Survey on Technologies Driving the Smart Energy Sector

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Sinergy

Capacity building in Smart and Innovative eNERGY management

Overview

- Motivation
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  - EU Policy context
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- Conclusion

…the requirement to improve the Institute Mihajlo Pupin proprietary VIEW4 SCADA that is currently deployed at many parts of the Serbian electricity value chain

This project has received funding from the H2020 programme of the European Union under GA No. 952140

Smart Energy Management - Challenges

- Challenges are related to
  - **Digitalization of the energy sector**, enabling thus higher levels of operational excellence with the adoption of disrupting technologies
  - **Modernisation of the European electricity grid**, by introducing new smart grids services, providing access to cheaper and **sustainable energy** for energy consumers and maximising social welfare
  - **Integration of renewable energy sources (RES)**
  - The need to **increase renewable energy consumption,** improve **smart grids** management, increase **energy efficiency** and **optimise energy asset management**

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EU Policy Context

› the *EU Strategy for Energy System Integration* (July 2020) envisions a "coordinated planning and operation of the energy system 'as a whole', across multiple energy carriers, infrastructures, and consumption sectors"

› the *EU Data strategy* aim is to create a single *European data space*

- 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

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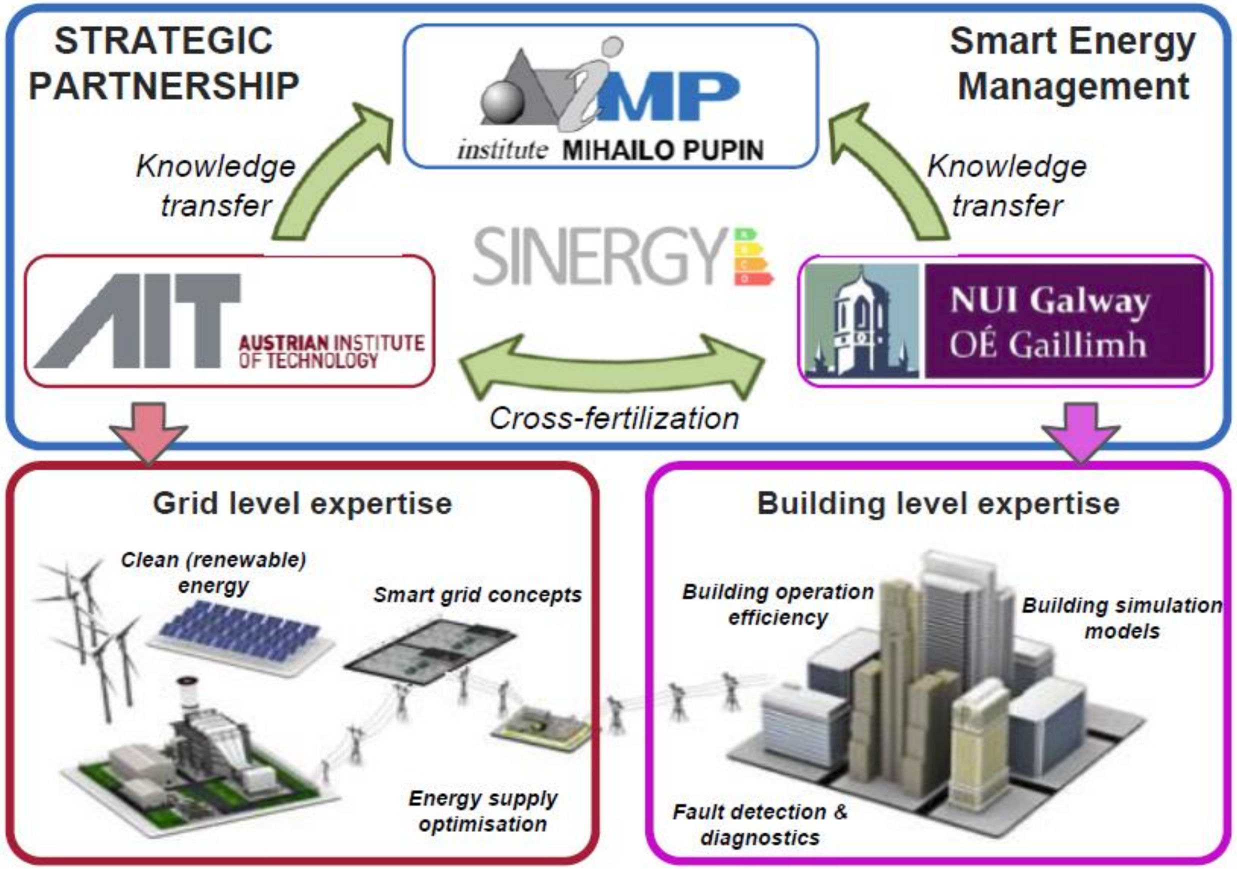
Focus of Research in SINERGY

