Integrated Energy Value Chains - Overview of Technologies and Lessons Learned

III INTERNATIONAL SCIENTIFIC-PRACTICAL CONFERENCE – CIBEK 2021

The Mihajlo Pupin Institute
University of Belgrade

About Institute Mihajlo Pupin

- 40 years in Process Control Systems (Thermal and Hydro PP)
- Supervisory Control and Data Acquisition Systems (SCADA) and Digital Control Systems (DCS)
- 10 years in Solar and Wind PP, Natural Gas PP, Biomass PP

- Research related to **EU climate and energy targets ("20-20-20")**
  - **10 EU projects just in the last 3 years**
    - **InBetween** - ICT enabled BEhavioral change ToWards Energy EfficieNt lifestyles; **IDEAS** - Novel building Integration Designs for increased Efficiencies in Advanced climatically tunable renewable energy Systems; **RESPOND** - Integrated demand REsponse Solution towards energy POsitive NeighbourhooDs; **REACT** - Renewable Energy for self-sustAinable island CommuniTies, …
    - **TRINITY** - TRansmission system enhancement of regIoNal borders by means of IntellIgenT market technology; PLATOON - Digital platform and analytical tools for energy, …
  - **SINERGY -** Capacity building in Smart and Innovative eNERGY management - **Regional Centre of Excellence**

- Research related to Circular Economy
  - Danube-goes-Circular, **CIP/EIP** (GREEN, WEEEN, IMAGEEN), https://www.pupin.rs/en/research-and-development-projects/european-rd-projects/

About Institute Mihajlo Pupin

- SCADA
- DSC

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

Overview

- 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.
  - **Digitalisation** supports energy system integration – it can enable dynamic and interlinked flows of energy carriers, allow for more diverse markets to be connected with another, and provide the necessary data to match supply and demand at a more disaggregated level and close to real time.
- Motivation: Energy Data Ecosystem
  - The Case of Serbia
  - Actors & Challenges
- Energy Data Space – Vision
  - Industrial Data Space Concept
  - IMP contribution in the Energy Sector in Serbia
- IMP Innovative Solutions for the Energy Data Ecosystem
- Lessons Learned & Concluding Remarks

EU Policy Framework

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

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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
- **Guidelines for the Implementation of the Green Agenda for the Western Balkans, October 2020**
  - Clean Energy Transition - reduce energy imports, develop renewable energy sources, strengthen regional energy security, unlock greater economic growth
  - EU’s Framework Programme for Research and Innovation

https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

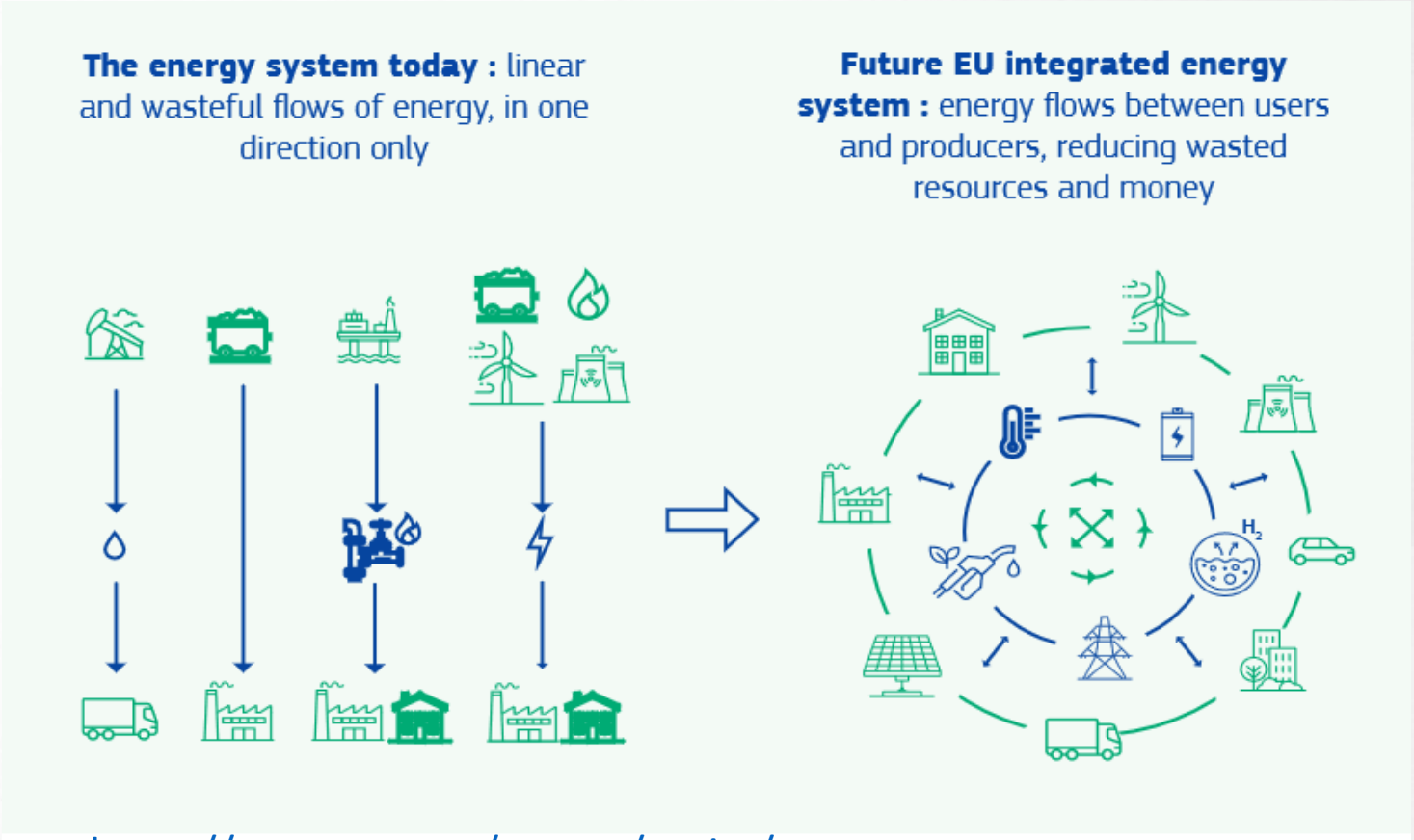
European Strategy for Data, February 2020

