# Managing Knowledge in Energy Data Spaces

2nd BDTIC dedicated to Building Digital Twins

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# OVERVIEW

- EU Energy Data Ecosystem
  - EU legislation
  - The vision
- Examples of Innovative Solutions for the Energy Data Ecosystem
  - Interoperability and Integration Framework
- Lessons Learned
  - The case of Serbia

Sinergy

Capacity building in **S**mart and **I**nnovative e**NERGY** management

PLATOON

Digital **PLA**tform and analytical **TOO**ls for e**N**ergy

# MOTIVATION

## Regional Centre of Excellence in smart energy management

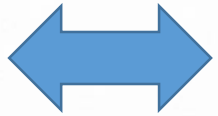
Sinergy

**Commercial Projects,**
https://www.pupin.rs/en/references


- Dispatching centers in Serbia
- Supervision of transmission network
- Supervision of entire distribution network
- Integrated  monitoring and balancing the SMM block

# CHALLENGES

- Digitalization of the energy sector
  - Energy Management Applications are fragmented, developed against energy data silos, and data exchange is limited to few applications
- Big Data in the energy domain
  - **modernisation of the European electricity grid** focuses on new smart grids services through **knowledge exploitation** => innovative **data-driven services**
  - **multi-party data exchange** while ensuring data governance and data sovereignty
- Integration of renewable energy sources (RES)



## EU Policy Framework

- European Green Deal, December 2019
- European Strategy for Data, February 2020
- Energy System Integration Strategy, July 2020
- Data Governance Act, November 2020

# DATA STRATEGY, 2020

- aim is to create a single **European data space** where personal as well as non-personal data, including sensitive business data, are secure and businesses also have easy access to an almost infinite amount of high-quality industrial data, boosting growth and creating value, while **minimising the human carbon and environmental footprint**.


- Technical tools for data pooling and sharing
- Standards and interoperability (technical, semantic)
- Sectoral Data Governance (licensees, access rights, usage rights)
- IT capacity, including cloud storage, processing and services

# DIGITAL ENERGY ECOSYSTEM VISION

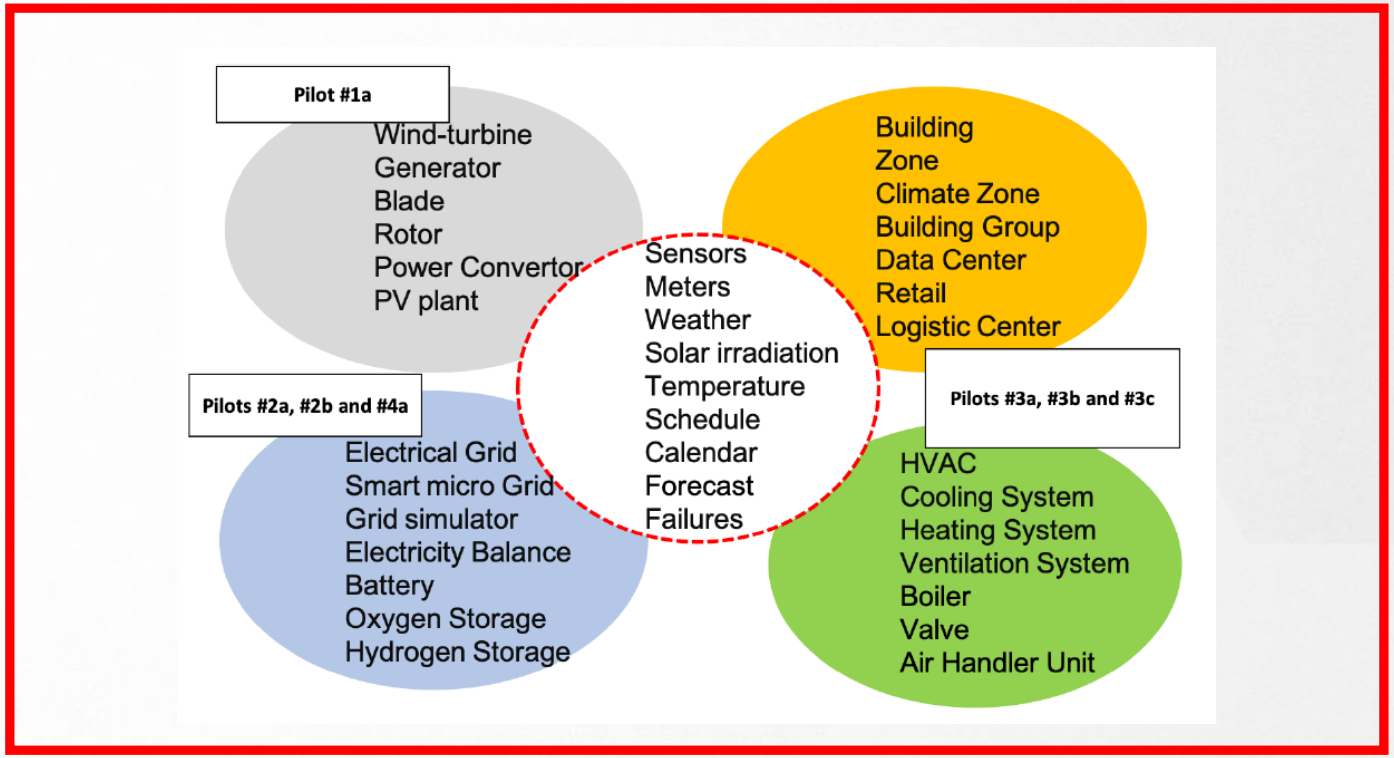
- **Digitalise the energy sector**, enabling thus higher levels of operational excellence with the adoption of disrupting technologies.
- Use SGAM (SG Architecture model)-compliant reference architecture for big data processing for the  energy sector.
  - => **interoperability** layer based open standards to ensure compatibility with different platforms and legacy systems.
- **Reinforce the European efforts for the modernisation of the European electricity grid**, as it focuses on new smart grids services through data knowledge exploitation => **data-driven services**
- **Enabling multi-party data exchange** while ensuring data governance and data sovereignty