- **Cross-fertilization and aggregation of competences and experience** related to the smart grid technologies and energy efficient building operation
- **Developing high impact applications** that significantly contribute to national, regional and European sustainable development and **support the transition to reliable, sustainable and competitive energy systems**



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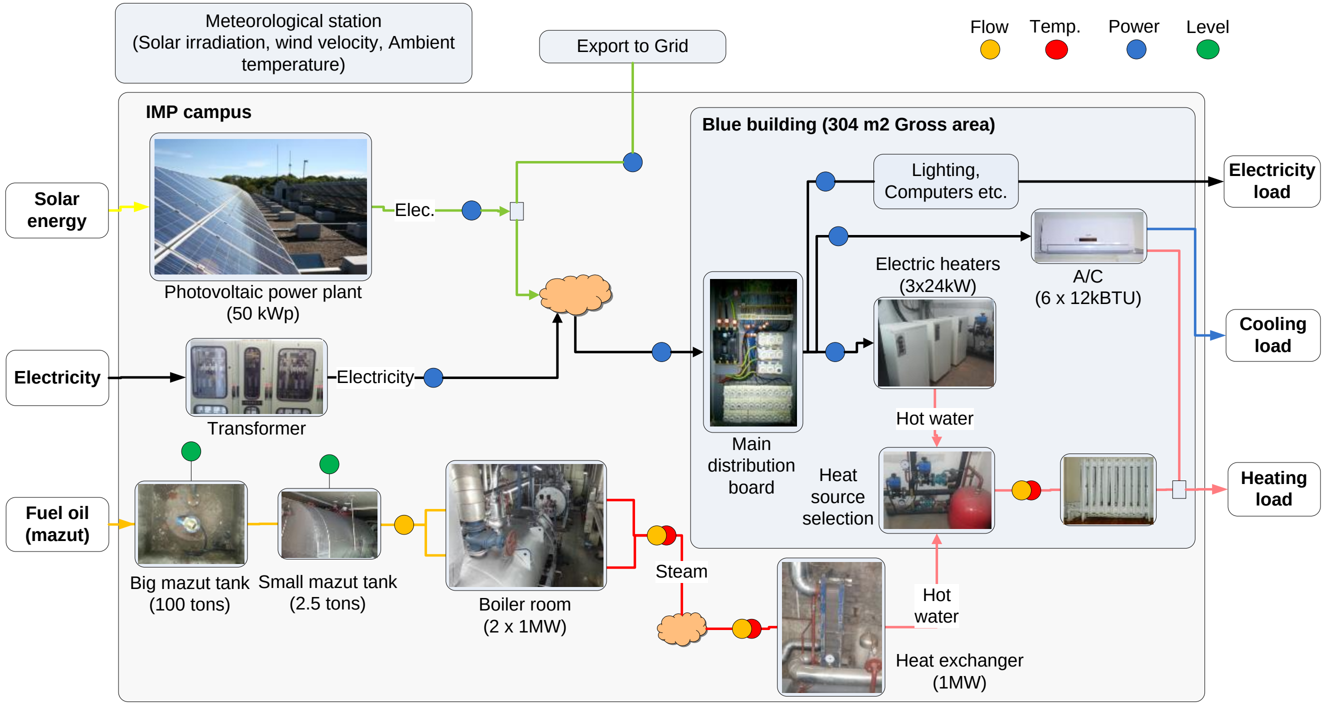
Case Study from Serbia:
IMP campus and “Blue building” Testbed

