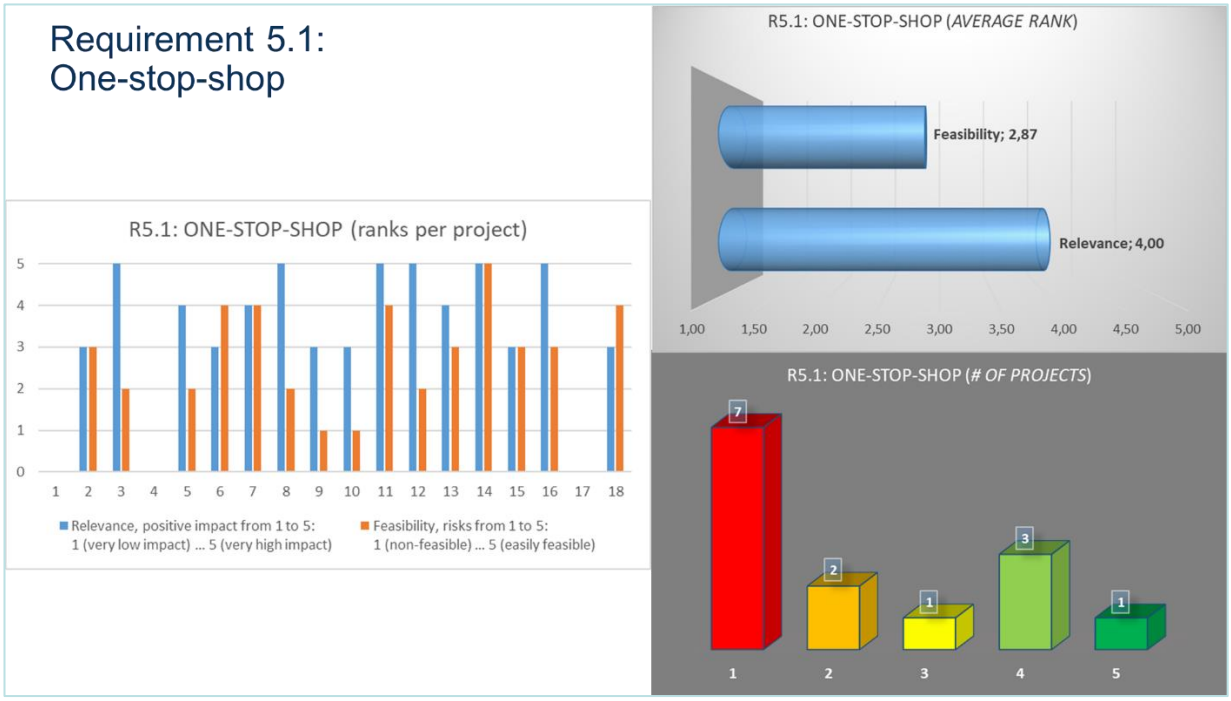


Figure 11. One-stop-shop – least feasible governance requirement according to the survey

Figure 12 lists the governance requirements' relevance and feasibility from highest to the lowest based on the scores given by the participating projects. It is advisable immediately to proceed with the design and implementation of the requirements which have relatively high scores for both relevance and feasibility – reference models, defining the responsibilities, free access to repositories, understanding the governance related rules of regulations and standards, consent management.

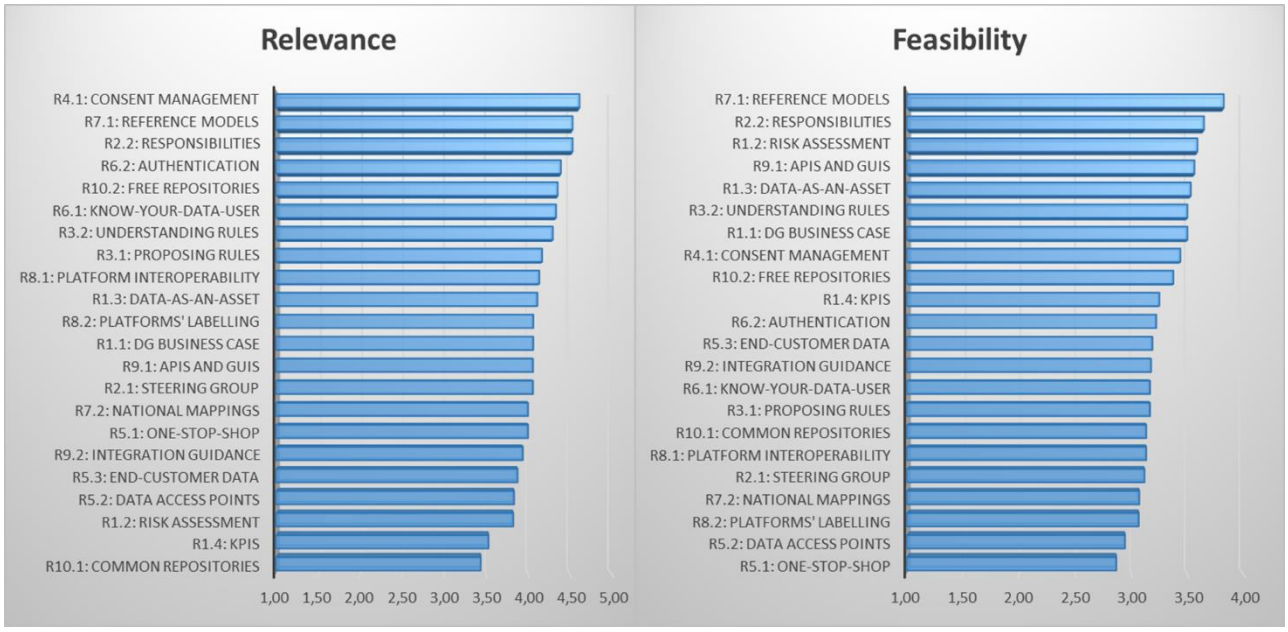


Figure 12. Relevance and feasibility rankings of the governance requirements according to the survey

4. Findings and recommendations

The first section of this chapter presents the outcomes of the survey. The second part of the chapter depicts the recommendations for DERA 3.0, which are based on the comments provided by the EU-funded projects.

4.1 DERA recommendations survey outcomes

Based on the report from last year, a survey was conducted in the scope of sub-action 3 to get feedback from the different EU-funded projects. As part of this work, the first goal was to understand if the projects follow DERA 2.0 recommendations and how important they consider the recommendations to enable cross-sector integration. The questions for the survey were created for the business layer (regulation, cooperation, process and data roles), functional layer, information layer (canonical data model, data models and profiles) and communication layer (protocols, data formats, data exchange platforms and data applications). Furthermore, the survey also allowed the participants to provide suggestions about DERA 2.0 recommendations.

The survey was conducted in a way to identify findings and gaps for the different layers of SGAM:

- Business layer
  - Regulation
  - Cooperation
  - Processes
- Data Roles
- Function layer
  - Information layer
  - Canonical data model
  - Data models and profiles
- Communication layer
  - Protocols
  - Data Formats
  - Data Exchange platforms
  - Data applications

The first question concerns the first recommendation from DERA 2.0 on all SGAM layers (Figure 13). From the answers, 64.71% of the participants follow this recommendation. Besides, most participants classified 4 the importance of this recommendation to enable cross-sector integration.

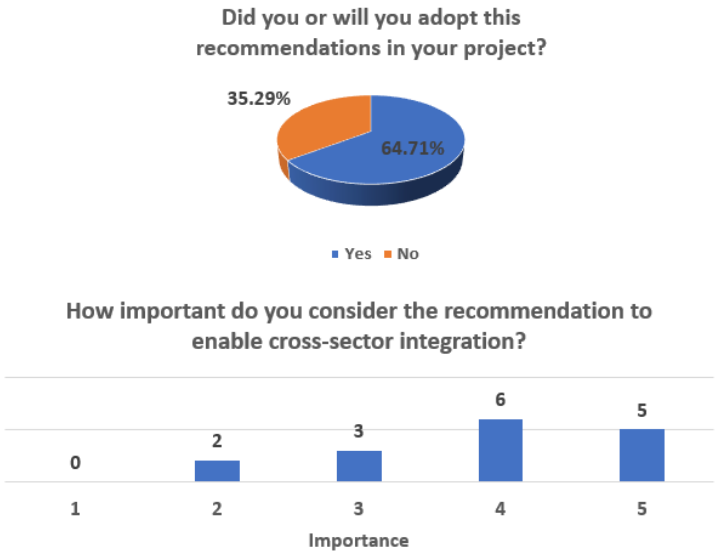


Figure 13. Question 1 of the survey about all SGAM layers

In the same way, in question 2 (Figure 14) the participants also say that around 63% of them adopt the recommendation on regulation (business layer), where mostly answered that it is highly important. Concerning the feedback provided by the projects, it is proposed to create a framework to solve the complex ownership of data (multiple stakeholders related to the same dataset, e.g., plant owner and operator may be different). For the same issue, one of the projects mentioned that data regulation and the common meaning of data are crucial for data exchange between different systems. Similarly, the projects also reported that reference models (e.g., IDSA RAM) are crucial for data space. It is depicted that common data governance is a key to cross-sector interoperability.