INTERNATIONAL DATA SPACES ASSOCIATION

# RESEARCH QUESTIONS

## Interoperability and Integration Framework

- Which are the **concepts** and **properties** that characterize the energy domain, and which **ontologies** cover the needs for modelling the electricity value chain and **ensure uniform access to data** collected with the proprietary SCADA system?
- How to build a knowledge graph that will enable the development of services to support future energy marketplaces?





•D. Popadić, E. Iglesias, A. Sakor, V. Janev, ME Vidal, Towards a Solution for an Energy Knowledge Graph, ISIC 2022 **(Best Paper Award)**

•V. Janev, ME Vidal, D. Pujić, D. Popadić, E. Iglesias, A. Sakor, A. Čampa, Responsible Knowledge Management in Energy Data Ecosystems, Energies 2022

# SEMANTIC MODELS

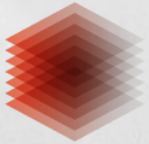
- The knowledge graph layer shall be based on **open standards** and **open APIs**.
- One of the first steps in our research is the **analysis of existing semantic models** already in use:
  - CIM – Common Information Model; it comprises concepts for software applications to exchange information about electrical networks
  - SAREF – Smart Appliances REFerence ontology; It is modular ontology for Internet of Things domain; it integrates vocabularies to represent smart cities, buildings, energy etc.
  - SEAS – Ontology developed in framework of the Smart Energy-Aware System project with the aim of designing a global ecosystem of services and smart things collectively capable of ensuring the stability and the energy efficiency of future energy grids.
  - DCAT – The Data Catalog Vocabulary provides a common understanding of the classes and properties that describe a catalog of datasets and data services.