- 40 years in Process Control Systems
  - Supervisory, Control and Data Acquisition (SCADA) Systems
  - Distributed Control Systems (DCS)

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



- Monitoring - Electricity consumption, Electricity production, Thermal consumption, Fuel oil consumption
- Control - Mazut flow, Heat-source, PV plant

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Smart Grid Landscape

- Power Electronics and System Components
  - power electronics converters are key enablers to couple all kinds of generation and loads effectively
  - the design usually depends on many different critical parameters such as for example efficiency, dynamics, cost effectiveness, power density, input/output voltage or input/output current capability
  - new semiconductor materials such as Silicon Carbide (SiC) or Gallium Nitride (GaN) are on the rise and more and more products on the market based on this technology can be expected in the future pushing the existing physical limits even further.
  - An application readiness map for commercially available GaN transistors 100 V-650 V is depicted in Fig. 1. As can be seen, the adoption is affecting different sectors from grid connected applications, transportation and even the robotics sector.

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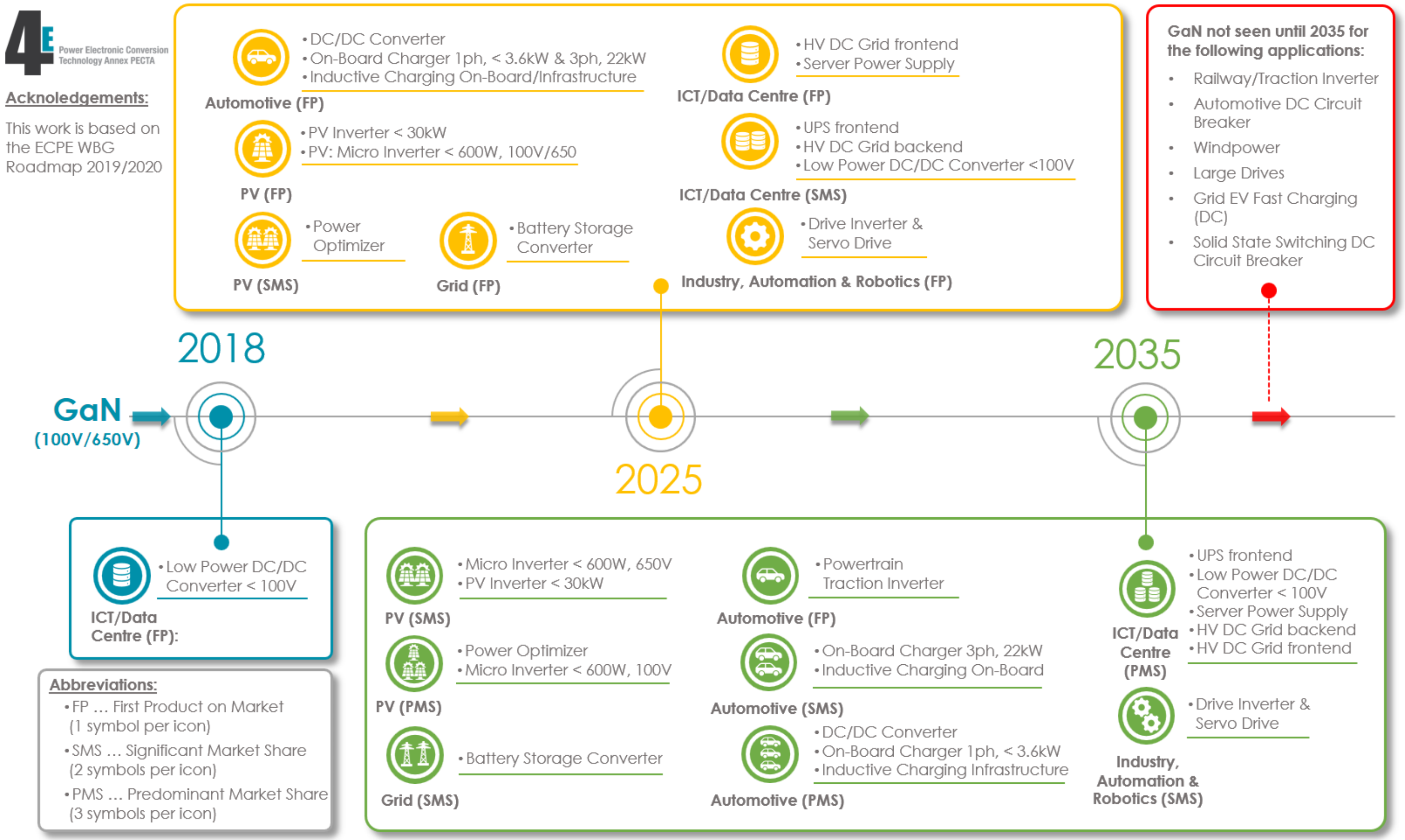
GaN-based Application Readiness Map (ARM)