- 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

Energy System Integration Strategy, July 2020

- This strategy will profoundly reform the European energy system.
- We are designing a more efficient and integrated system that links energy sources and infrastructure to support decarbonisation and build a climate neutral EU by 2050.
- It will help to build modern infrastructure, make European industry more sustainable and competitive, create jobs, and provide clean energy for citizens.



https://ec.europa.eu/energy/topics/energy-system-integration/eu-strategy-energy-system-integration_en

Data Governance Act, November 2020

- Data Space construction is a multilayer, interdisciplinary, and has technically several complexities (cybersecurity, software architectures, interoperability, standards, etc.
- **Data Governance Act defines measures** to foster the availability of data for use by increasing trust in data intermediaries and by strengthening data-sharing mechanisms across the EU.
- 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

Motivation: Energy Data Ecosystem

- Serbia and the Power Infrastructure
- Actors and Challenges
- Integration and Interoperability

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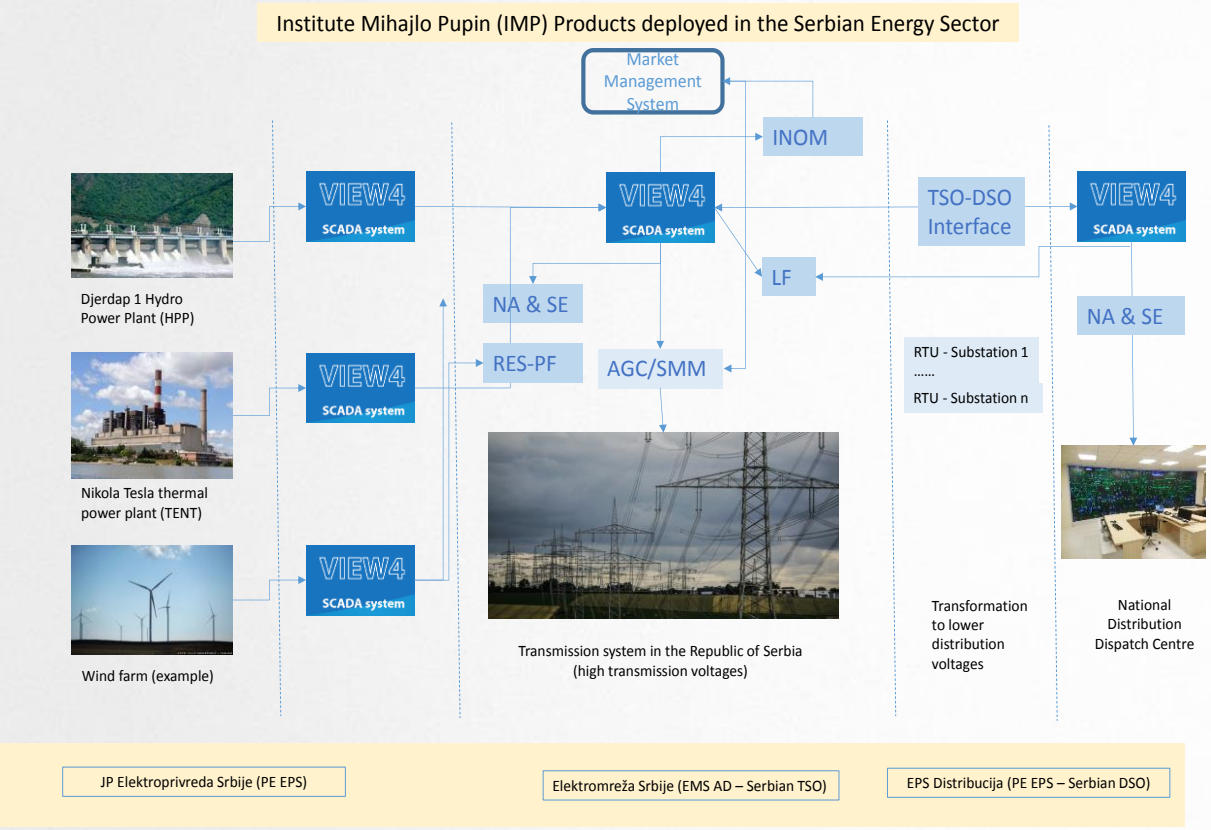
Motivation



- Energy management deals with monitoring and controlling the energy production, distribution and usage with different objectives including improvement of energy efficiency, increasing the flexibility and renewable generation share, and reducing the energy cost, **e.g.** the Serbian Energy Value Chain
- **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)**

Acknowledgement

ARTEMIS - ARTificial Intelligence in Energy Management Innovative Services
PLATOON - Digital PLAtform and analytical TOOls for eNergy
TRINITY – TRansmission system enhancement of reg**I**o**N**al borders by means of **I**ntelligen**T** market technolog**Y**

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 GENERATION COMPANIES	Manage geographically distributed asset fleets; Optimize energy sale strategies; 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