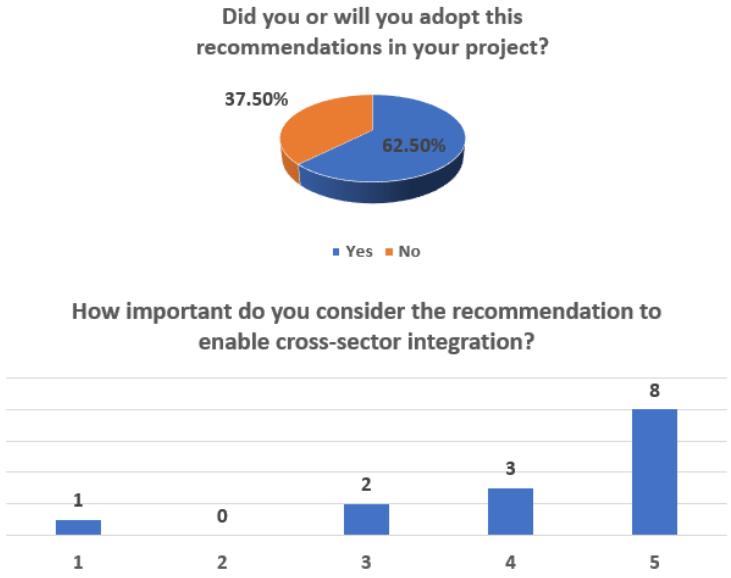


Figure 14. Question 2 of the survey about business layer (regulation)

However, on the third question (Figure 15) regarding cooperation (business layers), the participants answered that around 63% are not adopting this recommendation. Indeed, the participants mostly classify the importance of this recommendation as 3, but with a significant number also classified as 4 and 5.

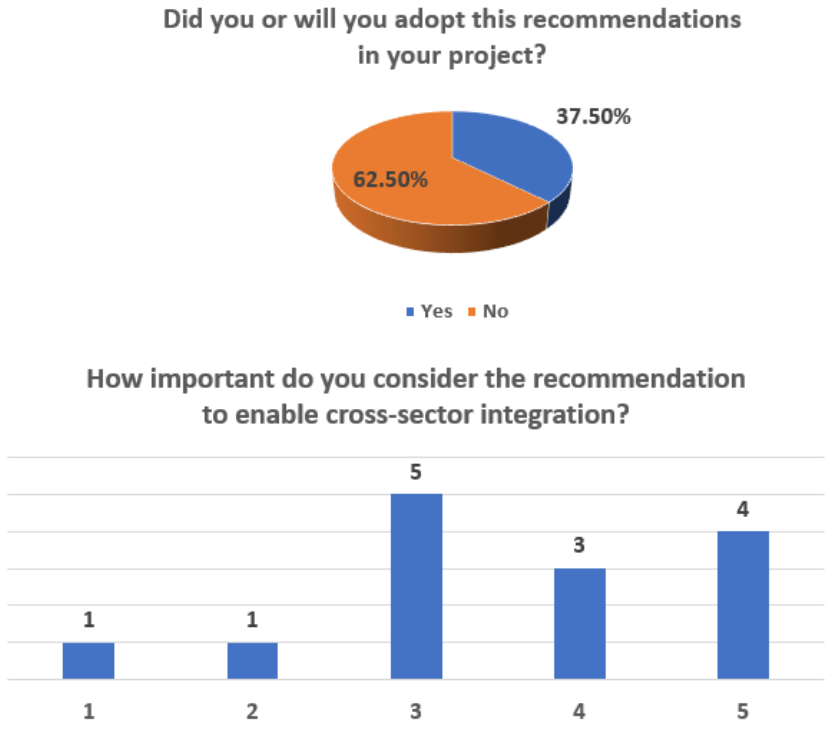


Figure 15. Question 3 of the survey about business layer (cooperation)

Hence, in this case, it becomes important to understand the reasons why the largest part of the participants do not adopt the recommendation. To do so, one should look at the gaps identified by them. Among the suggestions provided by the projects, one may highlight the need for alignment on different initiatives and frameworks (BRIDGE, ETIP-SNET, AIOTI, ISGAN), clarifications of the role and profile of a European data cooperation agency, and the existence of a similar platform like BRIDGE for energy smart grid projects as possible away to engage with "smart" projects from different sectors going beyond the Horizon projects including any R&D projects.

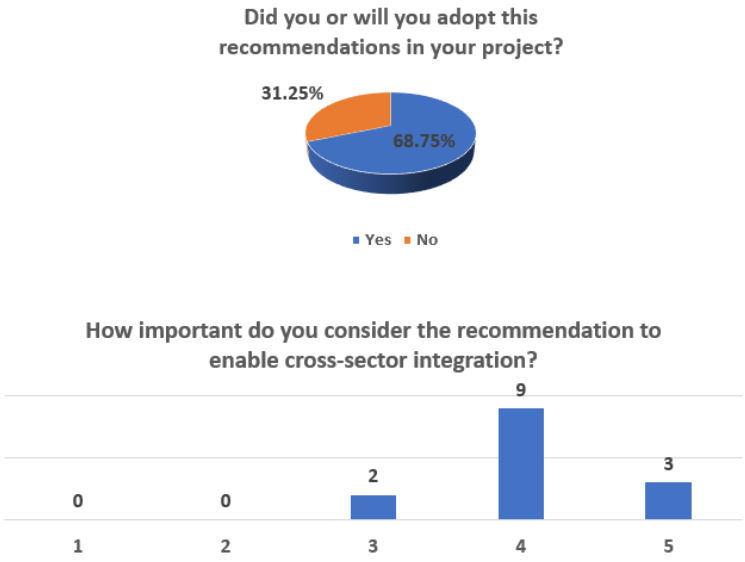


Figure 16. Question 4 of the survey about business layer (processes)

Regarding the business layer (processes) question (Figure 16), one may conclude that most of the projects adopt this recommendation and classify 4 its importance to enable cross-sector integration. Indeed, based on the feedback provided by the projects, a key point is the need to harmonise the use case repository. The projects suggest that the definition of the use cases should be compliant with IEC 62559-2/3 and the roles of the use cases must rely first on the HEMRM with additional roles created by some projects or roles coming from other associations (related to other sectors than electricity/ energy sector). For that purpose, it is proposed to open and promote the use case repository and align it with any potential peer repositories for other domains. As stated by one of the projects, as several initiatives are developing a use-case repository, interoperability between these repositories should be considered (e.g. based on 62559-3 XML serialisation but also by using common roles & information libraries). It is also suggested to develop a single-use repository for cross-sector data exchange use cases in Europe and create links between the use case repository, reference information model (IEC CIM), and reference role model (HEMRM).

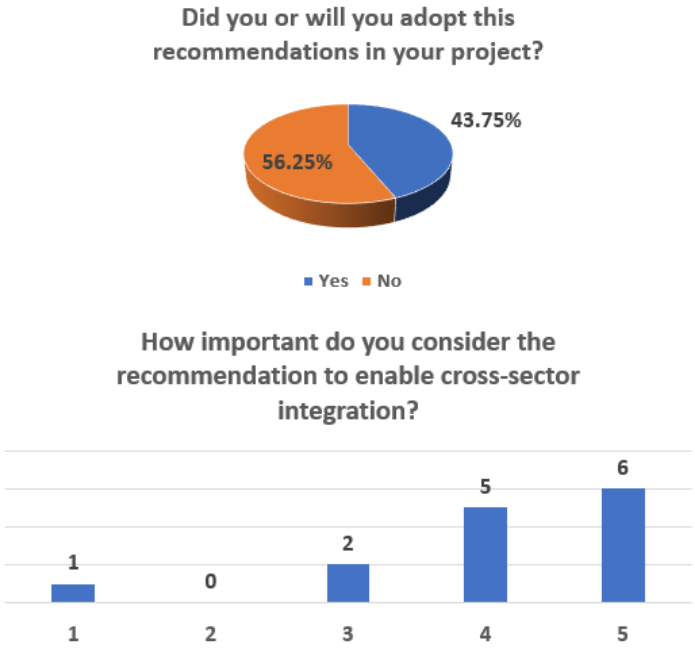


Figure 17. Question 5 of the survey about business layer (data roles)

On question 5 (Figure 17) concerning the data roles (business layer), around 56% of the projects say that they do not adopt this recommendation; however, most of the projects consider that this recommendation is very important to enable cross-sector integration (the classification is mostly 4 and 5). Looking at the feedback provided by the projects, one may conclude that they mention several times more coordination between the different role models to update and extend HEMRM to include new data roles (e.g. data owner, data engineer, data scientist, data analyst). Related to the HERM – Harmonised Energy Role Model proposed by BRIDGE, it is recommended that HERM should take a bottom-up perspective to accommodate pressing needs and roles coming from distributed generation.