* contact AIT

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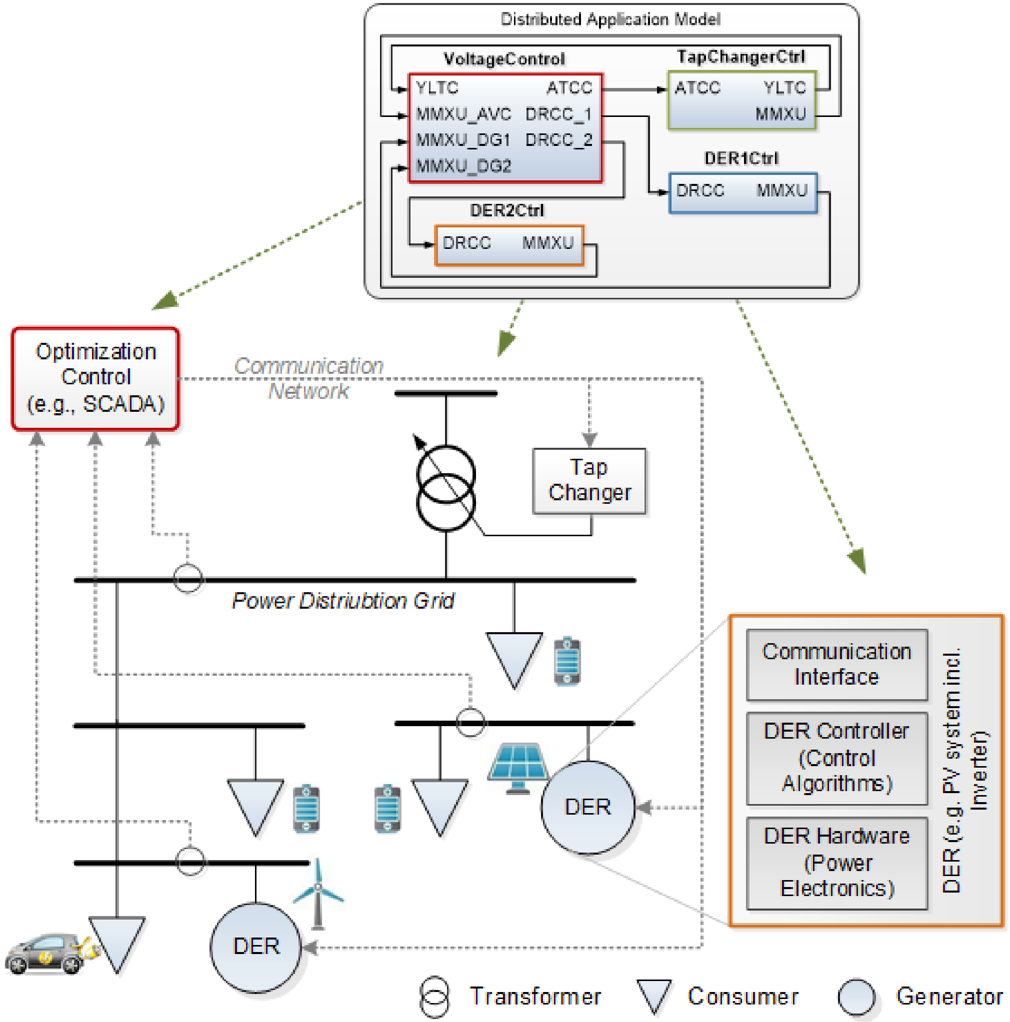
Power System Digitalization and Automation