# METHODOLOGY

- The work has been divided into the following phases:
  - **Requirement Analysis phase**: the authors, defined different business questions that we would like to answer with the knowledge graph
  - **Design phase**: relevant concepts are selected for modelling. Then, data connectors towards the SCADA database and the messaging mechanisms are specified
  - **Specification phase**: the knowledge graph is specified in terms of RML rules
  - **KGs in Action phase**: the authors are involved in automating the semantic pipeline and developing exploration GUIs

# Example of Innovative Solutions for the Digital Energy Ecosystem (DEE)

Research Perspective, 2021

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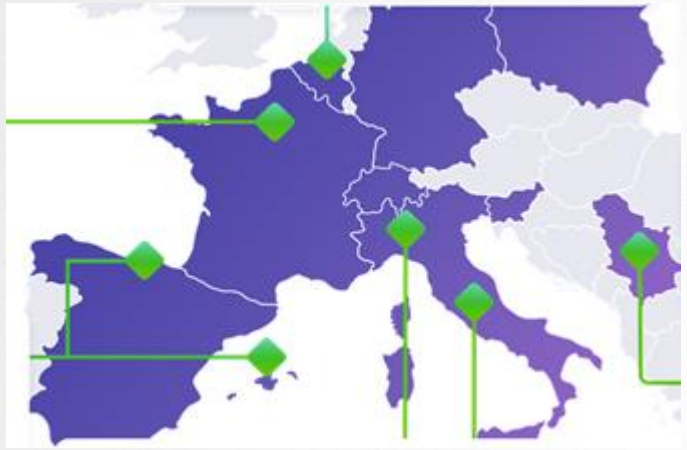
# PLATOON - Digital PLAtform and analytical TOOls for eNergy



**Challenges:** penetration of distributed generation (Wind / PV / Solar Power Plants) increases the variability and degree of uncertainty of power output from renewable sources

Data analytics toolbox (e.g. Accuracy of forecasting, production) and edge computing solutions are needed for optimised real-time energy system management

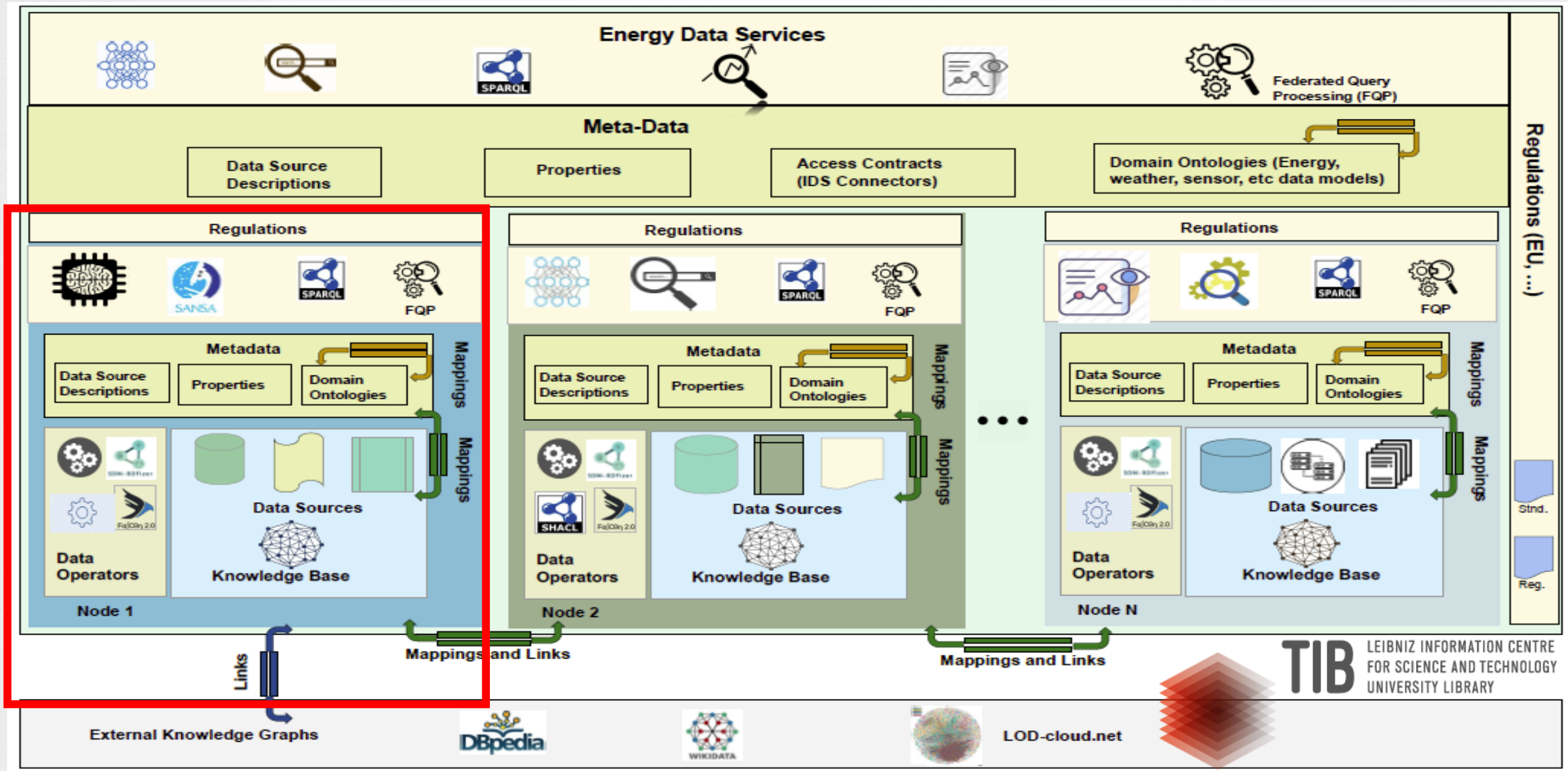
**Interoperability**
**Enabling data exchange and integrated value chains between platforms** using a wide spectrum of heterogeneous data sources, formats and interfaces.