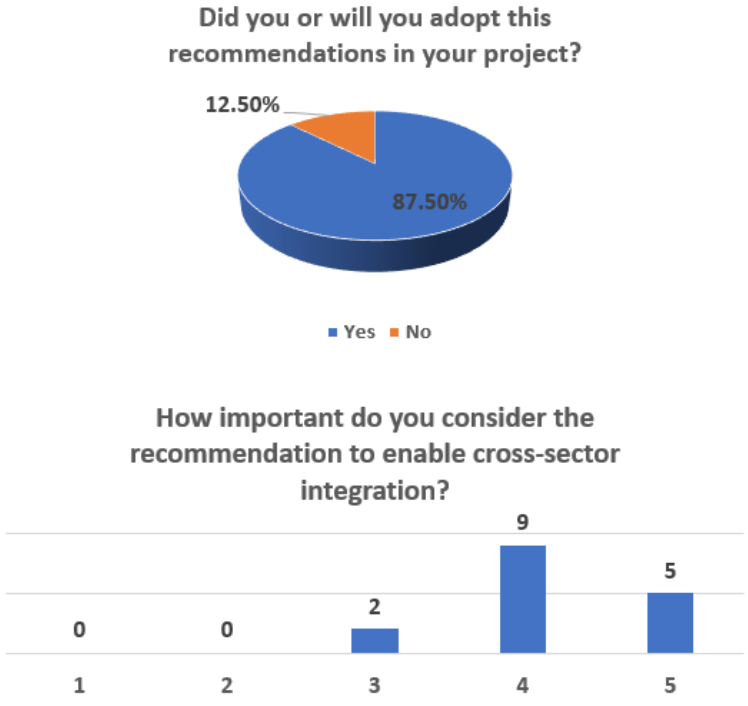


Figure 18. Question 6 of the survey about business layer (function layer)

For question 6 (Figure 18), which is related to the functional layer, around 88% of the projects follow this recommendation. Additionally, the projects classify as highly important to consider this recommendation for

enabling cross-sector integration. Even though the projects consider this recommendation very important, they also identify some gaps to be solved. One of the comments is that this recommendation might deserve a single and tailored recommendation in the future since it groups a lot of relevant topics. It is also suggested to harmonise the process of defining services and applications towards the marketplaces approach, as well as the creation of links between the use case repository and reference information mode (IEC CIM) and reference role model (HEMRM).

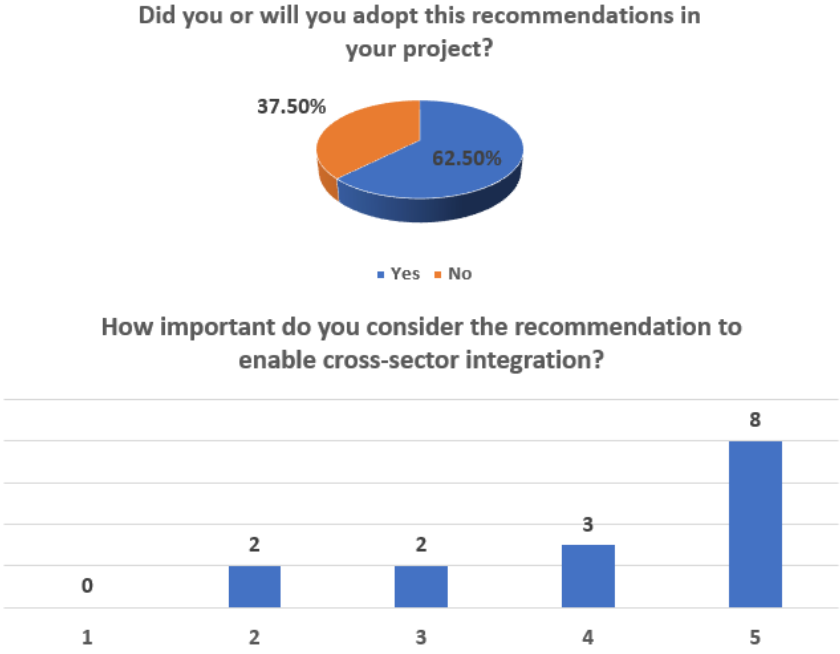


Figure 19. Question 7 of the survey about information layer (canonical and data model)

Regarding the canonical data model (Figure 19), 62.50% of the projects follow the recommendation and mostly classify it as relevant for cross-sector integration. Despite that, the projects state that IEC CIM is a wide standard, and its extension will be good, but simplification for small grid systems could be beneficial to the stakeholders. Besides, it is mentioned that it would be a challenge to agree on a common data model for all interested parties without entering into legal and business-oriented discussions. The projects also suggest providing open access to the list of canonical data models with the possibility to extend, revise and version it. Another point is the agreement on harmonised profiles for cross-sector integration. This is desirable since it streamlines the realisation of data and information exchange between the interested sectors. It is also mentioned that the SAREFization process introduced by the InterConnect project can be used as a best practice method for achieving semantic interoperability of legacy platforms and application services.

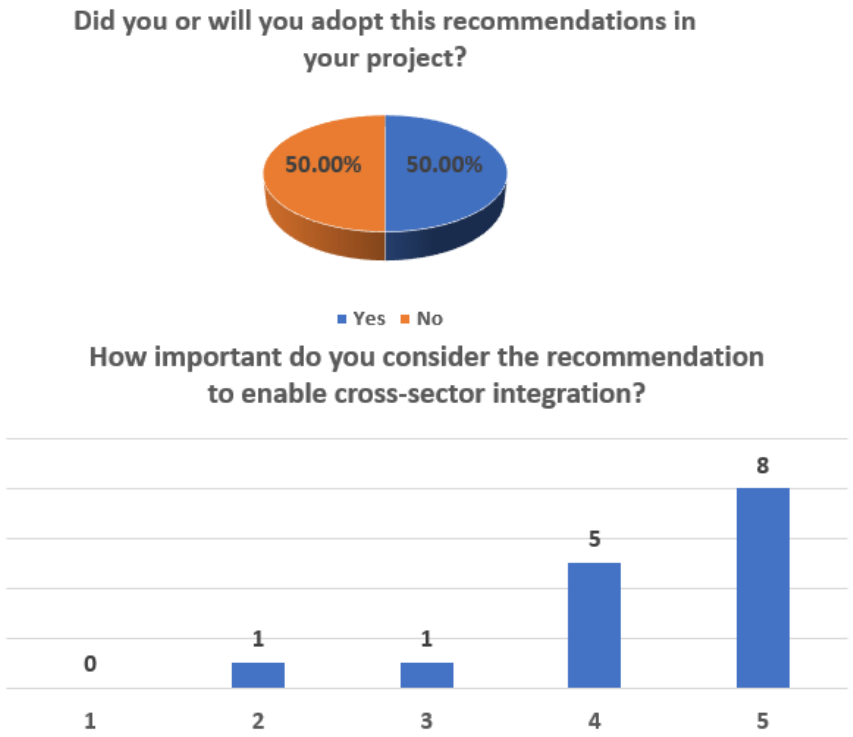


Figure 20. Question 8 of the survey about information layer (data models and profiles)

Still, half of the projects claim to follow the recommendation for the data models and profiles (Figure 20). And the projects also classify as highly important to consider this recommendation for broad implementation in cross-sector applications. Within the recommendations provided by the projects, they mentioned that the SAREF and the InterConnect ontology are good starting points. The project also claims to encourage the designation and sharing of schemes of data profiles. It is reported that Web-based languages using the linked-data principle can ease this (RDF, SPARQL, JSON-ld). In addition, the projects have also raised issues related to the exchange of private data, which is increasingly important, including in cross-sector data exchange. According to the projects, this should be supported by the availability of data modelling profiles, incl. for the management of data owners' consent.

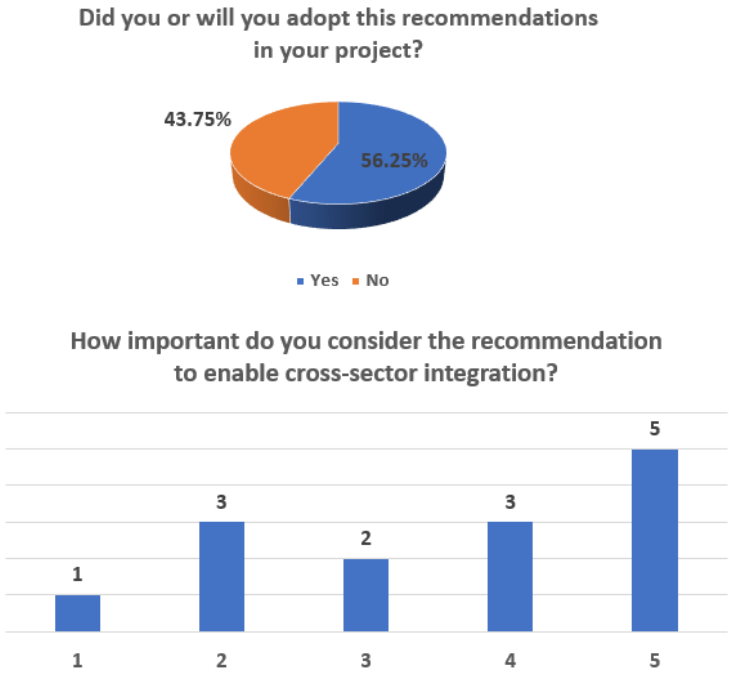


Figure 21. Question 9 of the survey about communication layer (protocols)

Concerning the communication layer (Figure 21), about 57% of the projects follow the recommendation on the protocols. However, the projects mention they will have to implement a given protocol for data exchange and communication, even if they are protocol agnostic. For example, it is mentioned that REST APIs are, from the practical point of view, a standard for interesting between platforms, and it is not protocol agnostic.