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**

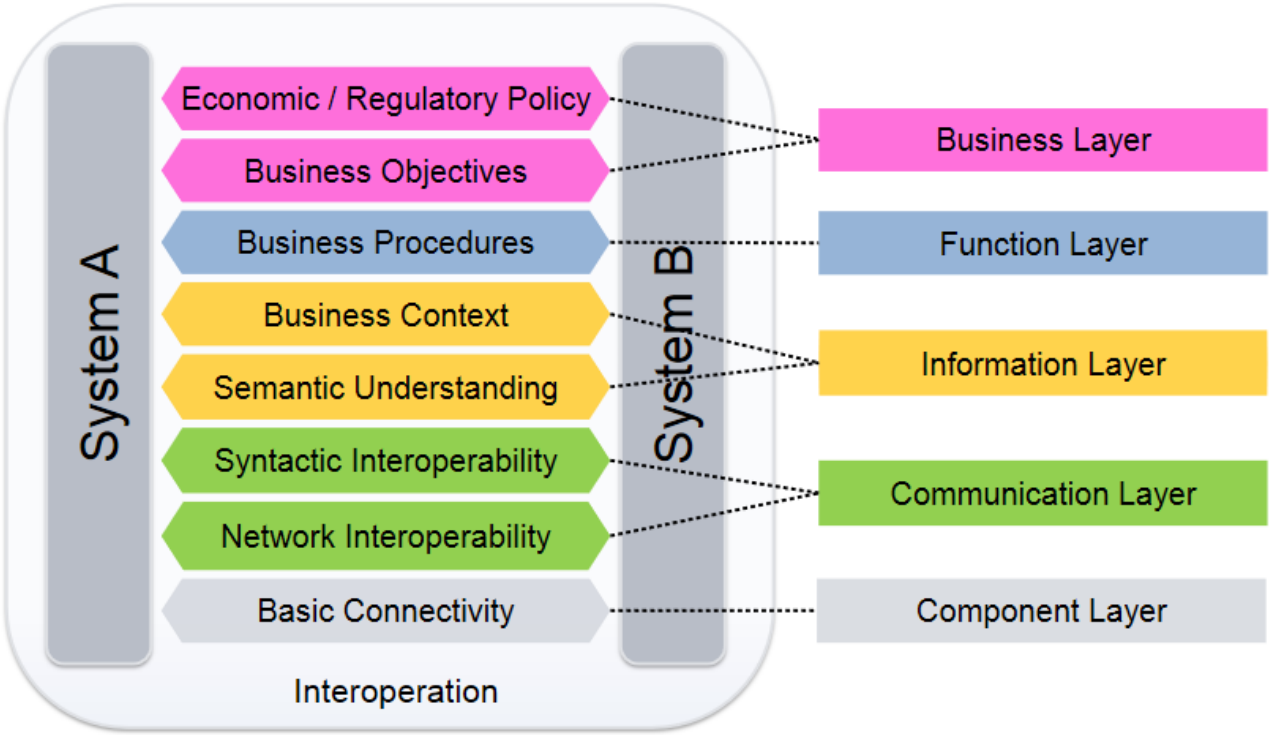


Figure 6: Grouping into interoperability layers

CEN-CENELEC-ETSI Smart Grid Coordination Group:
Smart Grid Reference Architecture

Energy Data Space – Vision

