Managing Knowledge in Energy Data Spaces

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Overview



- Actors & Challenges
- EU Energy Data Ecosystem
 - EU legislation
 - The vision
- Examples of Innovative Solutions for the Energy Data Ecosystem
 - The case of Serbia
- Scenario Analysis & Concluding Remarks



Capacity building in Smart and Innovative eNERGY management



<u>Digital PLAtform and analytical</u>
<u>TOOIs for eNergy</u>

About Institute Mihajlo Pupin



- 516 employees, 350 of them being researchers (December 2020)
- EU Commissionaire "Pupin as the best practice example for bridging academia and industry"
- 90% of turnover via TT
- Involvement in EU Research programs

Key Research and Development areas



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
- Integration of renewable energy sources (RES)

About Institute Mihajlo Pupin

Regional Centre of Excellence in smart energy management



- 5 dispatching centers done by PUPIN
- 182 high voltage transformation stations
- Supervision of entire distribution network
- Integrated monitoring and balancing the SMM block



Actors and Challenges



Actor	Challenges
TRADITIONAL POWER GENERATION COMPANY	Prepare to face the SmartGrid challenges soon; Use all the available information to optimize operations and extend asset useful life; Provide value to existing, often old generation facilities and be able to switch to best- in-class solutions
RENEWABLE POWER	Manage geographically distributed asset fleets;
GENERATION	Optimize energy sale strategies;
COMPANIES	 Forecast producible power and optimize energy bids
TRANSMISSION SYSTEM OPERATOR	 Extend the portfolio of energy services that can be provided; Optimize energy sale strategies; Use all the available information to optimize operations and extend asset useful life
DISTRIBUTION SYSTEM OPERATOR	 Manage hundreds/thousands of assets geographically distributed consumers; Extend asset useful life
ICT SUPPLIERS / TECHNOLOGY PROVIDERS	 Develop specific solutions to address industry problems; Promote the use of their platforms and solutions (e.g. Institute Mihajlo Pupin SCADA System); Extend the portfolio of services to be provided
AGGREGATORS AND ENERGY SERVICES PROVIDERS	Play a role in the energy market by grouping together the interests of many individual independent producers; Extend the portfolio of energy services that can be provided; Integrate multi-source data to benefit from opportunities and provide value to customers; Use multi-source data (weather, prices, etc.) to determine optimum consumption strategies; Optimize energy consumption, lowering costs; Extend the portfolio of energy services that can be provided

Actors and Challenges – EU Legislation



Policy Framework

Energy system integration refers to the planning and operating of the energy system "as a whole", across multiple energy carriers, infrastructures, and consumption sectors, by creating stronger links between them with the objective of delivering low-carbon, reliable and resource-efficient energy services, at the least possible cost for society.

European Green Deal, December 2019

- Set of policy initiatives by the European Commission with the overarching aim of making Europe climate neutral in 2050
- Aims to boost the efficient use of resources by moving to a clean, circular economy and stop climate change, revert biodiversity loss and cut pollution
- For the European union to reach their target of climate neutrality, one goal is to decarbonise their energy system by aiming to achieve "net-zero greenhouse gas emissions by 2050
- European Strategy for Data, February 2020
- Energy System Integration Strategy, July 2020
- Data Governance Act, November 2020

European Strategy for Data, February 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

Data Governance Act, November 2020



- The first of a set of measures announced in the 2020 European strategy for data. The instrument aims to foster the availability of data for use by increasing trust in data intermediaries and by strengthening data-sharing mechanisms across the EU.
- Data Space construction is a multilayer, interdisciplinary, and has technically several complexities (cybersecurity, software architectures, interoperability, standards, etc.
- Trustworthy data-sharing systems through four broad sets of measures:
 - Mechanisms to facilitate the reuse of certain public sector data that cannot be made available as open data.
 - Measures to ensure that data intermediaries will function as trustworthy organisers of data sharing or pooling within the common European data spaces.
 - Measures to make it easier for citizens and businesses to make their data available for the benefit of society.
 - Measures to facilitate data sharing, in particular to make it possible for data to be used across sectors and borders, and to enable the right data to be found for the right purpose.
- https://digital-strategy.ec.europa.eu/en/policies/data-governance

Digital Energy Ecosystem - Vision



- Digitalise the energy sector, enabling thus higher levels of operational excellence with the adoption of disrupting technologies.
- Use SGAM and COSMAG-compliant reference architecture for big data processing for the energy sector. => interoperability layer based open standards (e.g. SAREF, CIM, NGSI-LD) 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

