ENERGY DATA SPACES AND AI ANALYTICS: A FRAMEWORK FOR INTELLIGENT ENERGY SYSTEMS

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OVERVIEW

- Rapid digitization of the energy sector
- Challenges and opportunities
- Importance of energy data spaces and AI analytics
- Proposed framework for intelligent energy systems

CHALLENGES AND OPPORTUNITIES

Lack of Standardization:

- **Interoperability** is hindered by the absence of universal standards/ Current standards like **IEC 61850** are domain-specific (e.g., substation automation)/ A broader, standardized framework for the **entire energy sector** is needed.

Cybersecurity Concerns:

- Increased **cyberattacks** on energy infrastructure.
- Solutions: **Advanced encryption**, **federated learning**, and **secure multi-party computation** for data protection.

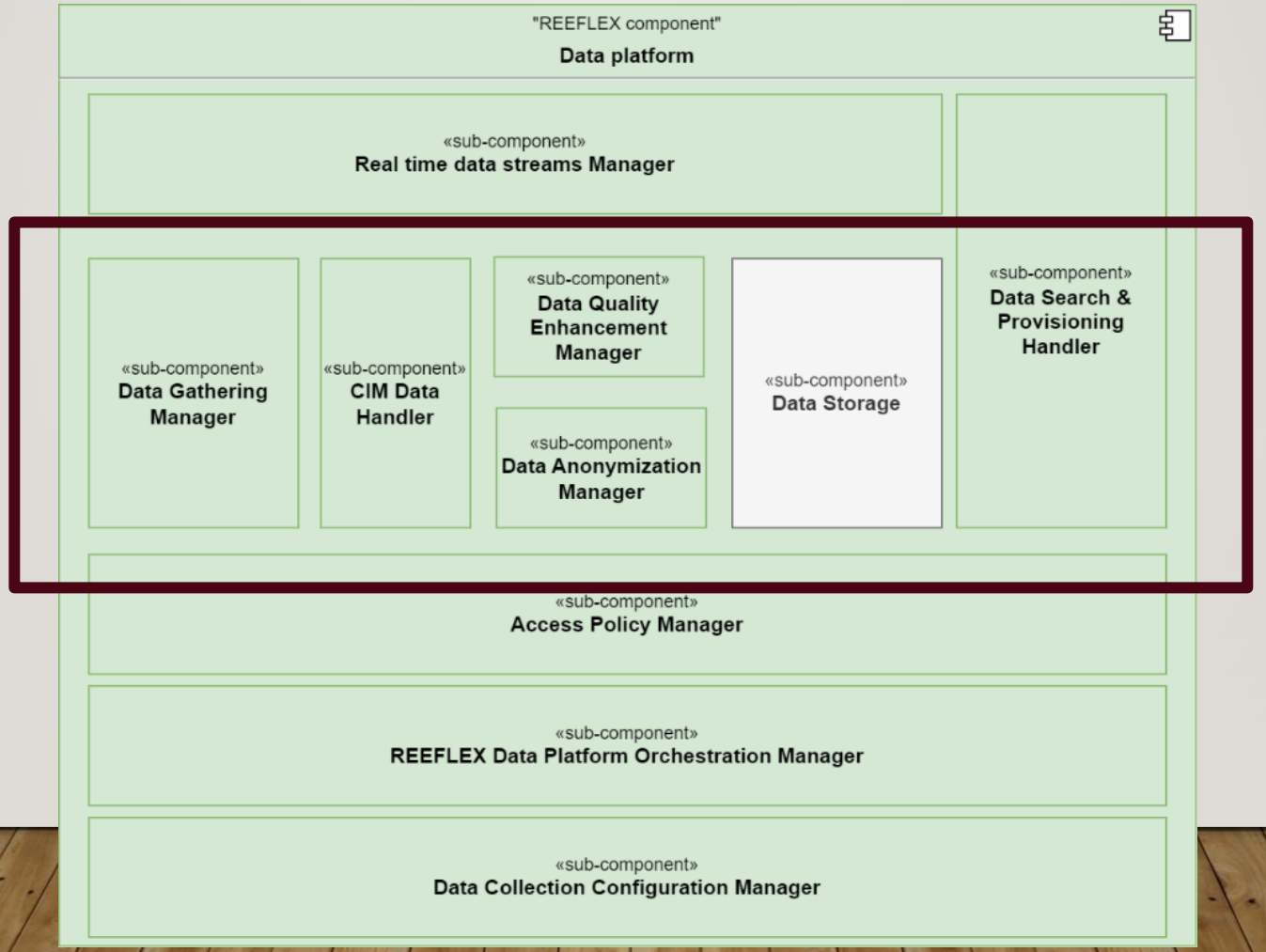
AI Analytics in Energy:

- **Data Quality & Availability**: Large-scale, high-resolution data is limited./ **Fragmented & Siloed Data**: Limited accessibility across stakeholders.
- **Variability of Renewable Energy**: AI models need to adapt to unpredictable factors (e.g., **weather** for wind/solar energy).

