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A Semantic Approach
to Integration
and Standardization

Presented by
Anna-Lena Peh

Achieving Interoperability in Energy Data Ecosystems

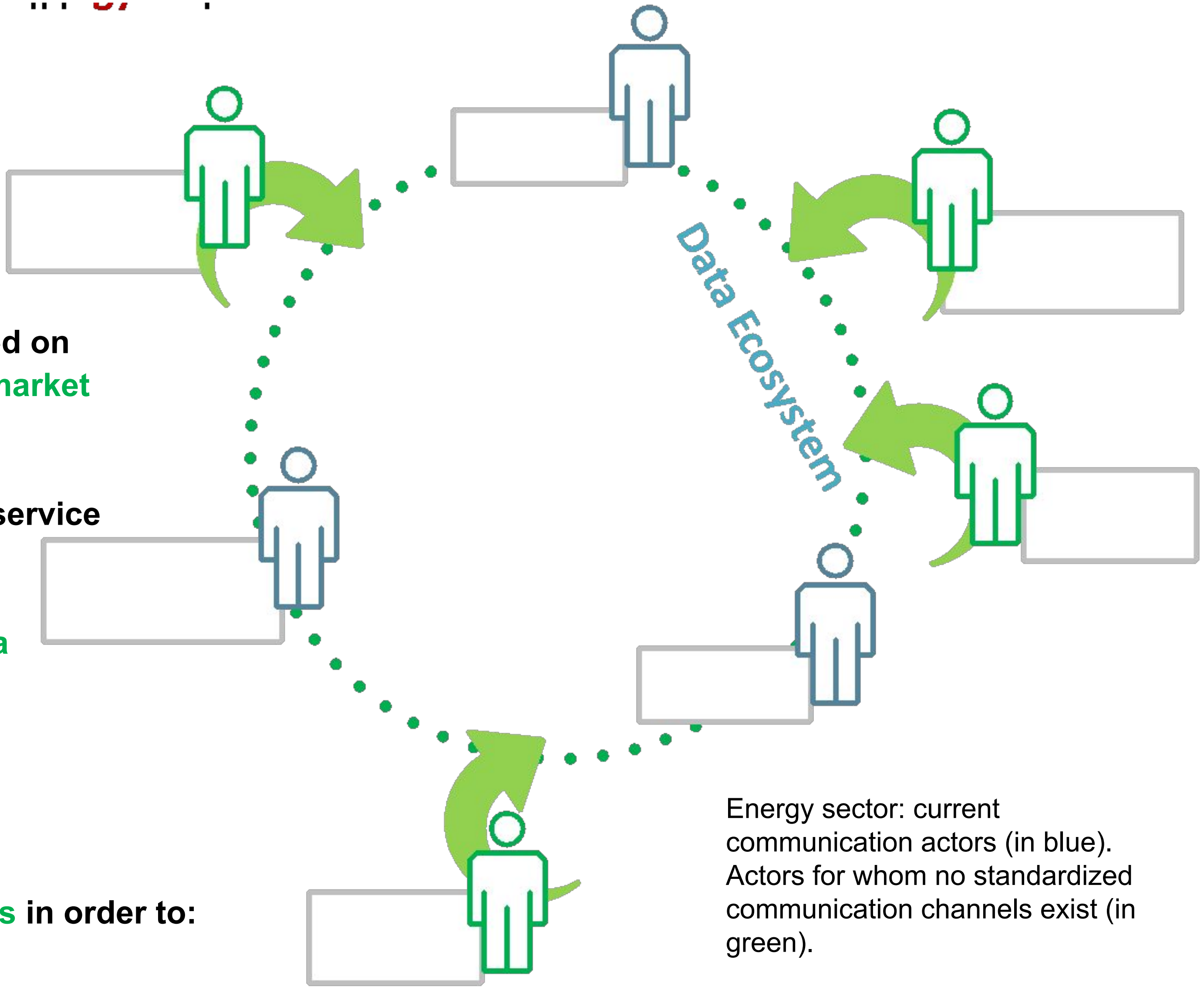
As of June 12, 2025

Challenges and objectives

of information exchange in the energy sector

Challenges in the energy sector

- **Communication in the energy sector has so far been based on legally regulated information exchange between defined market roles (e.g., grid operators, suppliers)**
- **Communication with other players (e.g., plant operators, service providers) – but without uniform, standardized rules**
- **The energy transition requires an open, interoperable data ecosystem that also integrates new players:**
  - Plant manufacturers
  - Hardware providers for energy grids
  - Forecast and data providers
  - Software service providers
- **Objective: These players should provide data and services in order to:**
  - operate the energy grid efficiently
  - optimize grid usage
  - support the transition to a renewable energy mix
  - success sector coupling



Energy sector: current communication actors (in blue). Actors for whom no standardized communication channels exist (in green).

unlock: innovation potential

[1]

Selected implementation concept – Data Space

What does the data space concept offer?