**Data Governance & Security**
**Addressing digital sovereignty challenges** of multiple data owners and providers for multi-party data exchange along the energy value chain via IDS-based connectors.

**Data Analytics Toolbox & Edge Computing**
**Deploying technologies for data processing and analysis** in batch and real-time to optimise the energy system management for the energy domain experts.

**Solution:** Real-time integration and Big Data analysis upon the high-volume data streams from metering devices and power grid elements
**Solution:** Decentralised Data Processing Architecture for processing multi-stream datasets of different velocity

# DEE EXAMPLE


Energy Data Services
SPARQL
Federated Query Processing (FQP)
Meta-Data
Data Source Descriptions
Properties
Access Contracts (IDS Connectors)
Domain Ontologies (Energy, weather, sensor, etc data models)
Regulations (EU, ...)
Regulations
SANSA
SPARQL
FQP
Metadata
Data Source Descriptions
Properties
Domain Ontologies
Mappings
Data Operators
Data Sources
Knowledge Base
Node 1
SHACL
Node 2
Node N
Stnd.
Reg.
Links
Mappings and Links
External Knowledge Graphs
DBpedia
WIKIDATA
LOD-cloud.net
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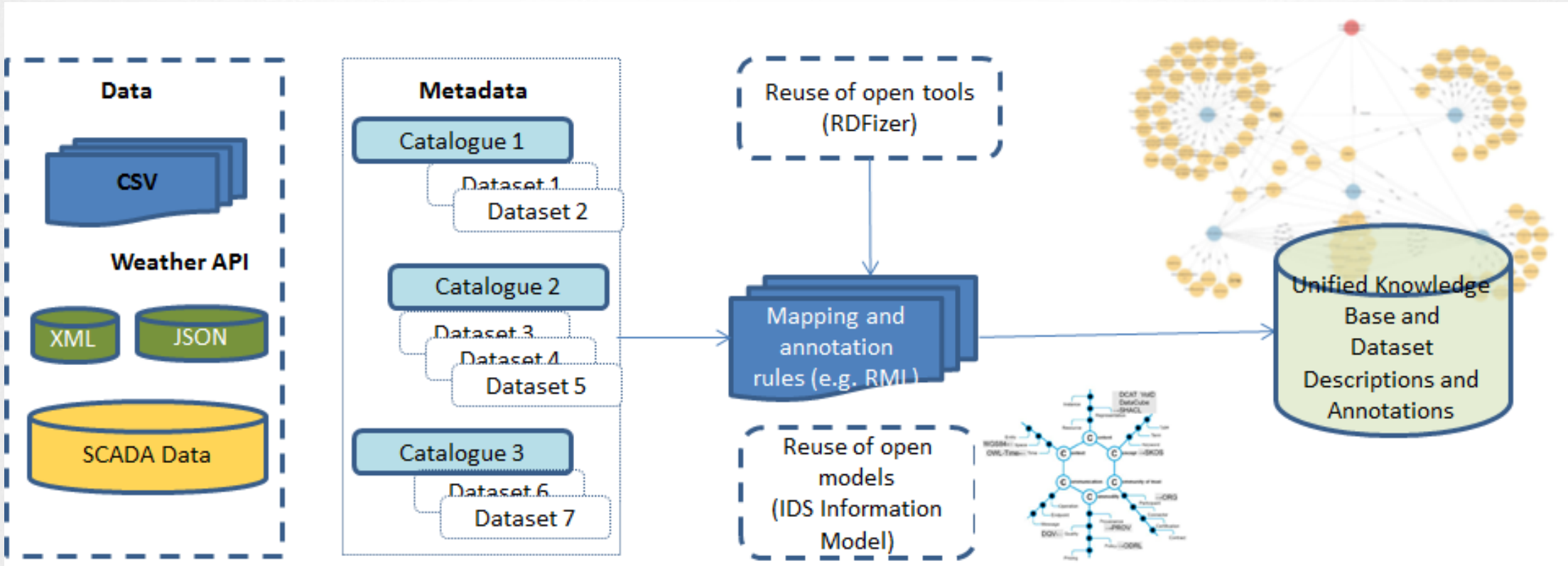
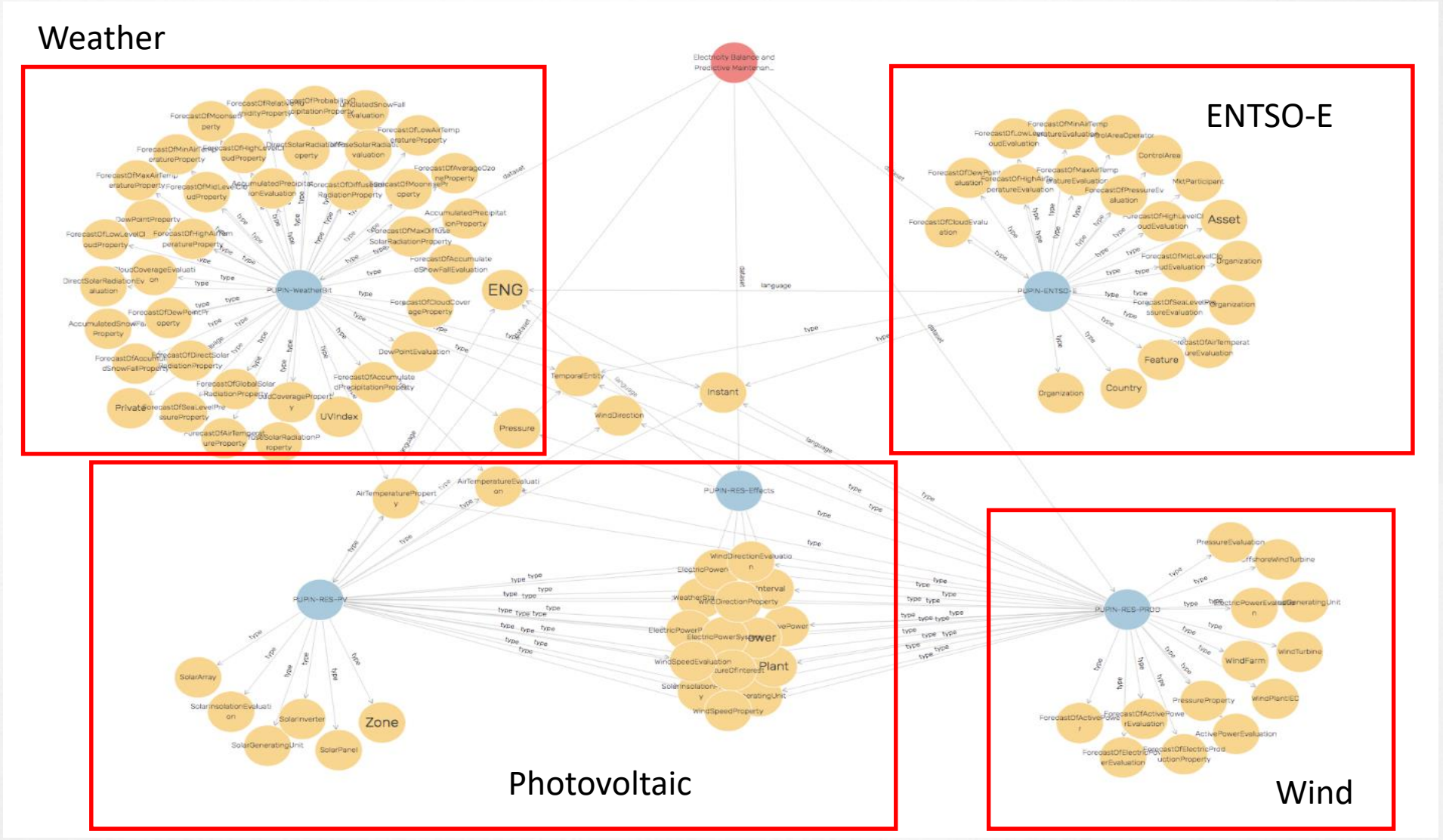
# SEMANTIC PIPELINE

