# Lessons Learned from Energy Data Spaces Cluster Projects:

## Challenges, Insights, and Best Practices

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SYNERGIES

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EUROPEAN DISTRIBUTED DATA INFRASTRUCTURE FOR ENERGY

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# CONTENTS

# 1. Introduction

This document presents the key learnings from pilot validations within individual Energy Data Space Cluster Projects (EDSCP). Together with the Blueprint of the Common European Energy Data Space (CEEDS) [1], these learnings aim to inform the implementation of and sketch a path forward to enable the deployment and adoption of future CEEDS.

## 1.1. Scope and reading suggestion

The document is designed to capture valuable insights, challenges, and best practices that emerged during the implementation and pilot validation phases[1] of the EDSCP. For details on specific implementations or building blocks, readers are encouraged to consult the CEEDS Blueprint [1]. Section 2 highlights key lessons learned, focusing on stakeholder engagement and integration challenges. In response to these challenges, Section 3 provides best practices and recommendations for the deployment of the CEEDS.

[1] At the time of publishing this document, the projects DATA CELLAR, EDDIE and SYNERGIES were still ongoing. Interested readers may refer to the project websites to find more details of the pilot validation.
DATA CELLAR Website: https://datacellarproject.eu/, EDDIE Website: Home - EDDIE - European distributed data infrastructure for energy, SYNERGIES Website: https://energydataspaces.eu/ . An overview of the projects' goals and results can also be found in the CEEDS Blueprint[1].

# 2. Key Lessons Learned

## 2.1. Stakeholder Engagement

Stakeholder engagement for data sharing is imperative to the success of a data space. All projects pointed out challenges encountered towards stakeholder engagement.

- The federated architecture of data spaces offers advantages for preserving data sovereignty compared to traditional data platforms; however, existing misconceptions are hindering stakeholder participation. Stakeholders falsely equate federation with full decentralization or treat it as the end goal, whereas in practice it involves dynamic, context-dependant distribution of responsibilities while maintaining crucial central functions[2].
- Establishment of robust data security, privacy, and confidentiality protection mechanisms plays a significant role in fostering stakeholder trust in data sharing.
- The need to interpret and comply with multiple overlapping regulations (General Data Protection Regulation (GDPR) [2], Data Act [3], ePrivacy [4]) complicates implementation and hinders new stakeholder participation. Moreover, few initiatives offer clear, automated ways to onboard or certify new participants, further slowing adoption.
- In federated data spaces, the responsibilities between data owner, data provider, and data intermediary are often blurred leading to conflicting or redundant duties performed by them. There is no unified way of defining who can do what with shared data, resulting in uncertainty and risk for stakeholders.

## 2.2. Integration challenges

- The integration of data space connectors into pilots is initially hindered by the varied technical expertise of involved stakeholders.
- Data Readiness Issues:
  - Although data may be technically accessible, it often requires extensive sanitization and normalization before effective sharing can occur.
  - Third-party repositories often resist granting access to data owned by others due to fundamental conflicts between data ownership rights and their strategic interests in maintaining control [5]. This reluctance stems from multifaceted concerns including security vulnerabilities [5], competitive advantage preservation, regulatory compliance complexities, technical integration challenges, and the absence of clear legal frameworks governing data sharing arrangements.

[2] Further insights on stakeholder misconceptions regarding data federation are presented in this blogpost: Blogpost link.

    - Such resistance creates significant barriers to collaborative data spaces by establishing data silos, undermining collaborative principles, and limiting the collective value creation potential that these environments are designed to facilitate.
- Insufficient and unclear documentation can impede stakeholder engagement as well as integration processes.
- The fast-paced nature of software releases from the data spaces building blocks often compresses timelines, making integration and deployment processes more complex.
- The integration of multiple data transfer methods (e.g., file transfer, Application Programming Interfaces (APIs), PubSub) within Energy Data Space connectors presents significant challenges.
- Achieving semantic interoperability can prove difficult unless all data space participants adopt a Common Semantic Data Model (CSDM). This facilitates improved communication and interoperability among systems. Lack of alignment in domain ontologies and vocabularies limits interoperability between platforms. There remain gaps in existing standards, which necessitate custom data modelling for new concepts. Despite the adoption of open-source standards to harmonise data exchange, long-term efforts are needed to fully align Energy Data Spaces, and support integration with future ecosystems.
- Integration of cloud-edge systems and near-real-time data presents scalability and efficiency challenges, with security considerations becoming increasingly important.
- Incomplete implementation of obligations stemming from the Clean Energy Package (CEP) [6] in certain member states complicates integration efforts.
- There are possibilities for coexistence of different forms of governance models, for e.g. voting based decentralized model vs central authority. This poses architectural challenges.
- Although they are vital, provenance mechanisms such as trusted logging, are rarely implemented systematically across projects causing traceability and replication problems.