Architectures for Energy Data Ecosystems



- Smart Grid Architecture Model (SGAM) that is a product of the standardization process in the EU Mandate M/490, the work of the CEN-CENELEC-ETSI Smart Grid Coordination Group
- THE INTERNATIONAL DATA SPACE (IDS) Information Model Virtual data space leveraging existing standard and technologies, as well as governance models well accepted in the data economy, to facilitate secure and standardized data exchange and data linkage in a trusted business ecosystem

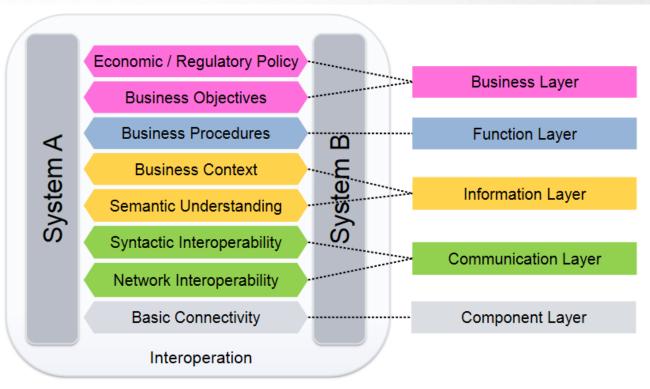


Figure 6: Grouping into interoperability layers

CEN-CENELEC-ETSI Smart Grid Coordination Group:

Smart Grid Reference Architecture

Smart Grid Actors & Available Technologies



Challenges: Variability and degree of uncertainty of power output from renewable sources increases with penetration of distributed generation (Wind / PV / Solar Power Plants) and 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.

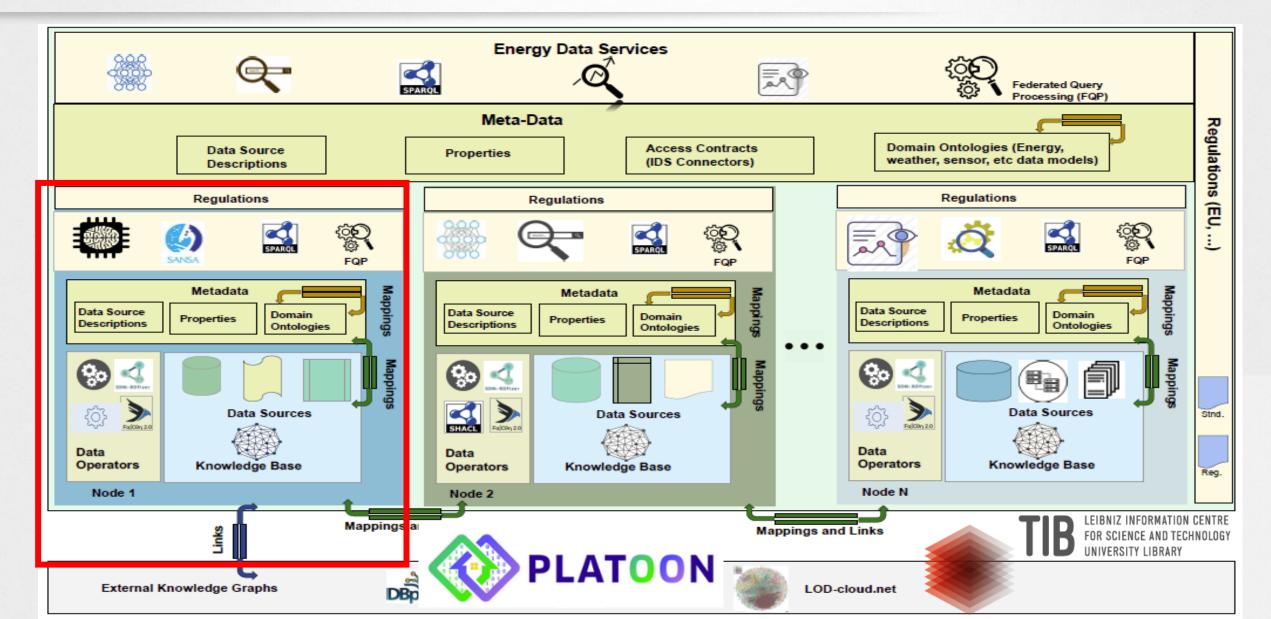
Data Analytics Toolbox
& Edge Computing
Deploying technologies for data
processing and analysis in batch
and real-time to optimise the energy
system management for the energy
domain experts.