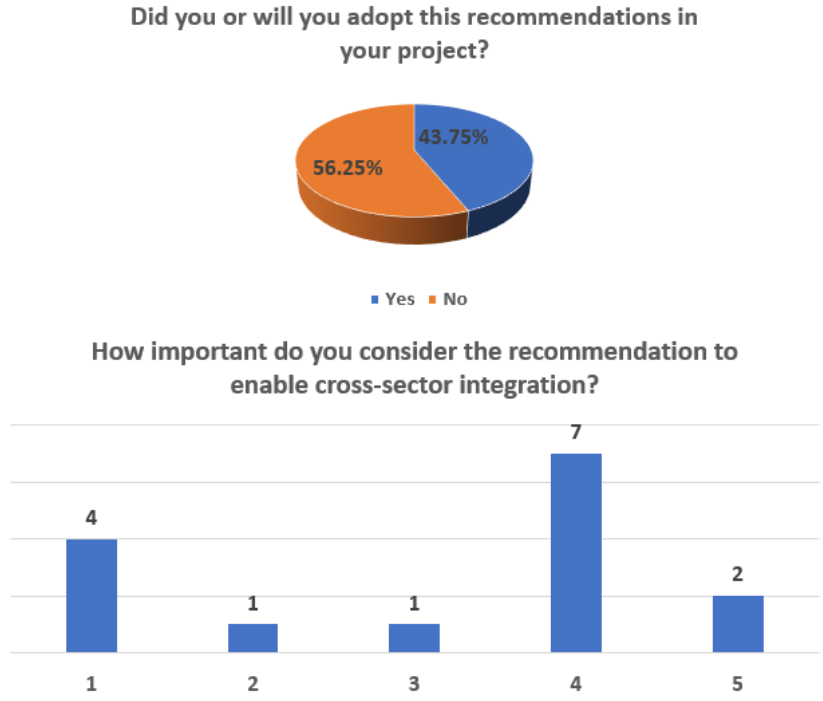


Figure 22. Question 10 of the survey about communication layer (data formats)

In turn, for data formats, around 56% of the projects are not following (Figure 22). However, the projects classify as 4 the importance of this recommendation to enable cross-sector integration. It is reported by the projects that the critical point will be selecting the format to be used, which makes sure it is open and standard. Also, it is important to share the methodology associated with profile definition, taking advantage of the outcomes from TDX-ASSIST or EU-SysFlex (using IEC CIM) or in PLATOON (using SAREF). These findings should be shared and well-known in order to reach semantic interoperability. In this sense, it is suggested the "Semantic Interoperability Framework" developed by the InterConnect project, which ensures that all data is exchanged with the common format supported by the semantic interoperability layer.

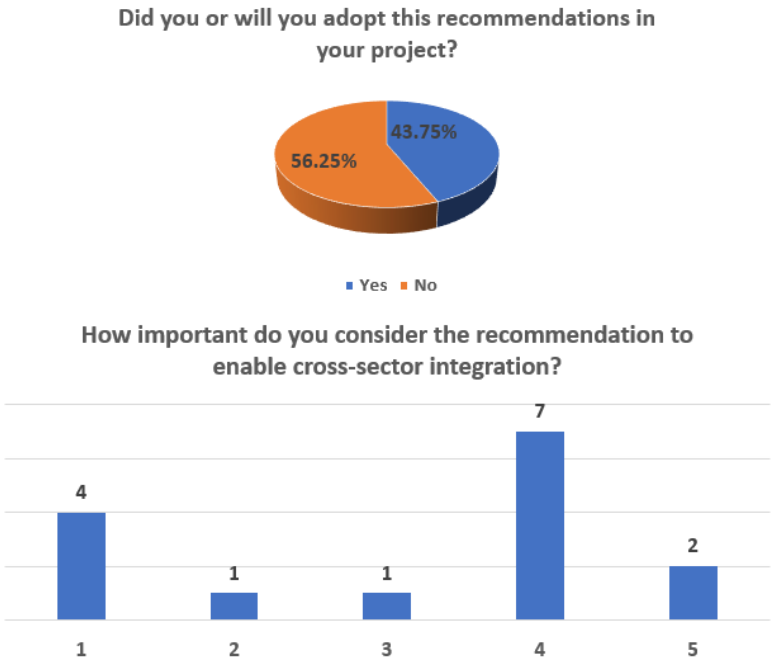


Figure 23. Question 11 of the survey about component layer (data exchange platforms)

In terms of the component layer (data exchange platforms), most of the projects (62.5%) follow this recommendation and give the highest classification of its importance for cross-sector integration (mostly 4 and 5). From the feedback provided by the projects, one can identify that interoperability is the main concern. It also reported the usage of DEP (Data Exchange Platform) like ECCo SP and ENTSO-E Transparency platform as platforms that allow publication of data and access data by using API. Moreover, the projects also claim that would be interesting to have a global overview of these different data sources, in which context they might be used, by which stakeholders and which are their APIs. One of the projects states that the DEP to be considered should be the ones that already exist or newly by the actors that will participate in data exchange arrangements. According to this project, the creation of data hubs playing as data intermediaries shall be avoided. The justification given by this project is that communications should be end-to-end when that's technically feasible.

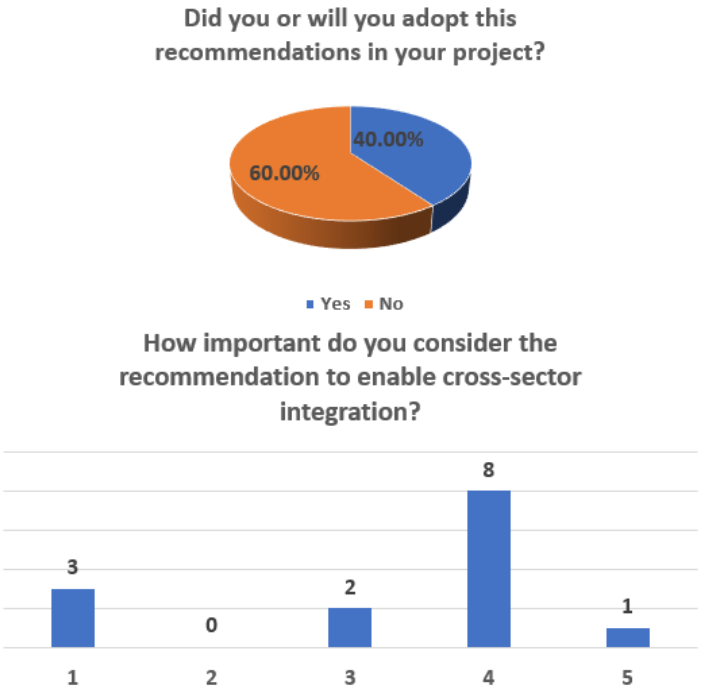


Figure 24. Question 11 of the survey about component layer (data application)

On the other hand, 60% of projects do not follow the recommendation for data applications (Figure 24). Nevertheless, the projects classify as 4 in this recommendation for cross-sector integration. In the suggestions given by the projects, they mentioned the diversity of sectors may make it hard to define universal data processing applications; however, data presentation can be done universally. They also suggest creating an open "data applications catalogue".

The final graphs (Figure 25, Figure 26 and Figure 27) depict how the projects give the classification to the importance of the recommendations for each SGAM layer. By analysing this graph, one can detect that for the business layer special attention may be needed for the cooperation sub-layer. In this case, most projects classified only as 3 the importance of cross-sector integration. For processes, a large part of the projects considers the importance of this sub-layer as 4, while for regulation and data roles, the importance has the highest grade for most of the projects. In turn, for the information layer, both canonical data model and data modes and profiles had the highest classification in terms of importance for cross-sector integration. Lastly, classification 5 was given to the protocols and data exchange platforms in the communication layer. Data formats and data applications got 4 the highest grade for the most part of the projects.