- *System level:* Approaches like power utility automation, demand-side management or energy management are tackled by this level.
- *Sub-system level:* The optimization and the control of sub-systems are carried out below the system level whereas the corresponding functions, services, and algorithms have to deal with a limited amount of components (RES, energy storage system, electric vehicle supply equipment, etc.). Examples for this level are micro-grid control approaches and home/building energy management concepts.
- *Component level:* Distributed Energy Resources (DER)/RES, distributed energy storage systems but also electric vehicle supply equipment is covered by this layer.
- *Sub-component level:* Intelligence on this level is mainly used to improve the local component behaviour/properties (harmonics, flicker, etc.). Power electronics (and their advanced control algorithms) are the main driver for local intelligence on this level.

To address the growing demand for communication due to the various new smart grid applications as well as for economic reasons, utilities need to move away from purpose-built networks and consolidate communication in integrated smart grid communication architecture. This transformation is currently ongoing.



Necessary intelligence in a smart grid system on different levels

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Energy Efficient Building Operation Landscape

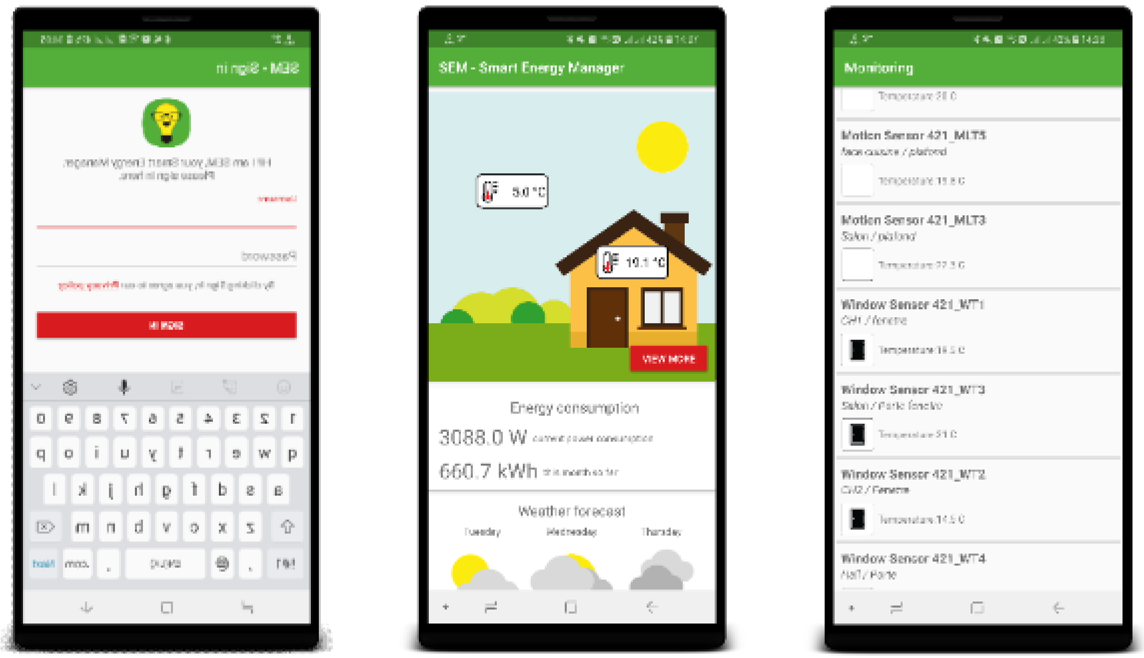
Three approaches to more efficient building energy efficiency [7]:

(1) Monitoring the operational stage of building lifecycle (BLC)

- Currently, there is a shift towards a circular view of this lifecycle, which represents a major paradigm change, including a reuse and zero-waste approaches, instead of the current linear model.