Solution:

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

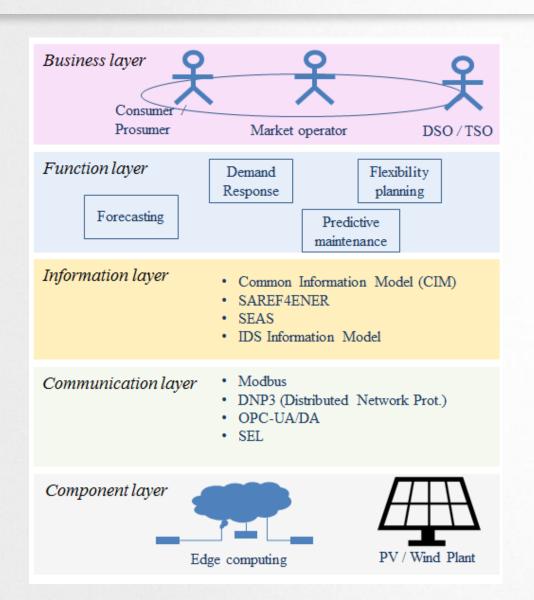
Example of a Digital Energy Ecosystem

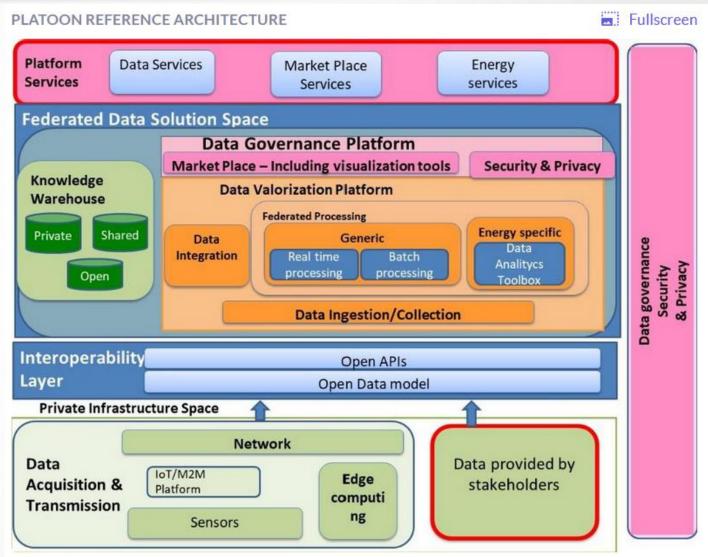




Architectures for Energy Data Ecosystems







Data Analytics – Technical Aspects



Title	Short Description	Benefits
Balancing in SMM Block	Services that allow the Serbian TSO (EMS) to balance the cross-border exchange more efficiently	Improved cross-border trading [under EMS and EPS responsibility]
Balancing the Serbian Grid	Services that allow the Serbian TSO to balance the Serbian grid more efficiently.	Better matching of demand and supply across the energy mix; Standardize the interfacing services [under EMS and EPS responsibility]
Demand forecast on transmission level	Services that allow the Serbian TSO to forecast the demand	Better matching of demand and supply across the energy mix; Standardize the interfacing services with the production plants [under EMS and EPS responsibility]
RES (Wind generation) forecasters	Service for forecasting the power output of wind farms, the related uncertainties, and the optimal use of wind power in power system operations in order to facilitate large-scale integration of wind generation	
Energy Sources on the	Service for analyzing and comparison between unexpected variations to voltage profile of the power system before and after RES integration to the power system	Reduce cost of Operations and improve quality of service [under EPS responsibility]
Predictive maintenance in RES power plants	This Scenario focuses on the design and development of predictive maintenance services using machine learning algorithms.	