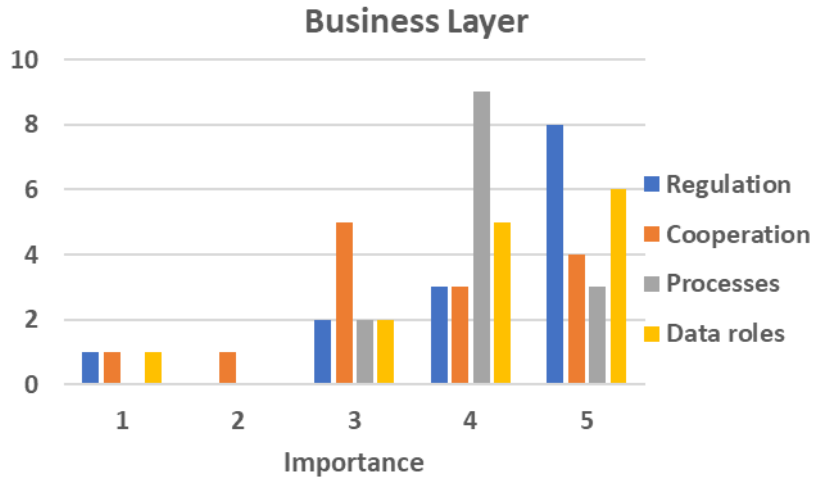


Figure 25. Classification of the DERA 2.0 recommendations for the business layer according to the survey

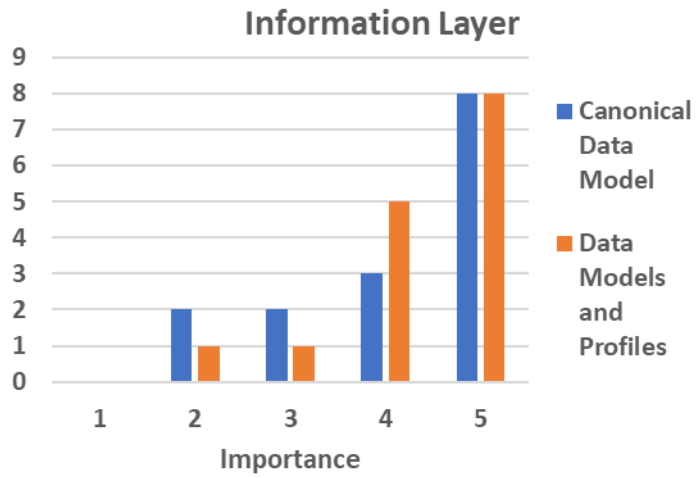


Figure 26. Classification of the DERA 2.0 recommendations for the information layer according to the survey

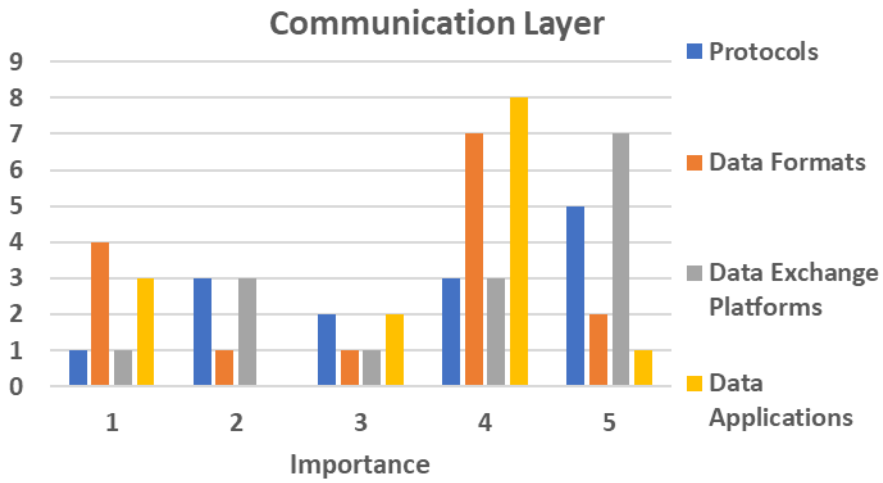


Figure 27. Classification of the DERA 2.0 recommendations for the communication layer according to the survey

4.2 Recommendations

This section presents and upgrades the recommendations towards implementing DERA 3.0. The upgrade of the recommendations takes the recommendations provided by the last version of the DERA (version 2.0) as a starting point. Then, the suggestions provided by the projects that answered the survey were considered to adjust the recommendations.

Topic	All SGAM layers
Findings	Smart Grid Architecture Model originated from European M/490 smart grid mandate. It was then used at IEC level and a document was published in 2021 (IEC 63200) explaining SGAM and the usage of domains, zones and the five interoperability layers. It explains how SGAM can be used and more importantly how architecture is defined with focus on Function Layer described through the System Actors. It has been extended to Gas and Heat. SGAM has also been used to document Power System Management Reference Architecture (IEC 62357-1). It's worthwhile to investigate adding additional or alternative components to SGAM satisfying the features of other sectors.
Recommendation	Leverage Smart Grid Architecture Model (SGAM) usage by completing it with data governance requirements, specifically from end-customer perspective, and map it to the reference architectures of other sectors (similar to the RAMI4.0 for industry – Reference Architecture Model Industrie 4.0; and CREATE-IoT 3D RAM for health – Reference Architecture Model of CREATE-IoT project), incl. for basic interoperability vocabulary with non-energy sectors.

Topic	Business layer – regulation
Findings	Electricity market directive is highly relevant in the context of meter data access and GDPR for personal data handling. Both indicate the increasing importance of private data to achieve interoperability inside electricity domain as well across sectors. Projects highlight the need to ensure data owners' control over their data. Many other emerging legislative acts are setting the scene for data

	management. In addition, IEC CIM is promoted through electricity network codes and guidelines.
Recommendation	Facilitate European strategy, regulation (harmonisation of national regulations) and practical tools for cross-sector exchange of any type of both private data and public data, e.g. through reference models for data space, common data governance and data interoperability implementing acts.

Topic	**Business layer – cooperation**
Findings	Inside the electricity sector the importance of TSO-DSO cooperation is deepening, it also has entered the area of data management. European institutions like EC and standardisation organisations (CEN, CENELEC, ETSI) promote cross-sector coordination and this is being taken on board by many BRIDGE projects. Several bottom-up initiatives are emerging to support cross-sector (and cross-border) data exchange – GAIA-X, FIWARE, IDSA, OPEN DEI, BDVA, AIOTI. Also the associations from different sectors (e.g. ICT4Water) could learn from each other and cooperate for further synergies, incl. in further defining of data exchange reference architecture. All this could be facilitated by some orchestration on European level.
Recommendation	Ensure cooperation between appropriate associations, countries and sector representatives to work on cross-sector and cross-border data management by establishing European data cooperation agency. This involves ongoing empowering/restructuring of the Data Management WG of the BRIDGE Initiative to engage other sectors and extend cooperation with projects that are not EU-funded and with European Standardisation Organisations (CEN-CENELEC-ETSI).

Topic	**Business layer – processes**
Findings	There are obvious dependencies of the electricity with other vectors of energy sector (e.g. gas, combined heat and power). Concurrently, the water sector presents interdependencies with electricity due the fact that water usage and delivery follows seasonal and weather changes. Projects from health, manufacturing and agri-food sectors confirm the feasibility and need for cross-sector business synergies. Data management business processes like data security & privacy, data analytics, etc. are similar to all energy vectors, also to water, but in many aspects also to any other sector (e.g. health, transportation).
Recommendation	Harmonise the development, content and accessibility of data exchange business use cases for cross-sector domain through BRIDGE use case repository. Track tools that identify common features on use cases, e.g. interfaces between sectors, and enable the alignment with any potential peer repositories for other domains. Also, the use case repository must rely on the HEMRM with additional roles created by some projects or roles coming from other associations (related to another sector than the electricity/energy sector).

Topic	Business layer – data roles
Findings	Considering the universal nature of the data exchange roles HEMRM could be renamed to Harmonised Energy Role Model in order to facilitate interoperability at least among energy sectors (electricity, gas, heating & cooling). Harmonising the electricity roles and gas roles is already ongoing.
Recommendation	Use BRIDGE use case repository for aligning the role selection. Harmonise data roles across electricity and other energy domains by developing HERM – Harmonised Energy Role Model and ensure access to model files. Look for consistency with other domains outside energy based on this HERM – cross-sectoral roles. Harmonised Energy Role Model shall have clear implications and connections with data (space) roles such as data provider/consumer, service provider etc.

Topic	Function layer
Findings	The key transformation of both electricity domain and the cross-sector domain is the data exchange and management. It is essential to identify a set of comprehensive functional data processes that will allow the data sharing, data governance etc. towards the exploitation of cross-sector exchanges to achieve certain business processes. Consequently, and in line with European Interoperability Framework [EC, 23.03.2017] in a common reference architecture common functional block can be defined for standardised data governance such as data source integration, data handling, consent management, etc.
Recommendation	Define and harmonise functional data processes for cross-sector domain, using common vocabulary, template and repository for respective use cases' descriptions. Harmonisation of functional data processes for cross-sector data ecosystems including Vocabulary provider, Federated catalogue, Data quality, Data accounting processes, Clearing process (audit, logging, etc.) and Data tracking and provenance.