# 3. Best practices and recommendations

## 3.1. Stakeholder engagement

- **Tailored workshops or videos that explain data spaces** can be valuable towards early stakeholder engagement. Such tools can maintain stakeholder engagement and keep them informed without overwhelming them.
- Utilising **effective communication strategies** from Social Sciences and Humanities (SSH) can engage stakeholders as integral parts of the process, fostering a sense of inclusion and participation.
- Stakeholders' participation can be fostered by presenting them with **clear use cases that resonate with their interests and demonstrate tangible benefits**. When preparing such use cases, a business perspective and benefits that data sharing offers in this context can be taken into consideration.
- Stakeholder concerns regarding data security can be addressed by highlighting the **need for owner-centric mechanisms for anonymization and access control**, which can be enabled by specific data space building blocks.
- **Implementation of data protection mechanisms** in compliance with the Data Act or with GDPR to bolster stakeholder trust in data sharing.
- Close collaboration between data providers and service providers is essential to align on Data Space architecture, data formats, metadata availability, and connection mechanisms.

## 3.2. Addressing Integration challenges

- Using solutions such as Connector as a Service (CaaS) solution can significantly simplify integration processes for data space connectors in the pilots. If such solutions are not found suitable, **regular hands-on workshops or demonstrations for pilots** on how to integrate data space connectors can also address these challenges.
- **Comprehensive documentation** including technical guides, API references, user manuals, and integration procedures is essential for supporting technical integration, ensured interoperability, and enhanced usability. It is also critical so that users can understand how to effectively utilize the software and data available within the space.
- **Continuous maintenance and updates** are crucial for ensuring the long-term stability of data space components and their integration throughout the data space development lifecycle. In this regard, documentation also plays an important role.
- Semantic interoperability related challenges can be addressed by data space participants adopting a **CSDM**. This facilitates improved communication and interoperability among systems. There remain gaps in existing standards, which necessitate custom data modelling for new concepts. The **IEC Common Information Model (CIM)** [7] family of standards, particularly the European Style Market Profile (ESMP), is a promising candidate to address these

challenges. Shared ontologies and semantic tools like Vocabulary Hubs are essential for aligning data models across domains and ensuring machine-readable interoperability.

- The **DSSC co-creation method** [8] provides an approach to address development as well as operational questions with reference to the business and organisational, and technical-building blocks.
- "One-size-fits-all" standardisation for data models is difficult; **building dedicated transformations** based on use case needs is recommended.

## 3.3. Data Value Creation

- Pairing technical advancements with innovative business models can facilitate data monetization and trading.
- Stakeholders can advocate for **legally binding agreements** that can be tailored to meet their specific needs and comply with regulatory requirements.
- Data space experts need to showcase **tangible benefits**, for instance by providing data driven services tailored towards specific use cases while ensuring that the technology is functional and dependable, directly addressing the needs of stakeholders.
- Stakeholders should focus on **initiatives that resonate with their demands and interests**, fostering a more inclusive and collaborative environment.
- Enriching **data space connectors with value-added services** can transform data into tradable commodities and Artificial Intelligence (AI)-ready artifacts, thereby engaging the EU Information and Communication Technology (ICT) and AI ecosystem in the creation of advanced data-driven services for the energy sector.
- Creating **user-friendly, intuitive web interfaces** can bridge the gap between technical complexities and user needs, promoting wider adoption. Visual interfaces can significantly improve transparency and ease of use for non-technical audiences, making it easier to interpret energy analytics, and insights. Further, providing user-friendly graphical user interfaces (GUIs) that follow a no-code approach can enhance stakeholder engagement and facilitate the adoption of energy data spaces.

## 3.4. Standardization and Regulatory Compliance

Prioritizing interoperability at multiple levels is crucial to avoid the creation of isolated solutions that cannot integrate with corresponding implementations. For example, it is essential to emphasize the need for alignment on connector versions and contracting methods (e.g., utilizing blockchain) early in the development process.