Example of Innovative Solutions for the Energy Data Ecosystem

Research Perspective



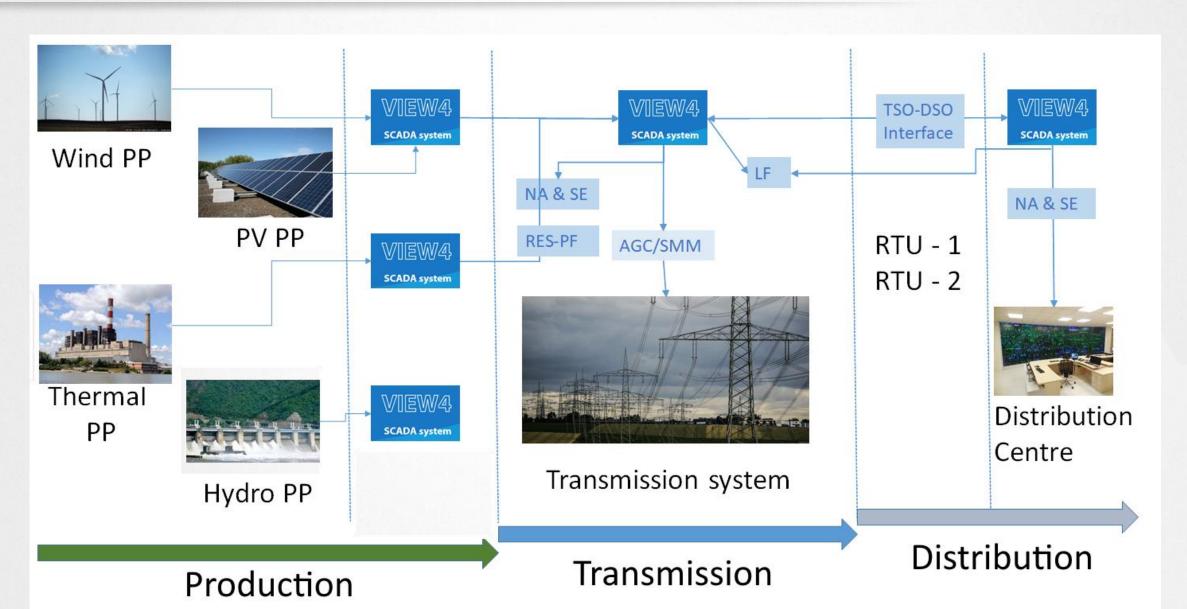






Energy value Chain





Multi-party data exchange solutions



- New smart grids services needed for effective and scalable semantic interoperability and creation of data spaces (also supported with EU Data Strategy)
- Message-based infrastructure needed to enable the communication of the different nodes and components in the energy value chain and integration in the European Energy Data Space



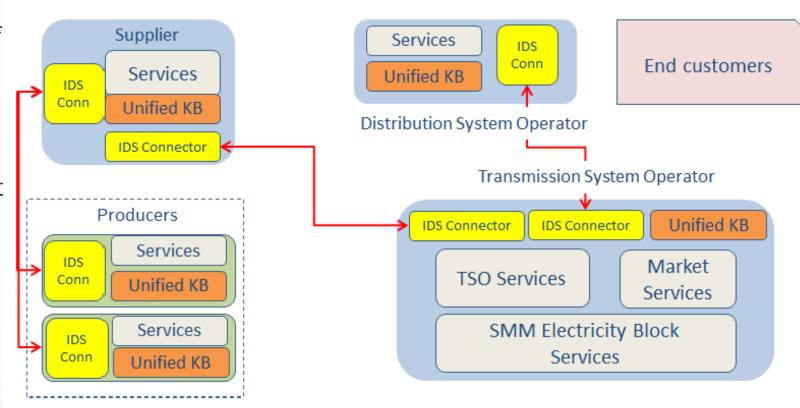


Figure 3: Multi-party data exchange based on IDS concept

Methodology – Interoperability and Integration Framework

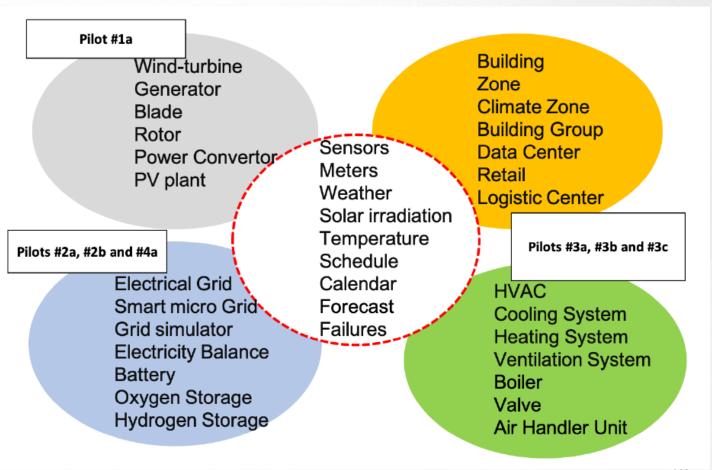


	Requirements Analysis		KGs v.1 Design	 KGs v.1 Specification)	Im	KGs v.2 plementation
Scenarios	Business questions	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Semantic models	Conceptual schema			Ontology rmalization
Scenarios	Data sources		Data connectors	Connectors and transform.			Semantic pipeline
Scenarios	Data exchange needs	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Mapping rules and security	> APIs			APIs