- We follow the Materialized Knowledge Graph Creation Process approach to create a knowledge graph – data is loaded into an RDF format and stored in RDF triplestore



# METADATA VISUAL ANALYSIS



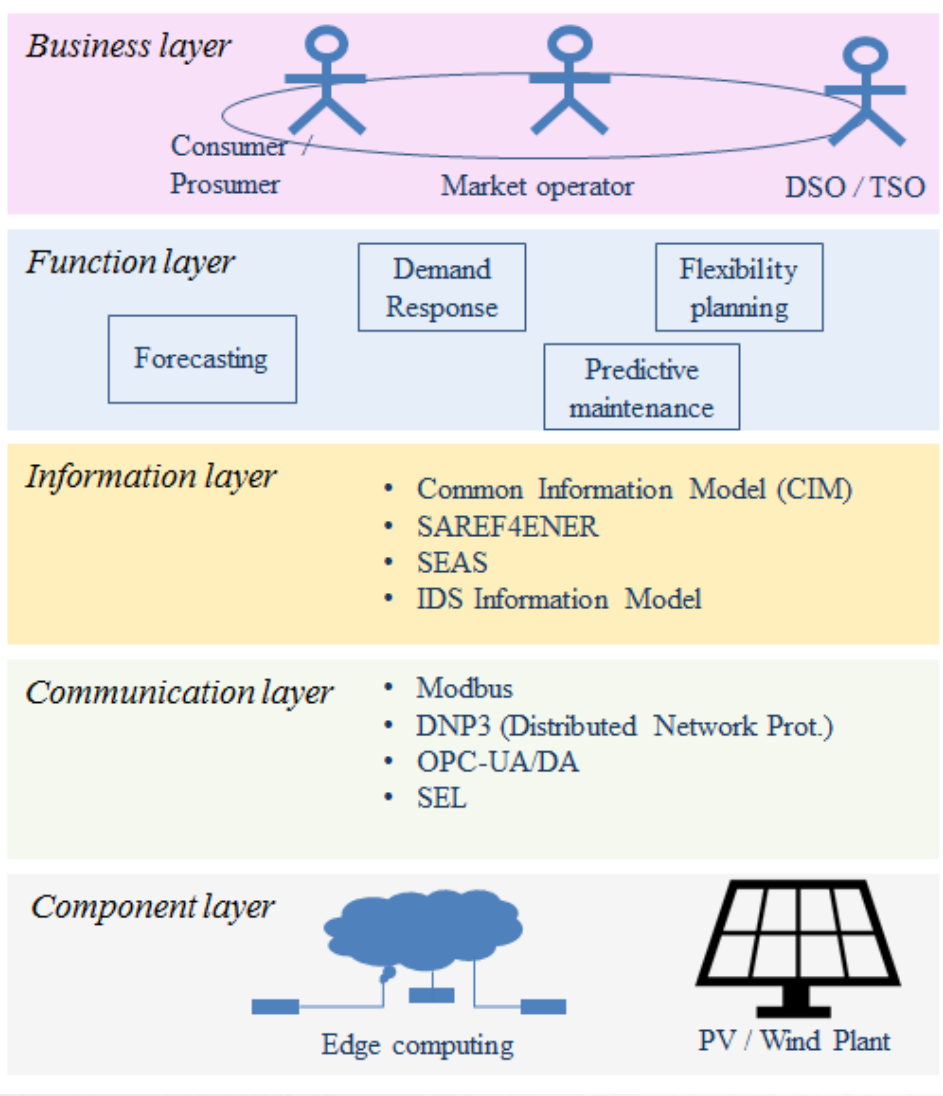
# KNOWLEGE GRAPHS VISUAL ANALYSIS

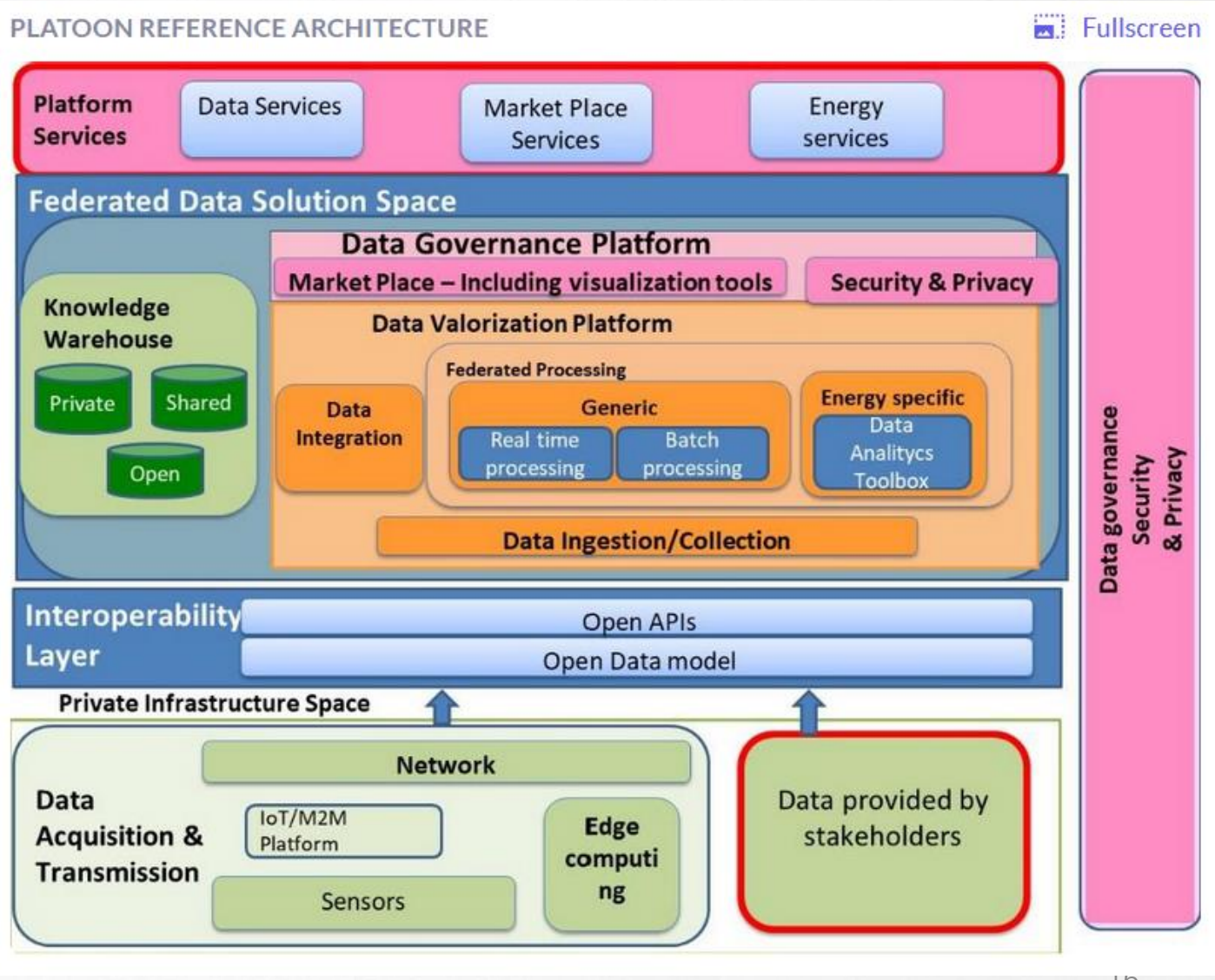



ENTSO-E
European Network of Transmission System Operators for Electricity

Visualization powered by Cystoscape

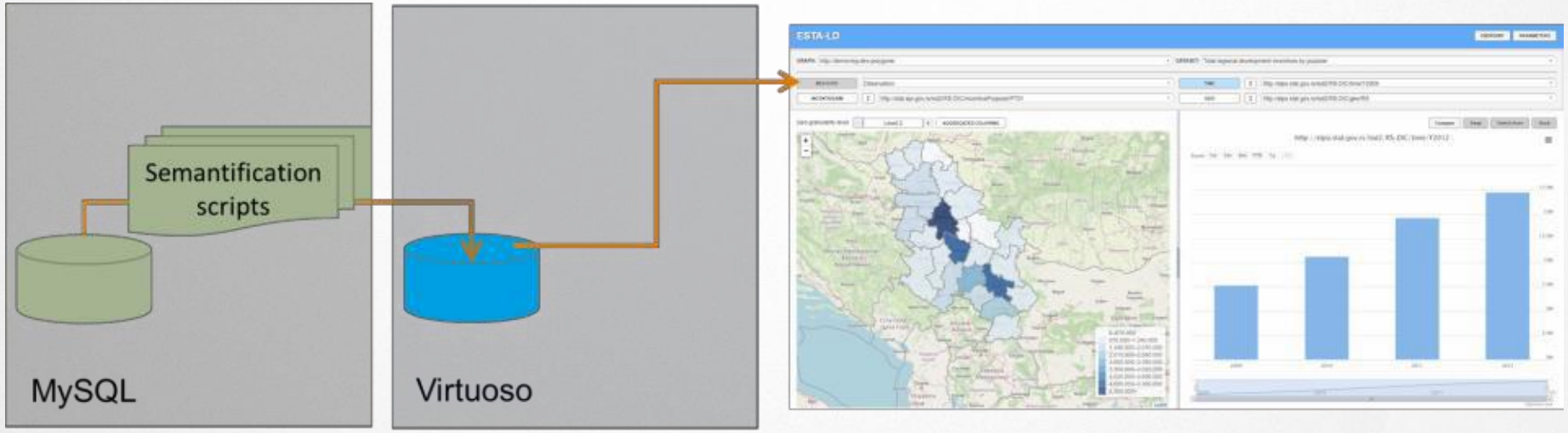
# ARCHITECTURES



# ENERGY ANALYTICS DASHBOARD

- Energy Analytics Dashboard (EAD) is visualization tool that aims to help users understand the results of AI-based analytics services used in synergy with SCADA KG.