(2) Analyzing the users' behaviour, patterns and implementing technologies to improve their perception of the building and provide with a more details on how savings could be achieved.

- New AI-based solutions e.g. non-intrusive load monitoring algorithms
- New applications that identify energy wastes, teach users how to conserve energy and steer their behavior to be more energy efficient.



(contact IMP)

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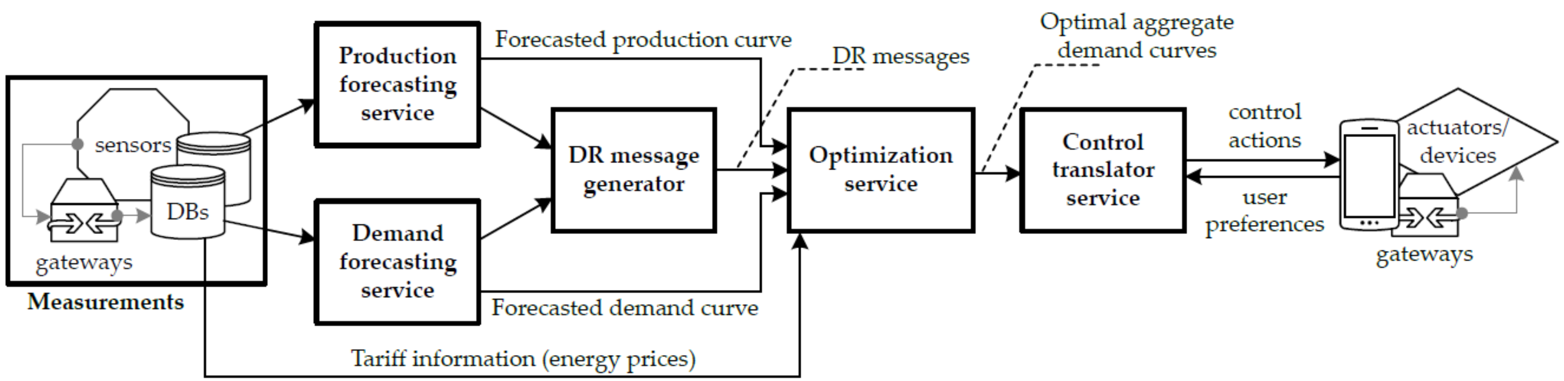
Using smart tools and methods for enhanced building operation

- Fault Detection, Diagnosis and Prognosis of HVAC systems;
- Model Predictive Control (MPC) algorithms for optimal control of various parameters (temperatures, valve positions, flow rates, pressures, etc.) taking into account a dynamic model, its utilization for enhanced building operation;
- AI services which supplement each other (e.g. edge services, cloud AI-enabled services for predictive maintenance, semantic technologies, advanced optimization algorithms).



AI-powered system for residential demand response (contact NUIG)