Interoperability Standards



- CIM Common Information Model (CIM, https://ontology.tno.nl/IEC_CIM/), officially adopted by the International Electro technical Commission (IEC).
- SAREF Smart Appliances REFerence ontology (SAREF, https://saref.etsi.org/saref4ener/ v1.1.2/). SEAS - Ontology developed in the framework of the Smart Energy-Aware Systems (SEAS, https://w3id.org/seas/).
- DCAT The Data Catalog Vocabulary (DCAT, https://www.w3.org/TR/vocab-dcat-2).

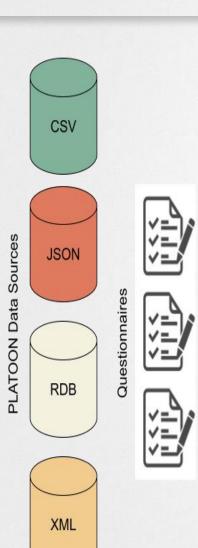


Methodology for Data Harmonization

Describe data sources in

the questionnaires





PLATOON Semantic Data Models and IDS vocabularies



Define Mapping

Data Models and

Vocabularies

Rules to Describe

Data Sources using



Software Developers



Software Developers



Generate harmonized descriptions of data sources by executing mapping rules

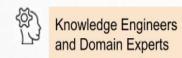


Exchange harmonized descriptions of data sources via APIs



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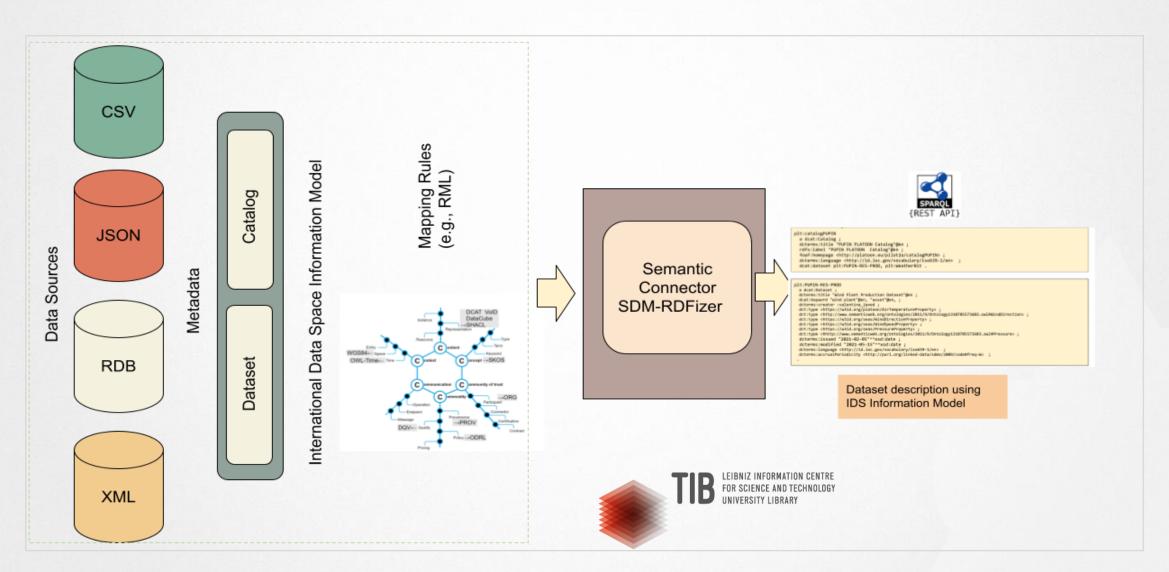
> Dataset description using IDS Information Model