- EAD allows the users to select data of interest, compare time series and visualize summary statistics on the geographical map.



# CONCLUSION

- **Standards, Integration, Interoperability and harmonization**
  - Although datasets are presented in diverse formats (e.g., CSV, JSON, RDB, JPEG) it can be characterized by concepts in the energy domain represented in the developed semantic data models.
  - Standardized data models (CIM, SAREF) relevant for energy management are available in different formats (UML, XML, RDF)
  - Development of the Semantic layer extends the reused common vocabularies and ontologies and the selection of models have to be done based on the target scenarios (e.g. for forecasting)
  - Data harmonization task completed in the EU project PLATOON showed that International Data Space information model (e.g., DCAT) additionally facilitates the generation of machine-readable description of the data sources and services and registration in a marketplace (under development).

# Thank you for your attention!

Capacity building in **S**mart and **I**nnovative e**NERGY** management

Digital **PLA**tform and analytical **TOO**ls for e**N**ergy

**TR**ansmission system enhancement of reg**IoN**al borders by means of **I**ntelligen**T** market technolog**Y**

**N**ext-Generation Integrated **E**nergy Services f**O**r Citizen Energy Commu**N**ities

**O**rchestrating an interoperable sovereign federated **M**ulti-vector **E**nergy Data Space built on open standards and ready for **GA**ia-**X**