- Industrial Data Space Concept
- IMP role in the Energy Sector in Serbia

BDV BIG DATA VALUE ASSOCIATION

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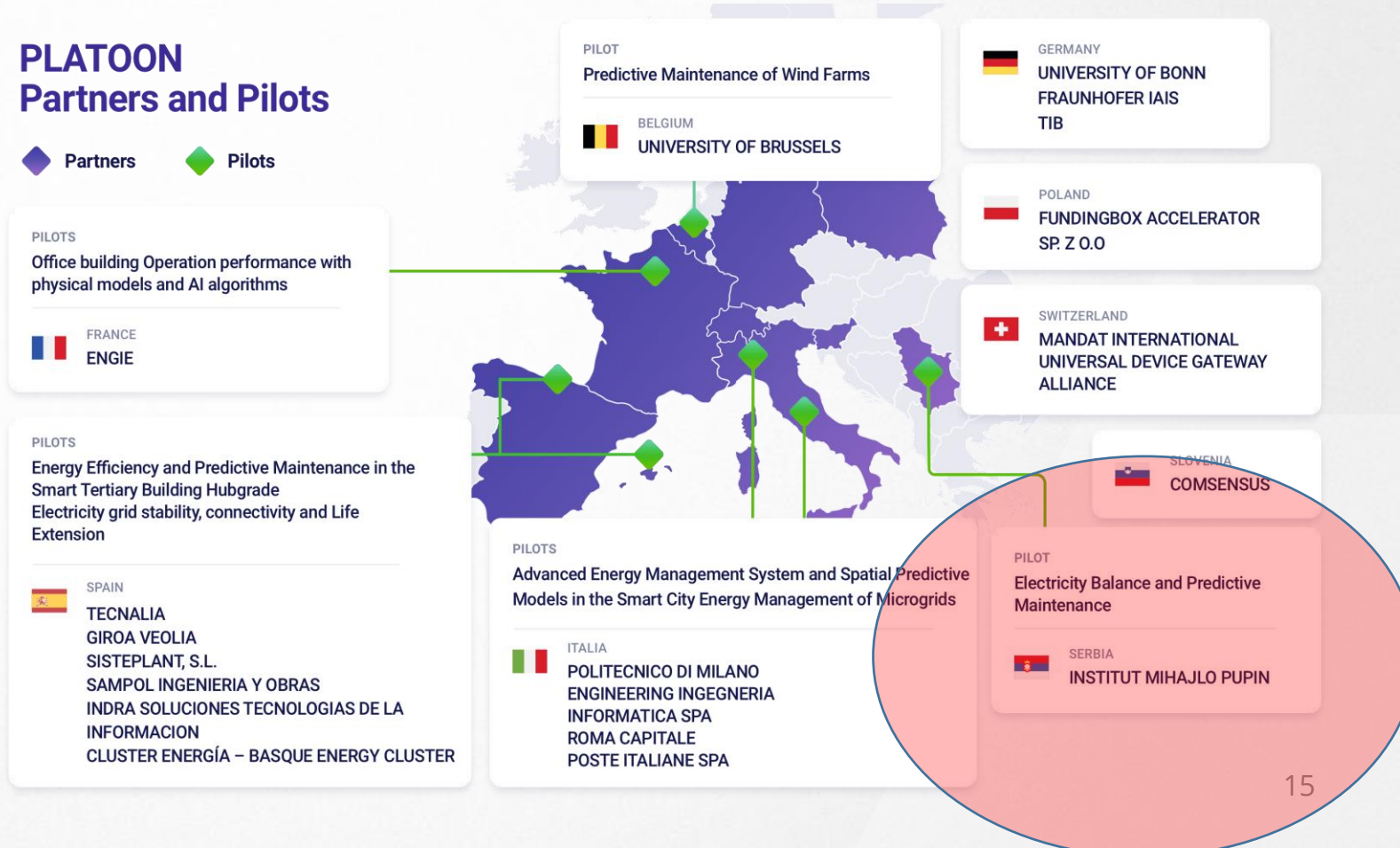
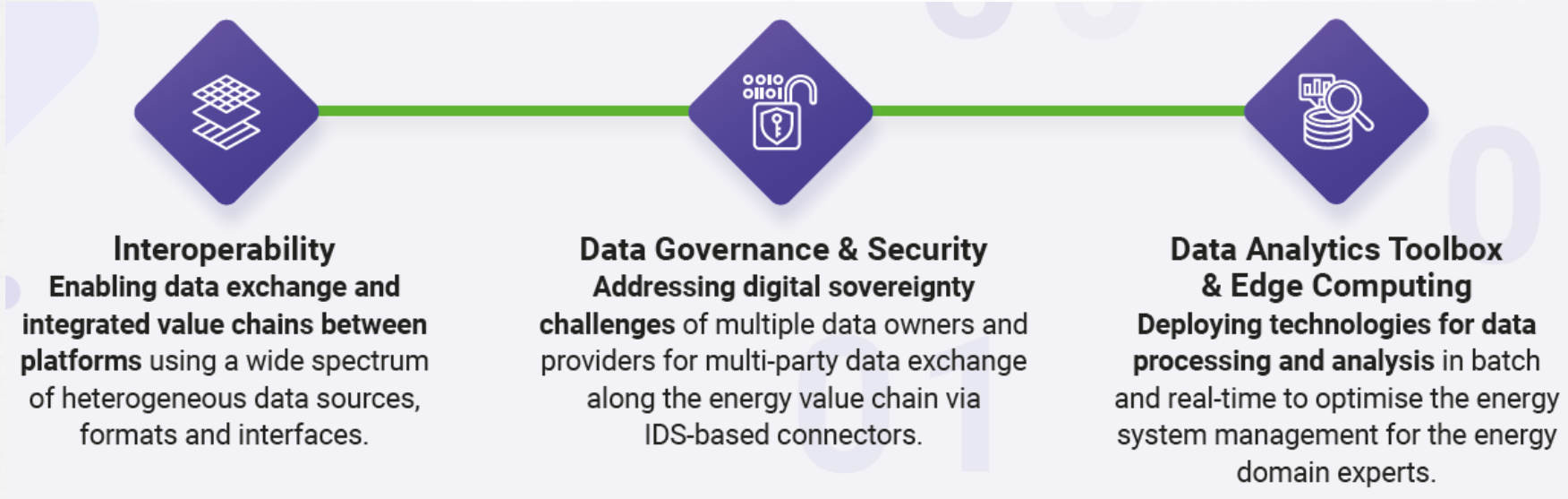
Design Principles for Data Spaces