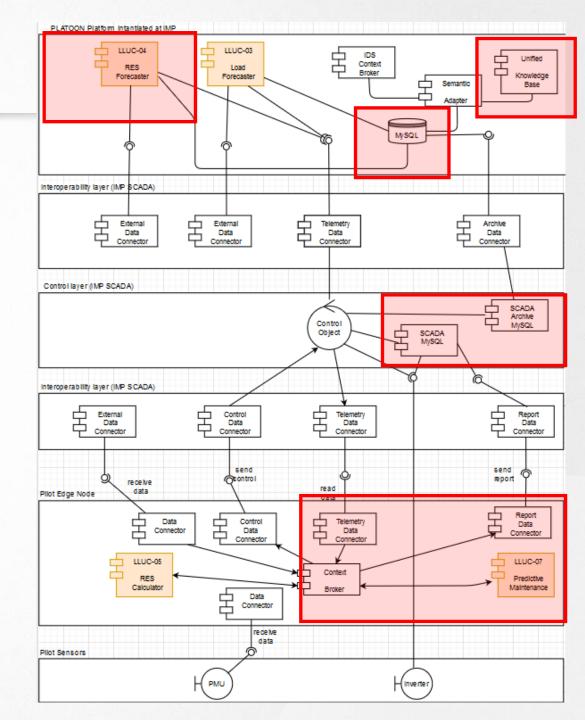
Pipeline for generating a harmonized description of the data sources





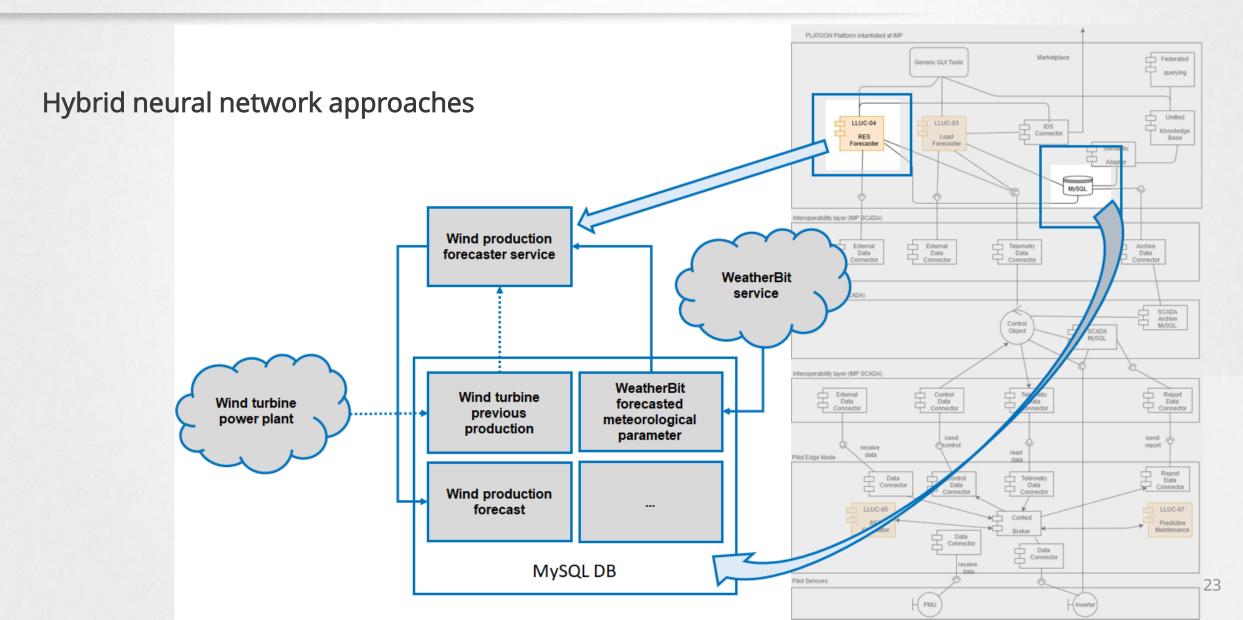
PUPIN Platform Architecture

- Balancing in SMM Block
- Balancing the Serbian Grid
- Demand forecast on transmission level
- RES (Wind generation) forecasters
- Effects of Renewable Energy Sources on the Power System (distribution level)
- Predictive maintenance in RES power plants