Topic	Information layer – canonical data model
Findings	The development of use cases according to IEC 62913-1 (Generic smart grid requirements) allows to define Business Objects which have to be exchanged between Applications, Systems, Functions providing interfaces. Business Objects define the semantics that has to be exchanged. The Canonical Data Model is used to define the Business Objects (information exchange requirement). It is equally important to develop mechanisms for life-cycle management of the canonical data model (facilitating enrichment with new concepts, extension to further domains, relations' management, etc.).
Recommendation	Define and maintain a common reference semantic data model, and ensure access to its model files facilitating cross-sector data exchange, by leveraging existing data models like Common Information Model (CIM) of International

	Electrotechnical Commission (IEC) and ontologies like Smart Appliances Reference Ontology (SAREF).

Topic	Information layer – data models and profiles
Findings	European electricity sector has put in place a robust methodology based on system approach, which promotes interoperability by using standards (Use Case definition, Harmonised Electricity Market Role Model, canonical data model like IEC CIM, Smart Grid Architecture Model). It would be valuable to extend this approach to other energy vectors and to cross-sector domain. In order to facilitate data exchange between sectors, it would make sense to develop cross-sector data models. Profiles define how the semantics of an interface relate to a common semantic data model. Profiling methodology is defined in IEC 62361-103. IEC CIM and IEC 61850 can be followed in elaborating the profiling methodology for common semantic data model.
Recommendation	Develop cross-sector data models and profiles, with specific focus on private data exchange. Enable open access to model files whenever possible.

Topic	Communication layer – protocols
Findings	Some communication protocols reported by the projects involve: HDFS (Hadoop Distributed File System) layered on top of the TCP (Transmission Control Protocol) / IP (Internet Protocol); internal data processes (e.g. data request and ingestion) among services are mostly following REST web services over secure HTTP connections; IEC CIM XML files can be exchanged through AMQP interface of ECCo SP.
Recommendation	Ensure protocol agnostic approach to cross-sector data exchange by selecting standardised and open ones.

Topic	Communication layer – data formats
Findings	Data profiles use data format, i.e. syntax: XSD, RDFS, etc. The choice of the syntax is closely related to the communication protocol, and implementation considerations. A profile can be derived in different syntax. In particular, the main information model syntax clearly appears to be IEC CIM XML format in its different versions according to the application.
Recommendation	Ensure data format agnostic approach to cross-sector data exchange. The work done by projects like TDX-ASSIST and EU-SysFlex (using IEC CIM), and PLATOON (using SAREF) must be shared and made known to consolidate the approach in

	order to reach semantic interoperability. Metadata must also be taken into account.

Topic	Component layer – data exchange platforms
Findings	BRIDGE projects are increasingly using business process agnostic data platforms, e.g. ECCo SP, Estfeed, IEGSA, Atos FUSE, Enterprise Service Bus, Cloudera, etc. The platforms should be made available to other R&I projects. Interoperable data exchange platforms embody functionalities across all the interoperability layers as defined in the SGAM framework. The interconnection of such multiple data exchange platforms would release data-driven services among the different stakeholders.
Recommendation	Promote business process agnostic DEPs (Data Exchange Platforms) and make these interoperable by developing APIs (Application Programming Interfaces) which enable for data providers and data users easy connection to any European DEP but also create the possibility whereby connecting to one DEP ensures data exchange with any other stakeholder in Europe. DEPs shall explore the integration of data space connectors towards their connectivity with other DEPs including cross-sector ones.

Topic	Component layer – data applications
Findings	Projects use wide range of existing and newly developed applications for data management. For example, there are many applications in the area of Advanced Distribution Management Systems (ADMS), capable to interpret meter and sub-meter near-real-time data or historical data into useful information regarding the operational state of the power system.
Recommendation	Develop universal data applications which can serve any domain. Develop open data driven services that promote also cross-sector integration collectively available in application repositories.

5. Pilot implementation

This Chapter reports the efforts performed under sub-action 1 on the pilot implementation of the reference architecture, detailing the BRIDGE federated catalogue implementation as well as the use case story of a cross-project linkage implementation.

5.1 BRIDGE federated catalogue

5.1.1 Reference points

The implementation of this year focused on the design and development of the BRIDGE data and service federated catalogue. The catalogue aims to be a central reference tools towards the establishment of data, services and applications interoperability. The rationale relies on extending the implementations of OneNet project that proposed the OneNet Cross-Platform Services (CPS) for the energy sector and potential the energy data space instance [12]. The CPS were initially developed as a matter of establishing data and service interoperability among third party platforms, providing a formal definition and representation. A standardised process would define functional specifications, functional description, semantic definition and data quality requirements.

In BRIDGE, DERA the from its former versions addressed questions for the energy transition i) how to embody the demand side flexibility services derived from such new assets and actors into energy market, utilising them for operational and ancillary services capable to tackle any technical issues ensuring resilience, efficiency and reliability for the modern power networks, spanning flexibility potential – even from residential consumers – in the foreground of system operation and planning, ii) enabling data and service marketplaces assuring cross-sector integration (i.e., beyond energy sector) exploring cross-sector flexibility sharing. All these solutions need to assess interoperability features assuming also comparability, appropriate standardisation and transversal governance.

Accordingly, there is need at least for a platform/framework/architecture that enables different applications and (energy) roles and actors, able to be modular enough to serve multiple objectives and possibly capable to be used in cross-sectoral applications. It should be, also, able to use existing data models, and map these to a higher level of abstraction and (semantic) interoperability. Data models and architecture should be open source. Using standards is preferred. Security and privacy is important, but still difficult to embed from the start in the architecture. As reflected in previous Chapters the adoption of data space approaches addresses conceptually such issues, yet the actual implementation of open tools and components to orchestrate domain agnostic data, services and applications. For instance, both FIWARE and IDSA propose the **Vocabulary Hub/Provider** solution to provide a web-based vocabulary registry where all project stakeholders are able to seek for data vocabularies relevant to the project/use case. This includes both standard vocabularies (i.e. ontologies like OEO (Open Energy Ontology) but also others like Smart Data Models) and non-standard vocabularies (i.e., data models specifically for data from a certain use case in a pilot). Through the Vocabulary Hub, the developer of domain-specific vocabularies the tools and functions to create, improve, and publish their terms. While it is expected that these vocabularies follow the RDF pattern, further requirements like the Linked Data concepts or even formal ontologies are not enforced [13].

Another relevant important component stemming from data space initiatives is the **App Store/Data Apps** that acts as a secure platform for both service providers and service consumers. For service providers is important for the registration and maintenance of their applications, making them available (i.e., through the necessary meta-data descriptions), whilst for service users to discover and, then, use new applications.

5.1.2 Introducing the implemented BRIDGE federated catalogue

The rationale of proposing the BRIDGE federated catalogue relies on creating a reference tool that would support the creation and formalisation of interfaces for third party platforms from any sector (as a matter of fact supporting cross-sector linkages) as illustrated in Figure 28. The idea originates from the OneNet project's CPS that were developed to facilitate data exchanges among existing platforms, services, applications, and devices, to ensure system requirements' IEC standard formats (i.e., IEC 62325, 61970 etc.), standardised file formats, metadata, vocabularies and identifiers [12].

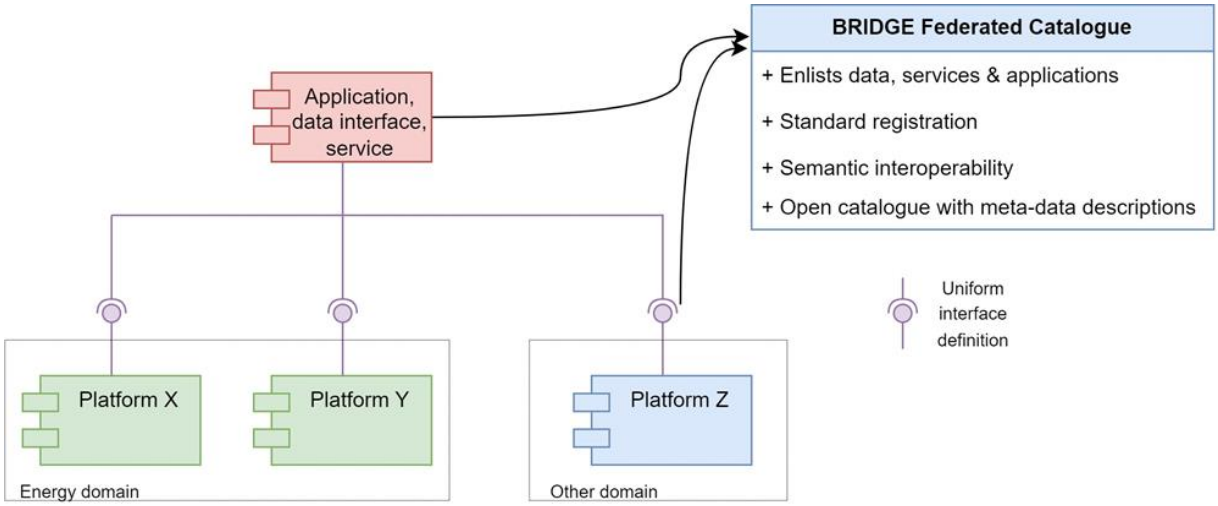


Figure 28. Federated cataloguing of services, data and applications' interfaces

The BRIDGE federated catalogue aims to propose a standard form to register data (business objects), services and applications (data-driven applications that transform data sources). These, in turn are useful for the realisation of data exchanges among different actors, systems, platforms assuming the technical specification of those interfaces which are independent of any implementation or application. The actual realisation of these interfaces, meaning the operational realisation, including the communication protocols (e.g., APIs), can be based thereafter at any open specification and it is not part of this cataloguing process.