- Architecture Model – Data Spaces Stack
  - Data sovereignty
  - Data level playing field
  - Decentralized soft architectures
  - Public-private government



PLATOON Architecture for Smart Grid



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.

- Real-time integration and Big Data analysis needed upon the high-volume data streams from metering devices and power grid elements (e.g. switches, transformers, etc.)
- Decentralised Data Processing Architectures needed for processing multi-stream datasets of different velocity
- 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

Integrated value chains between platforms

- Data sources may have different data models, follow various data representation schemes, and contain complementary information
- 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

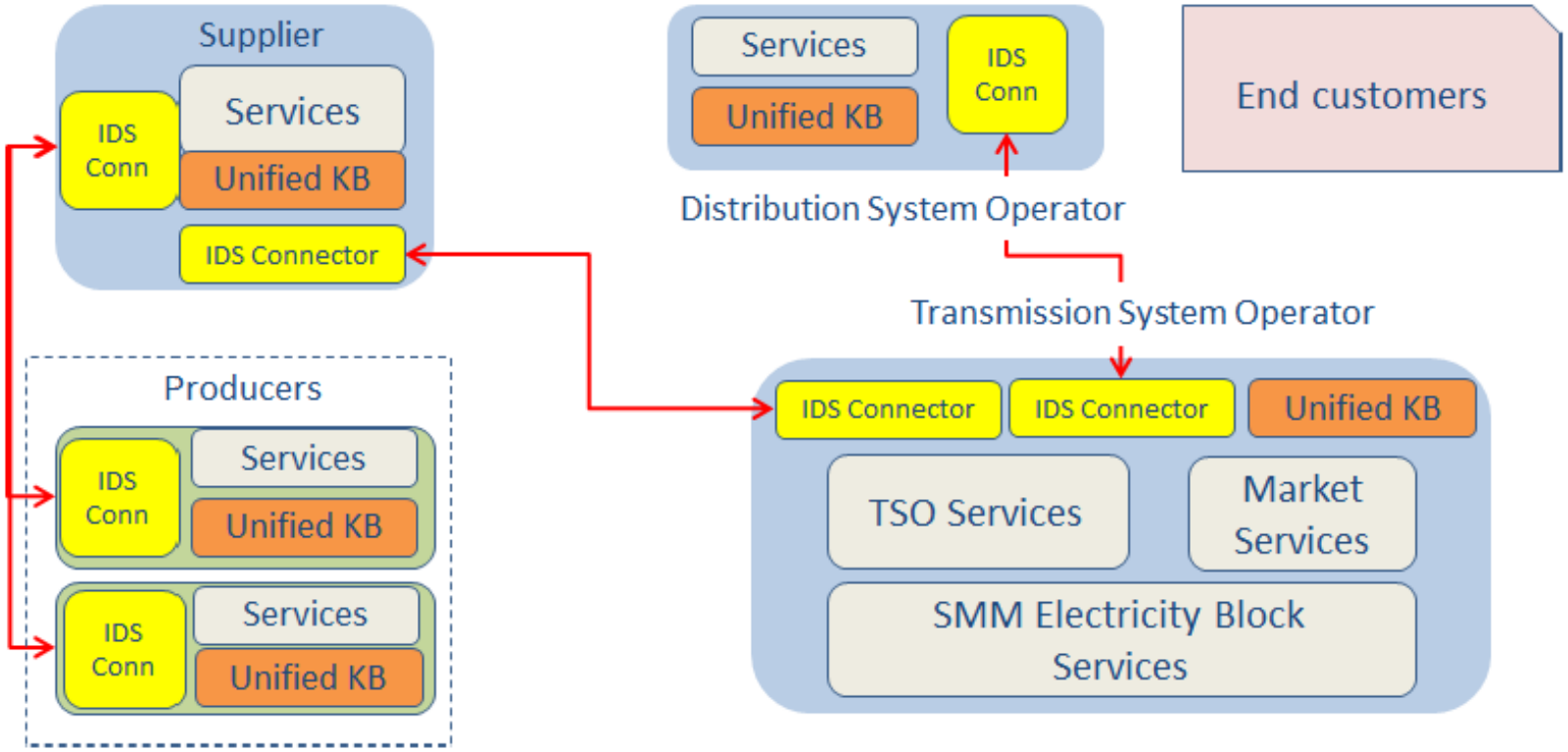
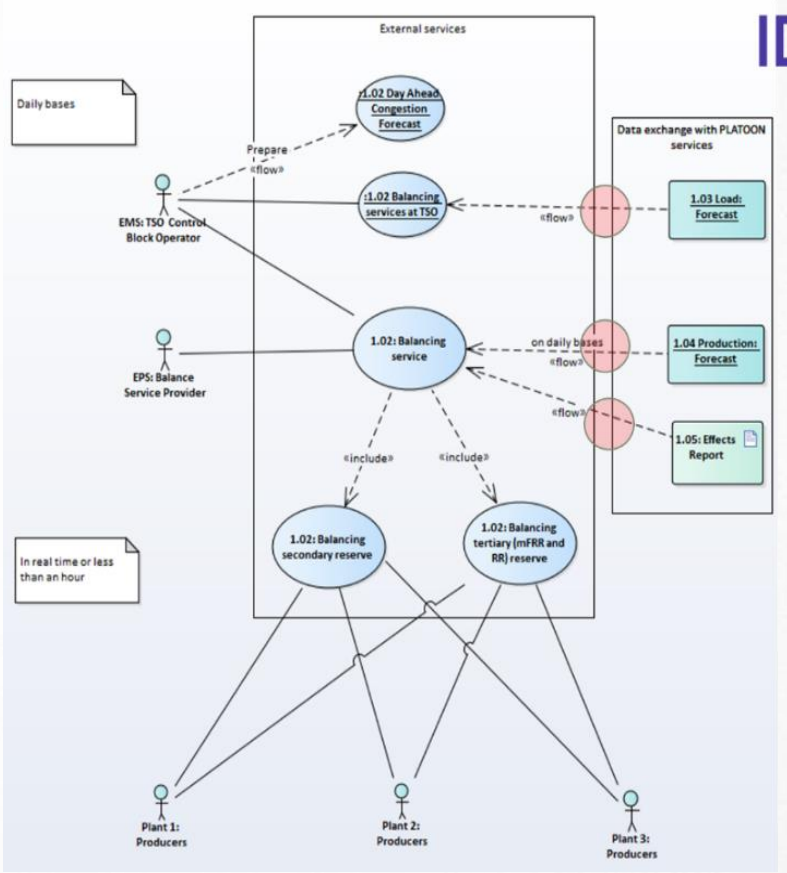


Figure 3: Multi-party data exchange based on IDS concept

Architecture & Components

- Multi-paradigm AI tool-stack encompassing data-driven (deep learning) and model-driven (black/grey box) technologies
- Unified Knowledge Base
- Semantic Adapters and Federated Querying
- IDS-based connectors
- Edge services



IDS Compliant Services

- Load Forecasters
- RES Forecasters
- Power Quality services for RES Effects calculation