A data space is a collective, cooperative management of data for federated information exchange [2, 3]

According to the European Commission, the creation of common data spaces will enable the exchange and reuse of data within and between sectors (sector coupling). [7]

The Gaia-X Hub Germany white paper describes a data space as a concept that enables the efficient use and exchange of data by leaving the data where it is and only bringing it together when needed. [4]

Data spaces should provide and use federated and open components and infrastructures for sovereign data exchange based on common agreements, rules and standards [13,14]

The Data Space Support Centre (DSSC) bases its definition of data space on the ICS 35.030 standard for trusted data transactions. The definition of a data space is provided here. An interoperable framework based on common governance principles, standards, practices, and supporting services that enables trusted data transactions between participants. [5, 6]

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Benefits of the Data Space concept

Added value and benefits of data spaces

According to the European Commission, the creation of common data spaces will enable the exchange and reuse of data within and between sectors (sector coupling). [7]

reuse

FAIR principles

A data space is a collective, cooperative management federated of data fc

cooperative

federated

The data space does not belong to anyone alone, the group decides

Preserving the independence and autonomy

The Gaia-X Hub Germany white paper describes a data space as a concept that enables the efficient use and exchange of data by leaving the data where it is and only bringing it together when needed. [4]

only bringing it together when needed

Distributed Data Architecture. reduces entry barriers

Data spaces should provide and use federated and open infrastructures for sovereign data exchange based on common agreements, rules and standards

open

Open Standards. facilitate exchange

sovereign data

Participants stay in control of their data

standards

creates trust and increases willingness to share data

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interoperable

possibility of exchanging data between different systems

trusted data

generates willingness to participate

[8, 9, 10, 15]

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Challenge – federated, data sovereign and trusted Data Ecosystem

Federated information exchange

Federated Data Ecosystem: leads to greater willingness to participate in the data ecosystem

What is the challenge when implementing a federated data ecosystem?

- **Lack of central control**
  - No higher authority to set standards
  - Difficult coordination of data formats, and semantics
- **Heterogeneous system landscape**
  - Different, often proprietary IT systems
  - No uniform software solution for data provision and use
- **Tension between autonomy and interoperability**
  - Autonomy of participants is a central principle – but:
  - Without binding specifications, compatibility problems arise between data sources and sinks.
- **Challenge. Interoperability**
  - Data inconsistency. Without central data storage, there is a risk of inconsistent interpretation
  - Need for common standards. For data definition and exchange

If there is to be no dependency between components, the meaning of the data must always be present throughout the entire data ecosystem so that it can be integrated using innovative intelligent methods.

→ **Interoperability must be achieved at the semantic level.**

Semantic Interoperability

[8, 9, 10]

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Implementation: Different Data in Data Ecosystem

Utilization of Semantics in all Areas and Components

Internal asset data mapped semantically to its meaning

- **Semantically Annotated Offer Description (Metadata)**
  - Enrichment of data with knowledge through inferences
  - Improved search for offers
  - Accurate description of offers

- **Semantically annotated transmission data**
  - Integration of data across systems
  - Transmission of data with meaning
  - Shared understanding of data by all