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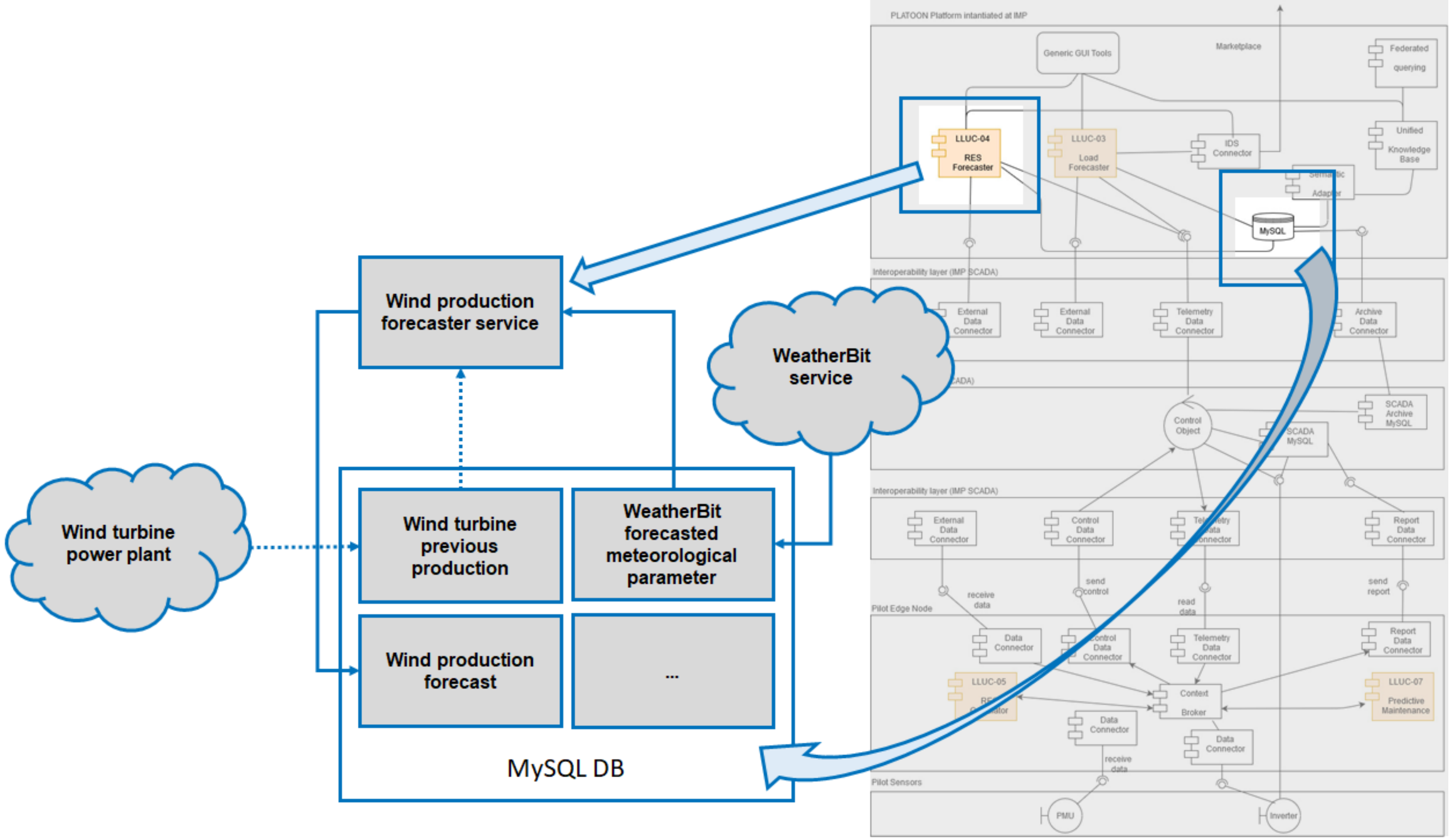
Emerging ICT Technologies and Trends

› *Interoperability, Standardization, Data Spaces*

› *Big Data and IoT*

› *Artificial Intelligence*



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Interoperability, Standardization, Data Spaces

› EU foresees transformation of existing industry value chain processes, introduction of intermediaries and **marketplaces**, introduction of SOA 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 – trusted environment for data sharing