IMP Innovative Solutions for the Energy Data Ecosystem – Research Perspective

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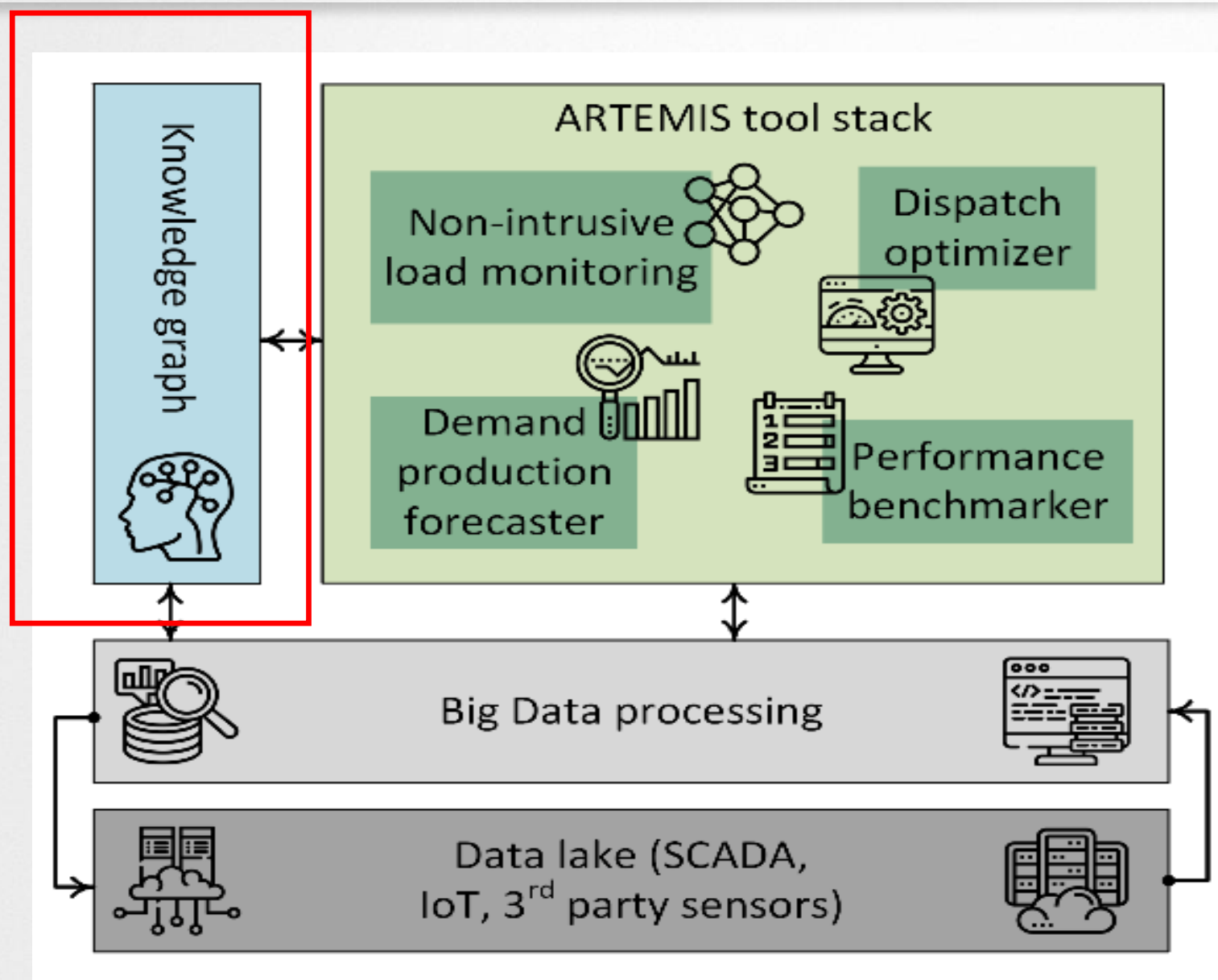
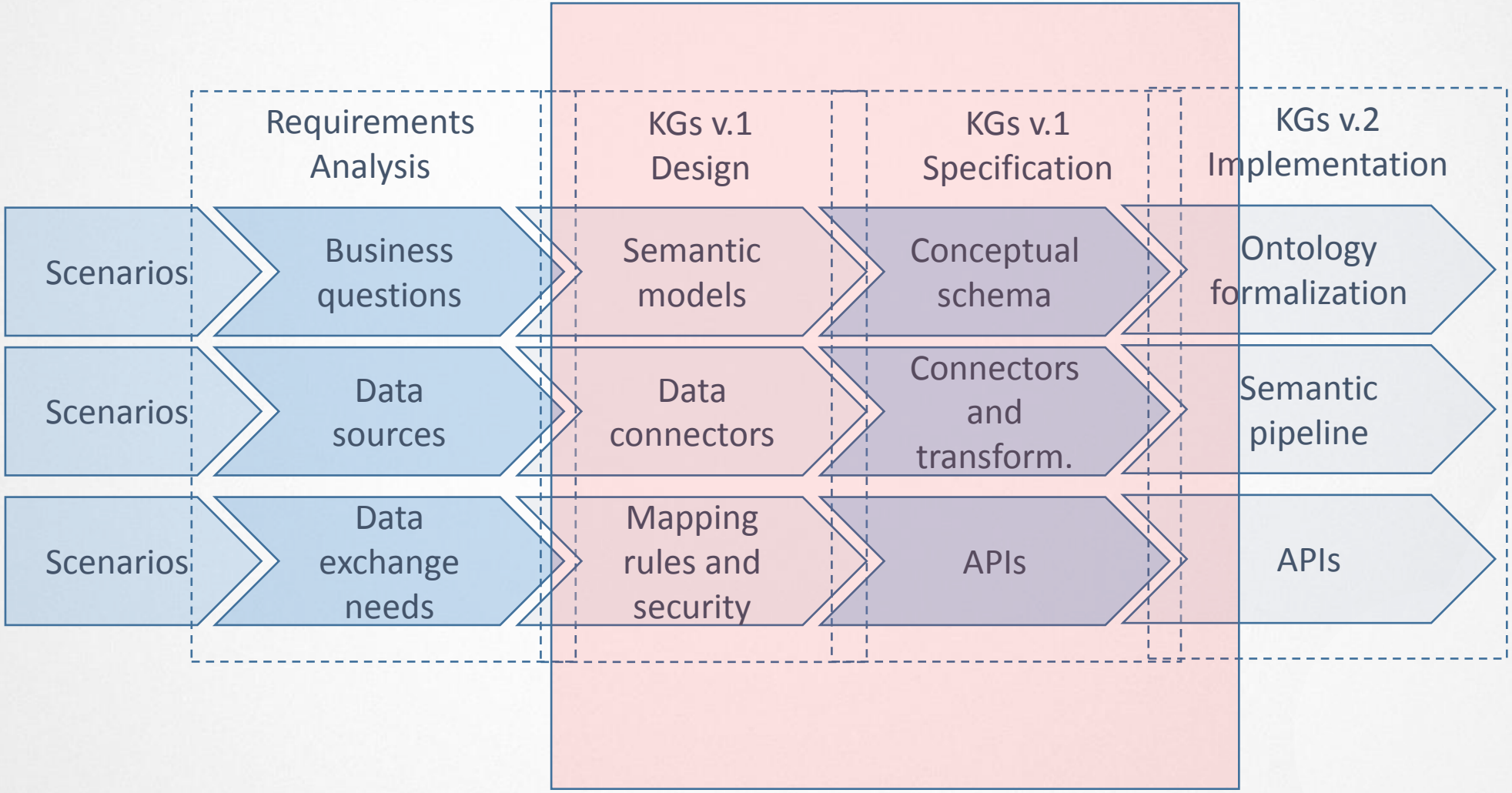
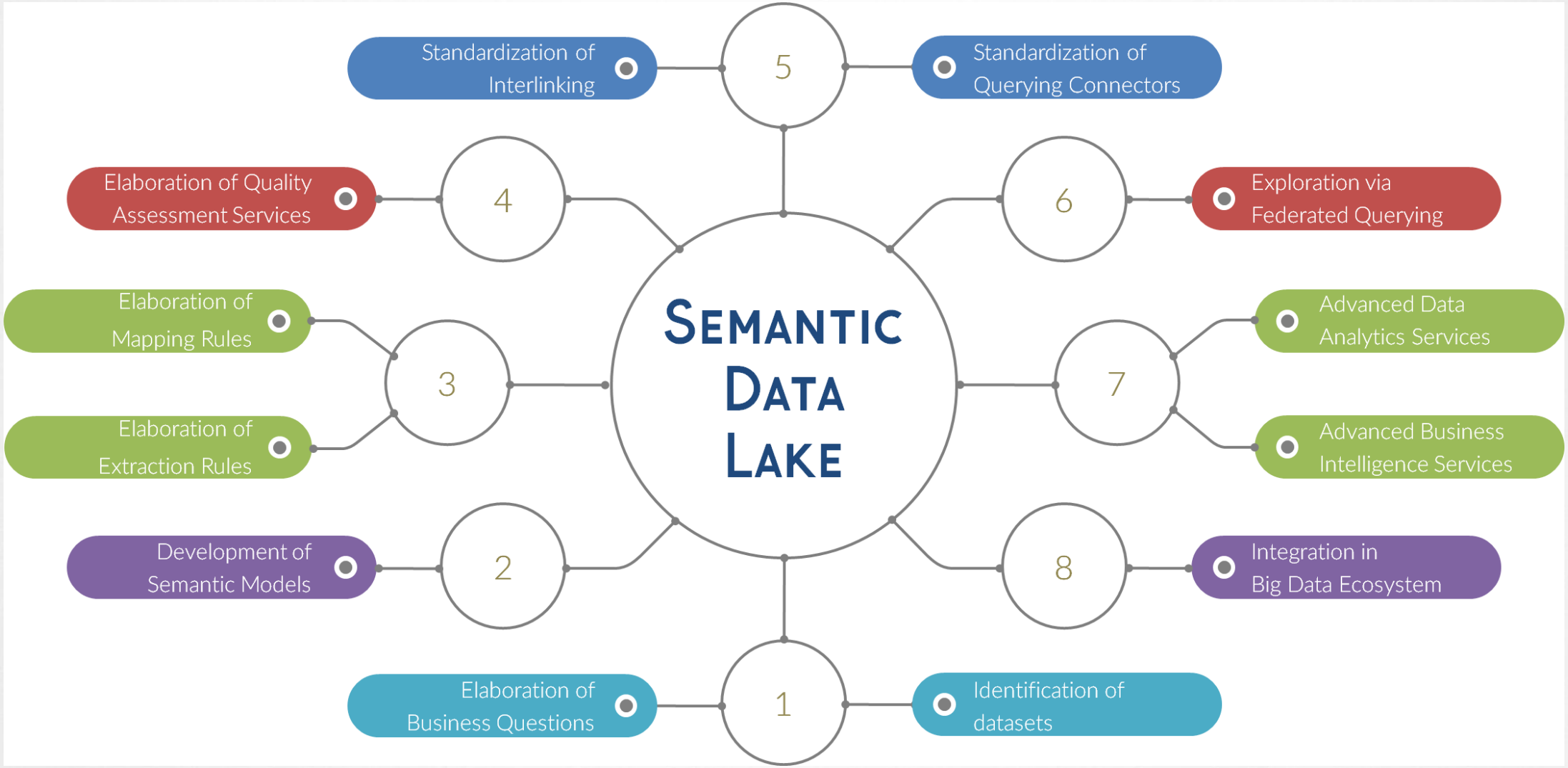
ARTEMIS Solution