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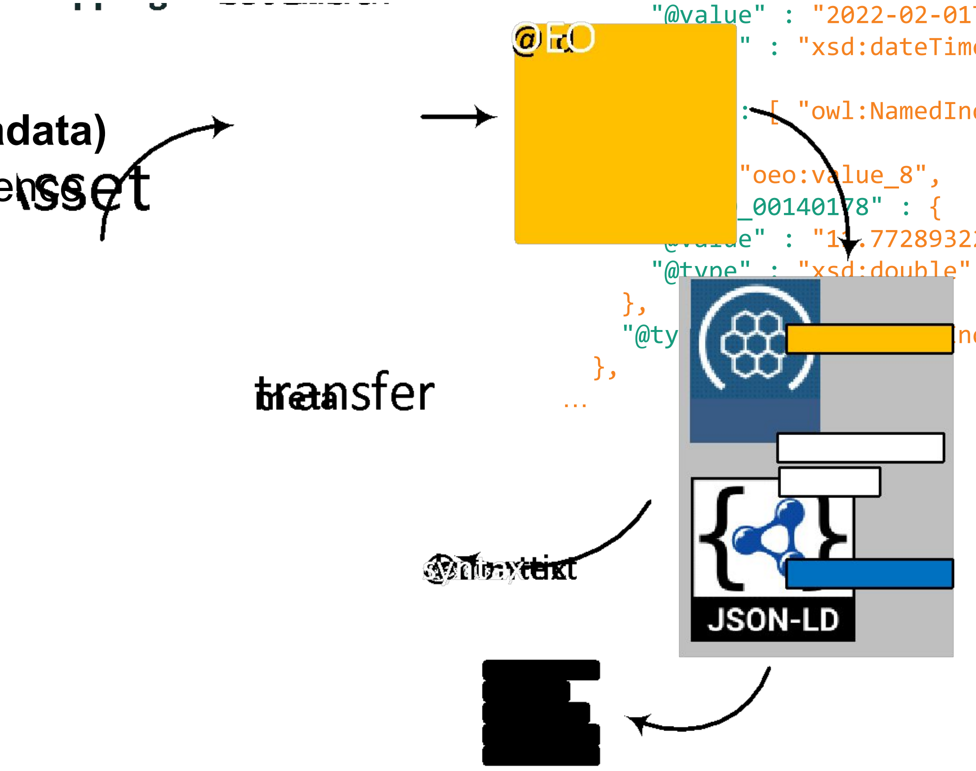

Transmission of Asset Data: OEO (Open Energy Ontology), Syntax: JSON-LD

[11, 12]