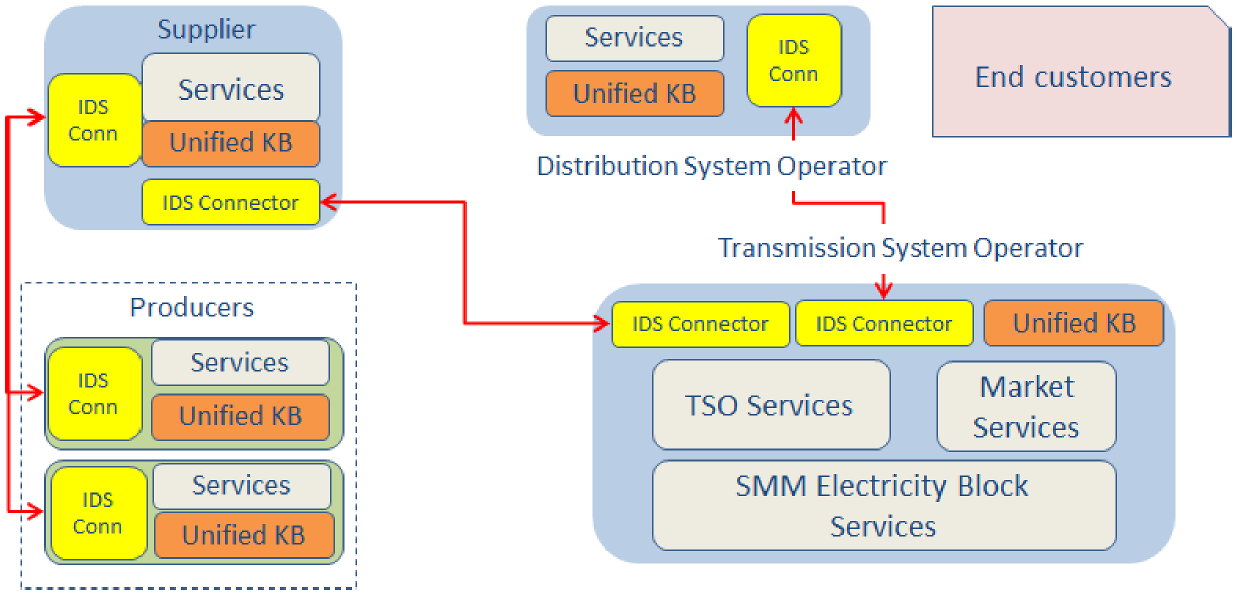

Figure 3: Multi-party data exchange based on IDS concept

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AI-based Services

TABLE 1. INSTITUTE MIHAJLO PUPIN SOLUTIONS

Service	***Methods***
Non-Intrusive Load Monitoring [11]	Recurrent Neural Networks (RNNs) with the accent on Long Short Term Memory (LSTM) and Convolutional Neural Networks (CNNs).
Wind turbine production forecaster [12]	Deep neural networks; various architectures have been tested including different combinations of LSTM, Convolutional, Dense and Dropout layers.
Consumption prediction [13]	Random forests, K-Nearest Neighbor (kNN), SVM, Linear regression and Neural networks.
Demand response for the residential sector [14]	Auto regressive integrated moving average, linear regression, support vector regression and kNN.

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Conclusions

- Smart Grids are the next evolution step of the traditional power grid, and are characterized by a **bidirectional flow of information and energy**.
- According to recent EU regulations, energy services in future will be offered via **business (2) business (2) consumer (B2B2C) marketplaces** that will enable integration of the energy data in a European Energy Data Space. Such approach will directly contribute to quality of life of citizens by making them active stakeholders in the electricity market chain.
- Due to the changing framework conditions, like the liberalization of the energy markets and **new regulatory rules for boosting competitiveness through interoperability and standardisation**, **novel approaches for design, planning, and operation of the electric energy system** are needed.
- Taking the presented analysis into account and assessing the current deployment of the VIEW4 proprietary system, **further research is needed to achieve adoption of the above mentioned novel concepts and technologies in the Serbian energy value chain for optimal energy production, distribution and consumption**.

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Thank you very much!

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DIGITAL TRANSFORMATION TECHNOLOGY Webinar [IEEE IAS/PELS/IES Austria Chapter]