The proposed BRIDGE federated catalogue aims to leverage data, services and applications from different domains, including the cross-sector ones, fact which justifies the term of federation. It is assumed to be a web-based tool, which would allow users to openly view, register and propose improvements in existing business objects, services and applications. The conceptual registration of new items is presented on Figure 29.

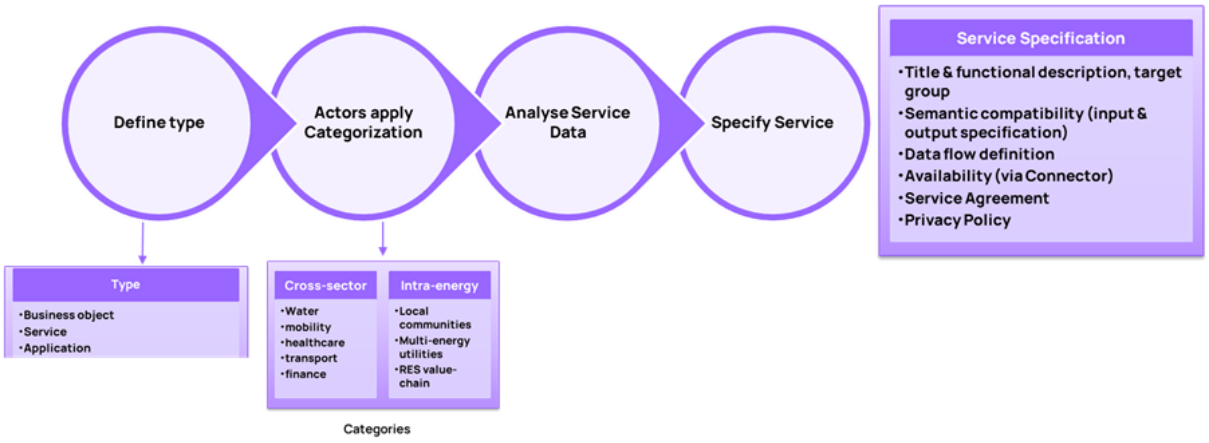


Figure 29. Preliminary proposal for registering new item in the BRIDGE federated catalogue

The Figures 30-32 depict a first draft version of the BRIDGE federated catalogue. The domain specification refers to linking information of interest for the new item (i.e., that is used for tagging and querying purposes, as well as for their taxonomy).

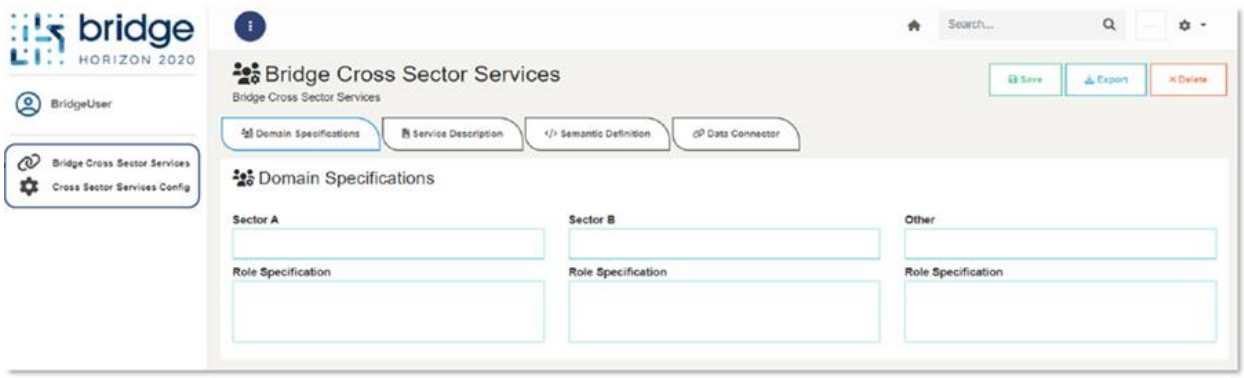


Figure 30. Registering new item: Domain specification

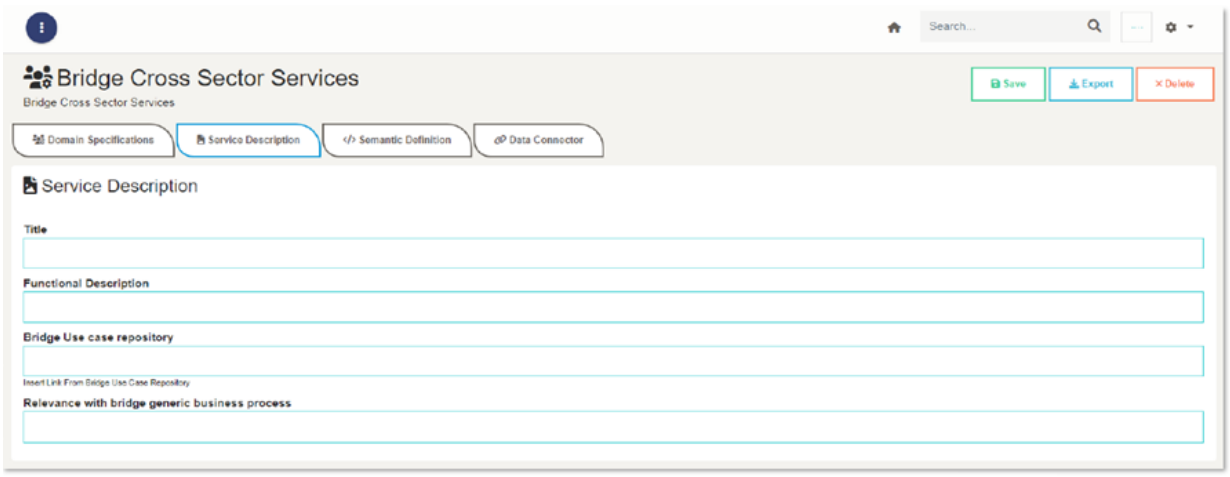


Figure 31. Registering new item: Service description

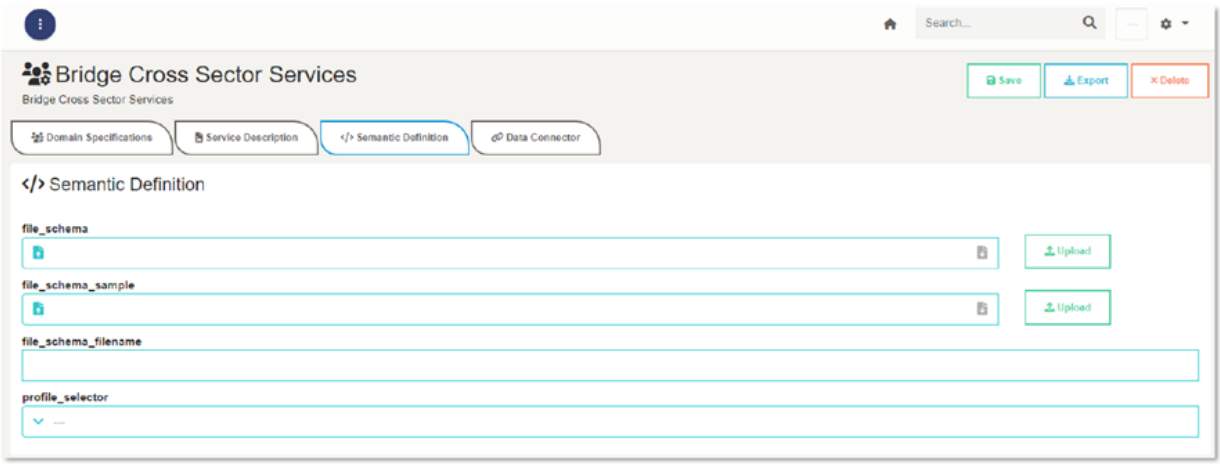


Figure 32. Registering new item: Semantic schema specification

5.2 Cross-project integration: A Use Case

Related to actual implementation of realising BRIDGE cross-project interoperability, OneNet project with its developed solution, the OneNet connector, proposed in this regard an energy specific Use Case linking together Platone and INTERRFACE projects [11]. The OneNet project reflects its developments and compliance with DERA and promotes the cross-project data exchange implementation by exploiting its technical developments for the realisation of open services. Based on these services, the proposed approach is to utilise the OneNet connector as the facilitator of seamless and secure cross-project data exchange. The technological developments allow for the discoverability of third-party platforms from different projects opening the path for cross-sector interconnectivity.