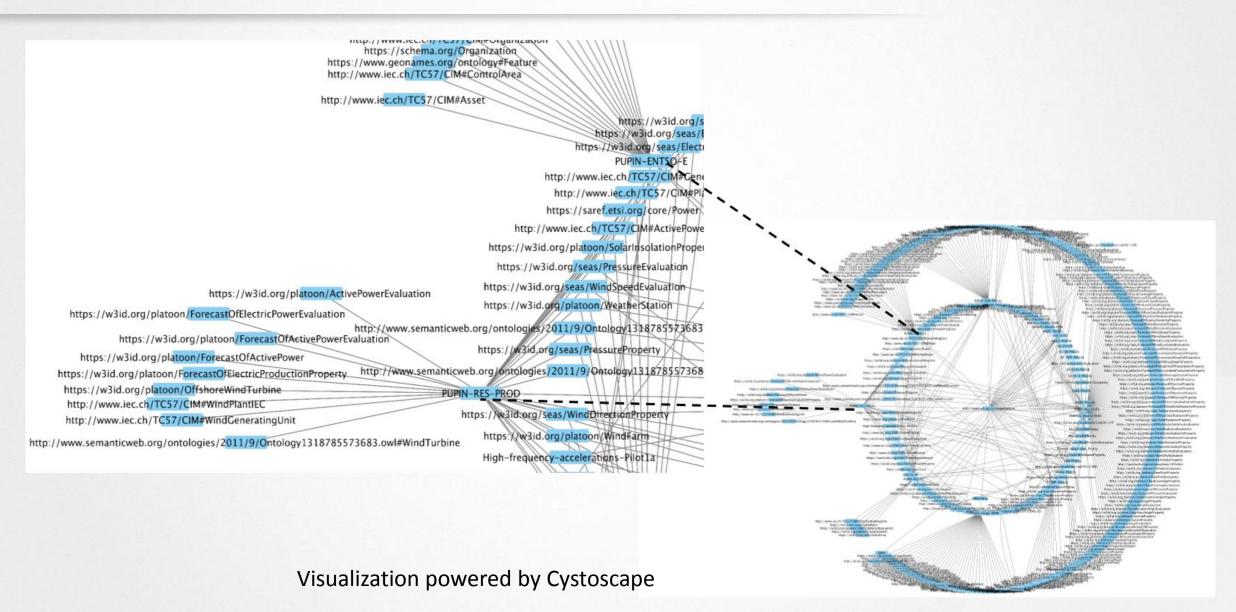
Forecasting Service Integration





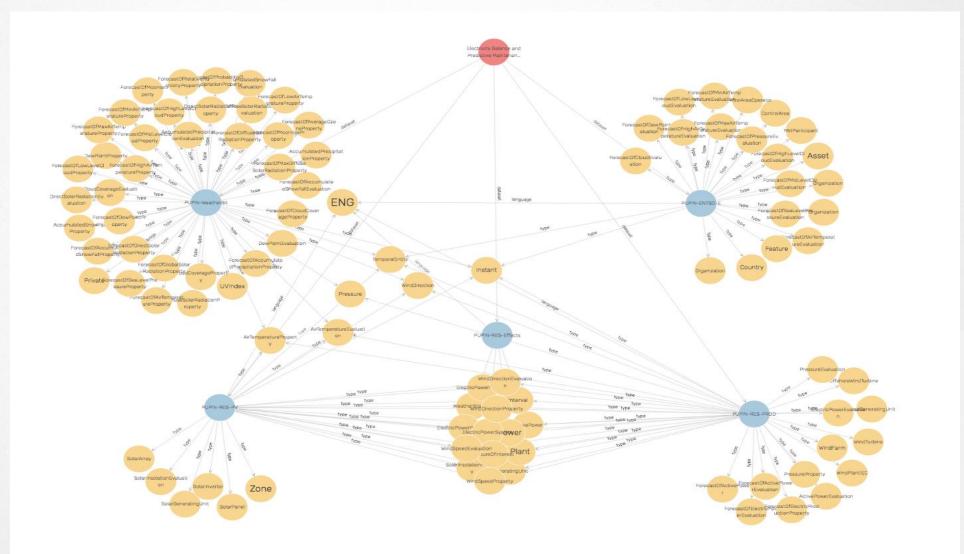
Visual Analysis of the Metadata (1 dataset)





Visual Analysis of the Metadata (5 catalogs)