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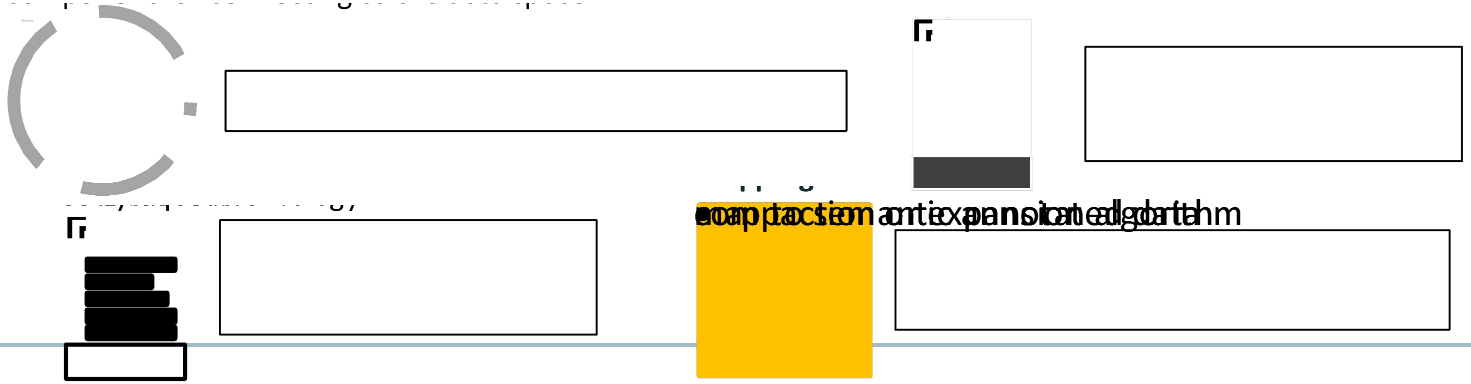
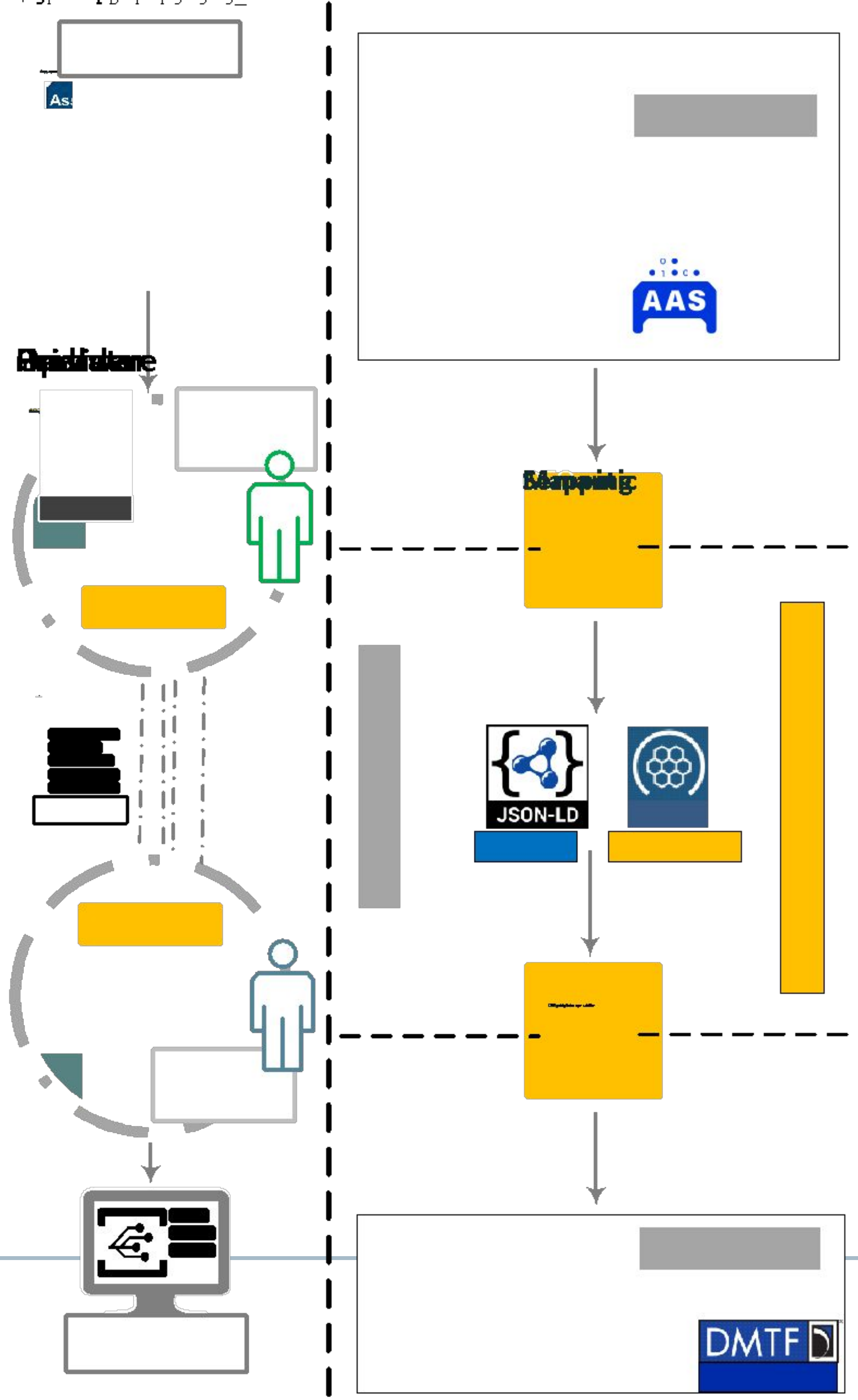
Implementation: Digital Twin via Data Space
Offering and transferring digital twins in data spaces

The data flow between the backend systems of the hardware provider and the grid operator when providing a digital twin (DT) via the data space

Energy Digital Twin Transfer

- **Hardware Provider**
  - Offer of physical components
  - Representation of DT in Asset Administration Shell (AAS)
- **Grid Operator**
  - Uses digital twin for grid simulation
  - Simulates whether the hardware is compatible with the grid
- **Interoperability**
  - Through Semantics





[11, 12]

Contact

M.Sc. Anna-Lena Peh
Department of Cognitive Energy Systems / Energy Informatics
anna-lena.peh@iosb-ast.fraunhofer.de

Fraunhofer-Institute of Optronics, System Technologies and Images IOSB
Am Vogelherd 90
98693 Ilmenau, GERMANY
www.iosb-ast.fraunhofer.de

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