The OneNet connector instantiates a broad part of BRIDGE DERA, including the usage of domain agnostic principles such as IDS Connector and FIWARE Context Broker. This enables the trusted data exchange, a virtual data space leveraging existing standards and technologies, as well as governance models well-accepted in the data economy, to facilitate secure and standardised data exchange and data linkage in a trusted business ecosystem. The utilisation of the OneNet connector provides access to a set of standardised data services (i.e., CPS), common authorisation and authentication services, peer-to-peer data exchange, easy to use via GUI or open APIs.

This use case, that can be generalized for any cross-sector interconnections, with the use of the OneNet connector, is depicted in Figure 33.

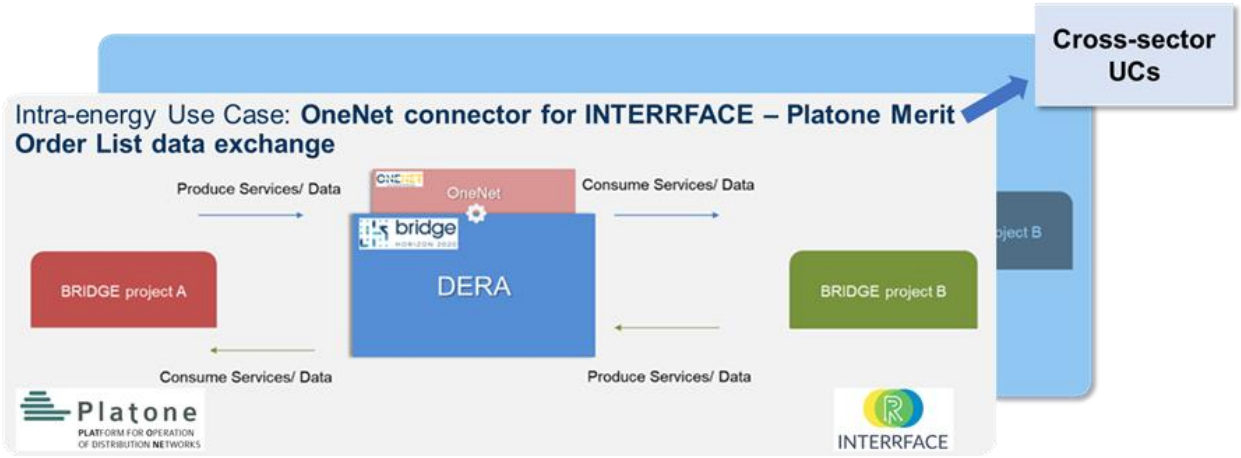


Figure 33. OneNet connector as the facilitator of cross-project data exchanges [11]

The implemented use case is energy related, where two different operational platforms exchange information in a decentralized manner using the OneNet connector. The main objective of this use case is the following:

1. Extract information about the Merit Order List (MOL) for a specific intra-day congestion management (CM) service, as assessed by both TSO and DSO at IEGSA Platform.
2. Retrieve the CM-MOL at Platone Market Platform and ingest the information there for the market realisation.

The internal steps for the discoverability of the two platforms, the service selection, subscription and information exchange are handled through the OneNet connector's GUI. It is important to note that both IEGSA and Platone platforms have performed the local deployment of the OneNet connector, allowing them to be part of the wider OneNet data ecosystem.

This use case showcased the streamlined interconnection of the two third-party platforms that managed their successful interconnection based on service and data interoperable solutions.

6. Next steps

Potential topics for 2024/2025:

- Next DERA version ("DERA 4.0") not to be prioritised (but maybe version 3.1 if needed for slight improvements);
- Making sure recommendations still apply to DERA 3.0;
- Restart work on data role model;
- Business requirements of data space – consider in later phase, once data space projects more advanced;
- Implementation, deployment of DERA 3.0 inside and outside BRIDGE –
    - Common data space perspective (Gaia-X, Int:net, data space projects, Data4Energy)
    - Data interoperability implementing acts perspective („Joint Working Group")
    - Industry perspective (ENTSO-E, DSO Entity, ESOs, SmartEn, other associations)
    - Customer/citizen perspective
    - Standardisation perspective (future IEC 63417 System Reference Document: "Guide and plan to develop Smart energy Ontologies"

Sub-actions for 2023-2024:

1. Release BRIDGE Federated Service Catalogue tool and associated process.
2. Release DERA interactive visualisation tool.
3. Follow up the implementation of DERA 3.0 in BRIDGE projects (mapping to DERA)
4. Update recommendations to comply with DERA 3.0.
5. Develop / enhance the "data role model".

Horizontal and continuous action: Foster implementation and deployment of DERA 3.0 inside and outside BRIDGE.

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Annex. Glossary

Term	Definition	Source
Architecture	Fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution.	CEN-CENELEC-ETSI [2012] with reference to ISO/IEC/IEEE 42010
Canonical data model	A semantic model chosen as a common dialect for a data exchange.	
CIM standards of IEC	IEC CIM standards aim to: • simplify integration of components and expand options for supply of components by standardising information exchanges; • reduce complexity with clear consistent semantic modelling among different points of integration; • clarify data mastership across any domain; • establish data flow between components without directly coupling their design.	[Britton]
Data format	Data format in the meaning of file format is a standard way that information is encoded for storage in a computer file. It specifies how bits are used to encode information in a digital storage medium.	Wikipedia
Data model	An abstract model that organises elements of data and standardises how they relate to one another and to the properties of real-world entities.	Wikipedia
Information model	A representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse. Typically it specifies relations between kinds of things, but may also include relations with individual things. It can provide sharable, stable, and organised structure of information requirements or knowledge for the domain context. An information model provides formalism to the description of a problem domain without constraining how that description is mapped to an actual implementation in software. There may be many mappings of the information model. Such mappings are called data models, irrespective of whether they are object models (e.g. using UML), entity relationship models or XML schemas. The information model now serves two purposes. First, to aid future software design in creating robust data models, for example by supporting different customer address types.	Lee [1999] Wikipedia McNamee [2018]

Term	Definition	Source
	Secondly, to enforce a common terminology across the system landscape and in the documentation	
Interoperability	The ability of two or more devices to exchange information and use that information for correct cooperation to perform the required functions. In other words, two or more systems are interoperable, if they are able to perform cooperatively a specific function by using information that is exchanged.	SGTF EG1 [2019], IEC 61850-2010 [2012]
Ontology	A representation, formal naming and definition of the categories, properties and relations between the concepts, data and entities that substantiate one, many or all domains of discourse.	Wikipedia
Profile	Specifies standards for particular business problems. Defines how the semantics of an interface relate to the Canonical Data Model.	[Britton]
Protocol	Communication protocol is a system of rules that allow two or more entities of a communications system to transmit information via any kind of variation of a physical quantity. The protocol defines the rules, syntax, semantics and synchronisation of communication and possible error recovery methods. Protocols may be implemented by hardware, software, or a combination of both.	Wikipedia
Reference architecture	A Reference Architecture describes the structure of a system with its element types and their structures, as well as their interaction types, among each other and with their environment. Describing this, a Reference Architecture defines restrictions for an instantiation (concrete architecture). Through abstraction from individual details, a Reference Architecture is universally valid within a specific domain. Further architectures with the same functional requirements can be constructed based on the reference architecture. Along with reference architectures comes a recommendation, based on experiences from existing developments as well as from a wide acceptance and recognition by its users or per definition.	CEN-CENELEC-ETSI [2012] with reference to ISO/IEC42010
(Reference core) process model	A representation of harmonised processes for information exchange within the energy sector so that these processes may be implemented as such or as the basis for a customised version according to regional/national business needs.	SGTF EG1 [2019]
(Reference) information model	A representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for the energy sector.	SGTF EG1 [2019]

Term	Definition	Source
Role model	A model representing core functions/responsibilities in the energy sector and their interdependence.	SGTF EG1 [2019]
Semantics	Understanding of the concepts contained in the message data structures. Understanding of the information that needs to be accessed/exchanged. The semantic aspect refers to the meaning of data elements and the relationship between them. It includes developing vocabularies and schemata to describe data exchanges, and ensures that data elements are understood in the same way by all communicating parties.	SGTF EG1 [2019], European Interoperability Framework [EC, 2017]
Semantic model	A structured description of the semantics of a set of information, using some information modelling language (e.g. UML). A semantic model is 'metadata' – 'data about data'. Many different semantic models are possible for the same semantics, even within one modelling language. Semantic modelling only represents information content – it does not include formatting/encoding (syntactical) specifications.	[Britton]
Semantic transformation	A procedure for converting a given semantics from one semantic model representation to another. This should be distinguished from a syntactic transformation that converts from one format to another (e.g. CSV to XML).	[Britton]
Syntax	Understanding of data structure in message exchanged between systems. Technical aspects (e.g. formats, technologies used) of the information that needs to be accessed/exchanged. The syntactic aspect refers to describing the exact format of the information to be exchanged in terms of grammar and format.	SGTF EG1 [2019], European Interoperability Framework [EC, 2017]
Use case	A list of actions or event steps typically defining the interactions between a role (known in the Unified Modelling Language (UML) as an actor) and a system to achieve a goal. The actor can be a human or other external system.	Wikipedia

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