- For seamless interoperability across data platforms, **define the technology stacks early**, specifying versions to minimize compatibility issues.
- It is vital to **establish identity systems from the outset**, along with clear documentation of participation and operational requirements. In this context, the use of electronic IDentification,

Authentication and trust Services (eIDAS) and electronic Identifications (eIDs)should be adopted by all relevant data platforms in the energy sector to ensure a common identification standard.

- Progressing towards pivotal information models and integrating with standardization processes is crucial for sustainable development. The **IEC CIM family of standards**, particularly the ESMP, is a promising candidate. Employing proven standards and technologies is vital for reliable data integration.
- While horizontal data space organizations[3] (e.g., GAIA-X, IDSA) advocate for **Data Space Connectors**, their maturity for commercialized data sharing requires improvement.
    - **Standardization within the data space technologies** is of utmost importance to ensure interoperability and prevent lock-in. It is recommended that Standardization activities of the committee ISO/IEC JTC/SC41 'Internet of Things and Digital Twins' be regularly monitored.
- Energy Data Space initiatives should also follow up closely with **standardization initiatives within the Energy sector** such as the activities of the IEC TC 57 "Power systems management and associated information exchange", particularly on the standards IEC 61850 and CIM. Furthermore, monitoring the activities of the standardization committee 'Platform for cross-sector data ecosystems' of the All Electric Society founded by the German Commission for Electrotechnical, Electronic & Information Technologies (DKE) is recommended[4].
- Understanding **region-specific factors** (e.g., hydrogen blending rules, cultural preferences for homeownership) and aligning with **local regulatory requirements** proves crucial for adapting data space solutions to each region's context.

## 3.5. Governance recommendations

- Using **federated identity and access control mechanisms** such as role-based, attribute-based, or verifiable credentials are critical to ensuring trust, security, and scalable participation in data spaces.
- Implementation of a **layered governance frameworks** is important to clearly define responsibilities across identity, access, policy enforcement, and tracking improve transparency, manage complexity, and foster accountability.
- Employ **trusted clearing houses and logging systems** to ensure traceability, support auditability, and enable enforcement of contractual and regulatory obligations.
- Testing on real-world pilots and testbeds can validate governance assumptions, surface operational challenges, and design adaptive, scalable governance models.

[3] More information of the goals of the organisations can be found on their respective websites. For GAIA-X: https://gaia-x.eu/ For IDSA: https://internationaldataspaces.org/

[4] For an extensive list of standards relevant for the energy domain, readers are recommended to refer to Annex C found in Deliverable 4.1 of the int:net project (accessible online, please see ref. [9]).

- The data space stakeholders should promote a **culture of interoperabilit**y by conducting workshops, sharing success stories, and offering training across stakeholder groups.
- A **dedicated interoperability management team** with clearly defined roles and responsibilities is beneficial for strategy and execution.
- Active engagement in **open-source initiatives** like OneNET[5] and the Eclipse Foundation[6] can foster adoption of common standards and encourage community-driven interoperability.
- **Collaborations with cross-sectoral Data Space Associations** (e.g., IDSA, DSSC) can be useful to share resources, governance strategies, and technical building blocks.
- Data space participants should align their governance frameworks with key European regulations and monitor evolving legal requirements.

[5] For more information on the OneNET project, please refer to: https://www.onenet-project.eu/onenet-framework/

[6] Please refer to the webpage of the Eclipse Data Spaces Working Group: https://projects.eclipse.org/working-group/eclipse-dataspace

# 4. References


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[9] B. Schmitt *et al.*, “D4.1 of the int:net project: Analysis of standards eenvironment relevant for int:net.”

# 5. List of Abbreviations

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **API** | Application Programming Interface |
| **CaaS** | Connector as a Service |
| **CEEDS** | Common European Energy Data Space |
| **CEP** | Clean Energy Package |
| **CIM** | Common Information Model |
| **CSDM** | Common Semantic Data Model |
| **EDSCP** | Energy Data Space Cluster Projects |
| **eIDAS** | electronic IDentification, Authentication and trust Services |
| **eIDs** | electronic IDentification |
| **ESMP** | European Style Market Profile |
| **GDPR** | General Data Protection Regulation |
| **GUIs** | Graphical User Interfaces |
| **ICT** | Information and Communication Technology |
| **IEC** | International Electrotechnical Commission |
| **ISO** | International Standards Organisation |
| **JTC** | Joint Technical Committee |
| **SSH** | Social Sciences and Humanities |
| **TC** | Technical Committee |
| **TSO** | Transmission System Operator |

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