Methodology – Interoperability and Integration Framework



Building a Semantic Data Lake for Energy Management



SGAM and IDS Based Architecture

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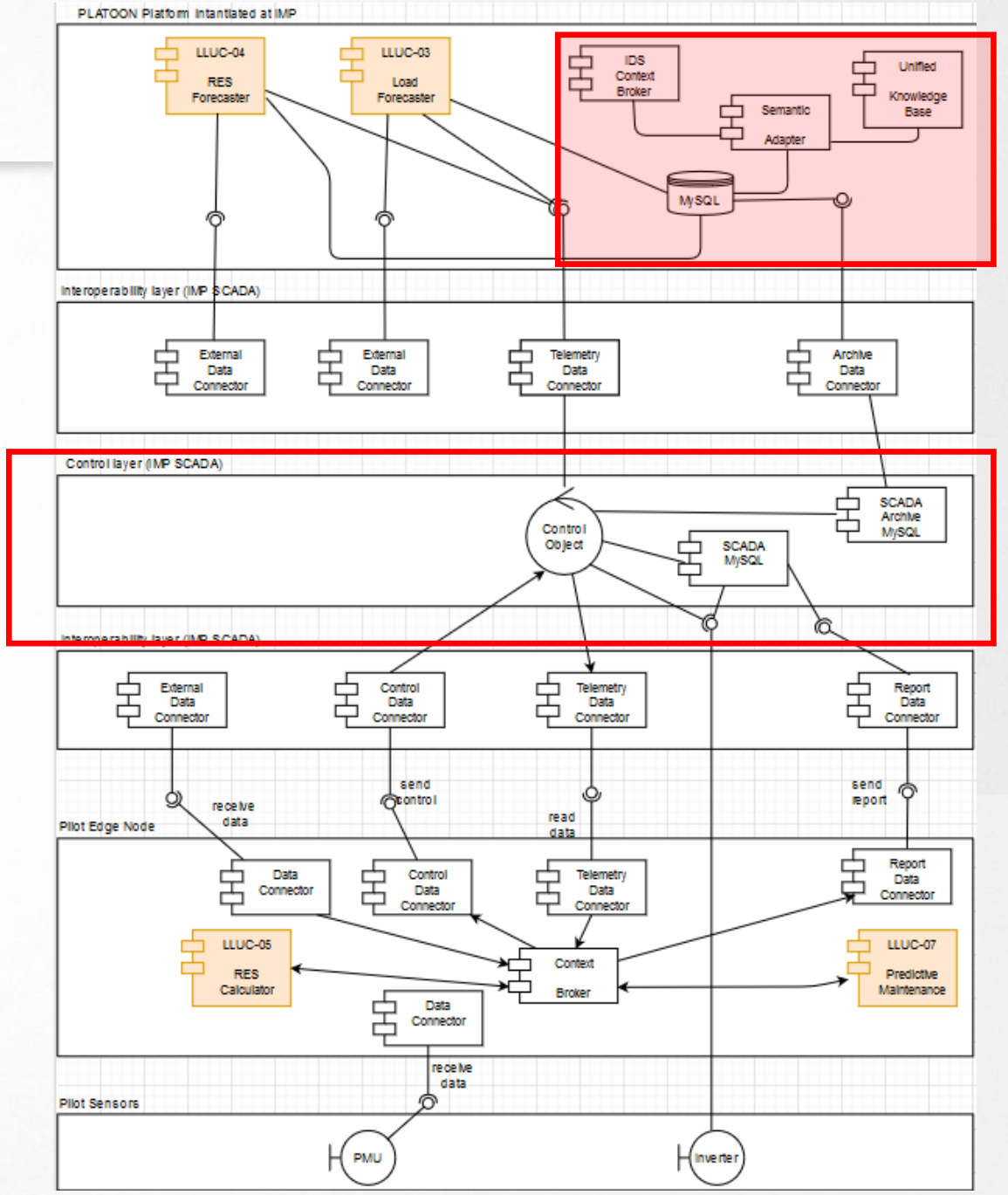
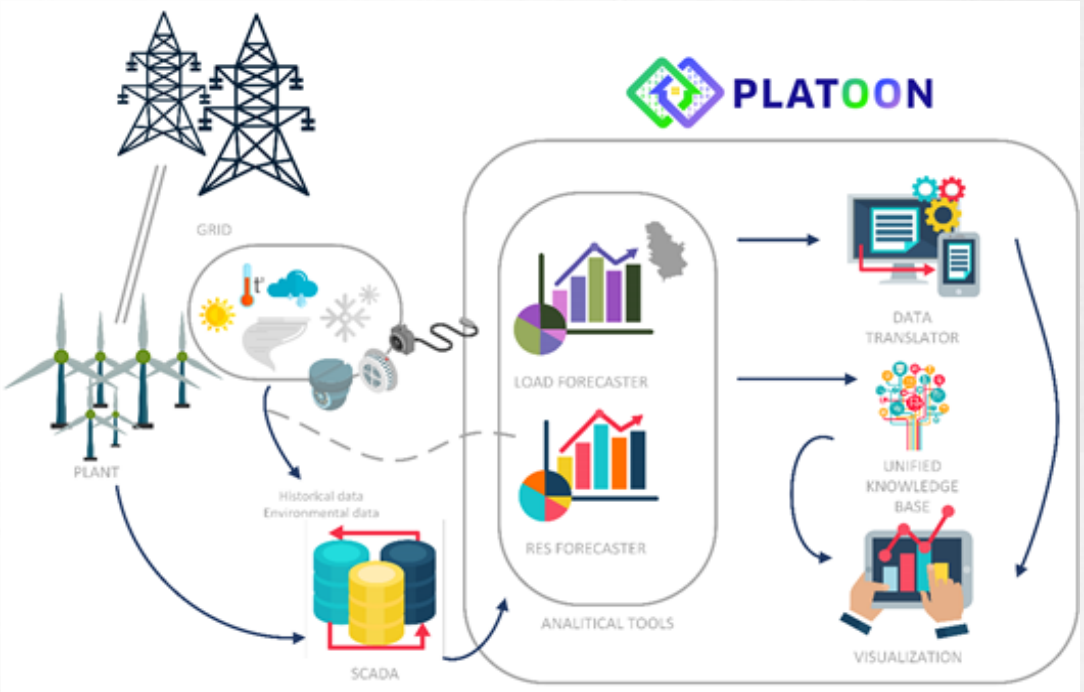


Explainable AI Services - Outlook

- **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



Lessons Learned & Concluding Remarks

- Adoption / Deployment of Innovations

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Lessons Learned

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
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
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
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	Increase reliability of supply; Increase renewable energy penetration;
Effects of Renewable Energy Sources on the Power System (distribution level)	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
Predictive maintenance in RES power plants	This Scenario focuses on the design and development of predictive maintenance services using machine learning algorithms.	Services will allow the Serbian biggest electricity producer – the Power Industry of Serbia (EPS) to improve plant maintenance and optimize asset performance.

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 and Interoperability
  - 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)
  - The meta-data layer in Digital Ecosystems (e.g. Energy Data Ecosystem for Serbia) can (1) facilitate the integration of services in future integrated energy systems and (2) improve the explainability of machine learning services / analytical applications (still under evaluation in PLATOON and ARTEMIS projects)
- Analytics Solutions
  - AI-based systems required for improving
    - Interpretability of the Output of Predictive Models
    - Enhance Reasoning
    - More accurate predictive models

Questions?

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Thank you for your attention!

Big Data Analytics Summer School, Belgrade, Serbia, June 2021

Doctoral Workshop 2021

TRINITY

PLATOON

Artemis

ARTificial Intelligence in Energy Management Innovative Services

Sinergy