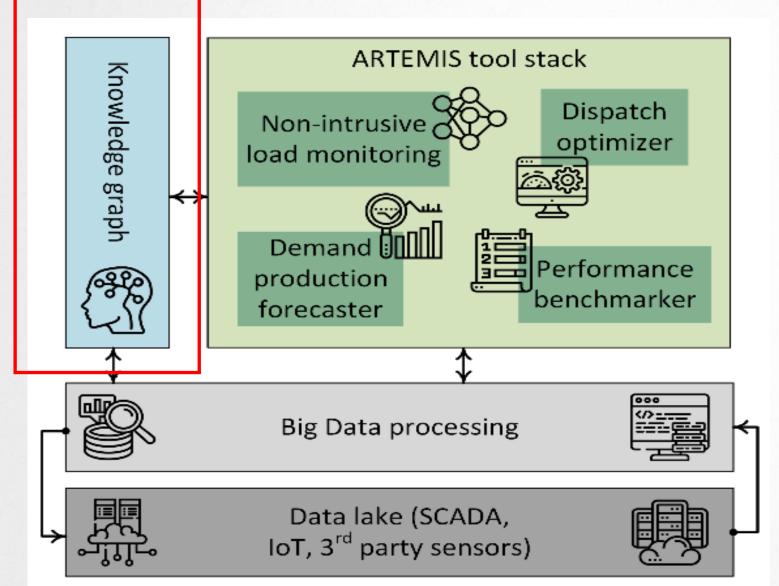


Further Adoption of the Approach:

ARTificial Intelligence in Energy Management







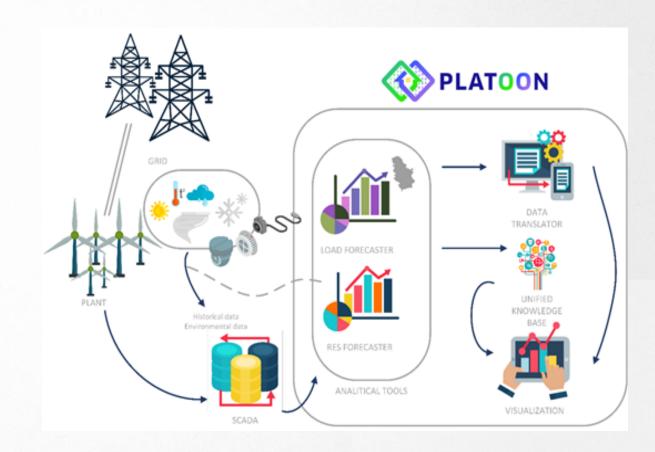


Empowering prosumers with a domain-specific Artificial Intelligence (AI) tool-stack, offering high-value services that provide intelligence and ability to interpret, understand and act in a specific energy context, characterized with local production availability, transmission/distribution constraints and consumption flexibility.

Explainable AI Services - Outlook



- DANN-based non-intrusive "behind the meter" (BTM) analytics offering appliance-level load disaggregation from smart meter measurements, i.e. featuring appliance status recognition (classification problem) and power consumption estimation (regression problem)
- Hybrid data and model driven local production forecasting offering energy generation prediction based on physical models and measured data (black/grey box modelling)
- Data-driven energy demand forecasting providing short and long-term forecast of different load types (i.e. electricity, heating and cooling)
- Hybrid ML-enabled energy performance assessment delivering a measure of consumer energy efficiency by normalizing energy consumption against context-related (e.g. climate, construction type, number of inhabitants etc.) and behavior-related aspects (e.g. deviations from expected consumption), which will be used for consumer benchmarking



Conclusion



- Large-scale penetration of renewables and EMS implies
 - Long-term energy supply sustainability
 - Decrease of Green House Gas (GHG) emissions
 - Avoidance of energy distribution costs and losses
- Standards, Integration, Interoperability and harmonization
 - 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)
 - 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.
 - Expressive vocabularies from the International Data Space information model (e.g., DCAT) facilitate the generation of machine-readable description of the PLATOON data sources.

Thank you for your attention!





Capacity building in Smart and Innovative eNERGY management



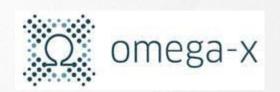
<u>Digital PLAtform and analytical</u>
<u>TOOIs for eNergy</u>



TRansmission system
enhancement of regloNal
borders by means of IntelligenT
market technologY



Next-Generation Integrated
Energy Services fOr Citizen
Energy CommuNities



Orchestrating an interoperable
sovereign federated Multi-vector Energy
Data Space built on open standards and
ready for GAia-X