A DECENTRALIZED PLATFORM FOR SECURE AND EFFICIENT DATA EXCHANGE

- **Data interoperability:** The ability of different systems, applications, and organizations to seamlessly exchange and use data, ensuring compatibility and cooperation across platforms.
- **Data sovereignty:** The concept that data is subject to the laws and governance structures of the country in which it is collected or processed, ensuring local control and protection of data.
- **Data privacy:** The protection of personal or sensitive information from unauthorized access, ensuring that individuals' data is handled responsibly and securely.
- **Data sharing:** The practice of making data accessible across entities in a secure, controlled manner, often with clear guidelines on its use and protection.
- **Standardization (IDSA, GAIA-X):** The establishment of common frameworks, like those from IDSA (International Data Spaces Association) and GAIA-X, that set the rules for secure, trusted, and interoperable data exchange in a digital ecosystem.

A DECENTRALIZED PLATFORM FOR SECURE AND EFFICIENT DATA EXCHANGE



AI ANALYTICS IN ENERGY

Key Features:

- **Data ingestion and preprocessing**: Collecting raw data from various sources such as sensors, meters, and IoT devices, followed by **cleaning, normalizing, and transforming** the data to prepare it for analysis and model development.
- **Model development and training**: Creating and refining machine learning models using historical and real-time data from the energy sector.
- **Model deployment and evaluation**: Implementing trained models into production environments where they can process live data.
- **Insight generation and visualization**: Using AI models to generate actionable insights, such as identifying energy efficiency opportunities or predicting maintenance needs.

AI ANALYTICS IN ENERGY

No	Title	Related Category
1	Prediction of comfort boundaries for an occupant	Pre-trained AI prosumers' comfort profiling analytics
2	Prediction of demand at device level considering the same operational conditions (2-3 hours ahead)	Pre-trained AI Prosumer-level energy demand and generation forecasting
3	Prediction of demand at device level, for different comfort/operational levels (2-3 hours ahead)	Pre-trained AI Prosumer-level energy demand and generation forecasting
4	Prediction of energy demand at building level in short-term (day ahead)	Pre-trained AI Prosumer-level energy demand and generation forecasting
5	Prediction of energy demand at LEC level in short-term (day ahead)	Pre-trained LEC level energy demand and generation forecasting
6	Prediction of energy demand at point of delivery	Pre-trained LEC level energy demand and generation forecasting
7	Prediction of energy generation at asset level in short term (day ahead)	Pre-trained AI Prosumer-level energy demand and generation forecasting
8	Prediction of demand flexibility at device level - short-term (2-3 hours ahead)	Pre-trained AI Prosumer-level context-aware flexibility analytics and forecasting
9	Prediction of demand flexibility at building level - short-term (6-24 hours ahead)	Pre-trained AI Prosumer-level context-aware flexibility analytics and forecasting
10	Prediction of storage flexibility at building level under a self-consumption framework- short-term (6-24 hours ahead)	Pre-trained AI Prosumer-level context-aware flexibility analytics and forecasting
11	Prediction of generation flexibility at DER level - short-term (6-24 hours ahead)	Pre-trained LEC level flexibility profiling and forecasting
12	Prediction of energy exchanged in P2P markets - short-term (day ahead)	Pre-trained AI Prosumer or portfolio-level context-aware flexibility analytics and forecasting

REAL-WORLD APPLICATIONS

- Smart grid integration → focus on the provision of services to the network operators
- Demand-side management → active enrolment of citizens/consumers
- Renewable energy optimization → with focus on minimizing curtailment through max self consumption
- Energy trading → with focus on minimizing energy pricing/PPAs
- Energy investments planning → for future planning of the network with RES/DER penetration

DEMO SITES AND DEMONSTRATION ACTIONS

Spain (Zaragoza, Aragon):

- Mix of **residential, office, and industrial consumers**.
- Focus: Integrating consumers and prosumers into **flexibility markets**.

Greece (Thessaloniki):

- **50 residential buildings**, 3 energy retail stores, large commercial facility.
- Focus: Consumer participation in **demand-side management**.

Switzerland (Lugano, Via Motta):

- Diverse prosumers: **Residential, offices, care home, warehouses**.
- Focus: Leverage smart metering and **renewable energy integration**.

Bulgaria (Sofia, Montana):

- **Data centers** with cloud services.
- Focus: Utilize **flexibility** through energy storage, UPS systems.

KEY OBJECTIVES AND FEATURES

- **Motivation**:
  - Optimize operations for stakeholders in the **energy sector**.
  - Enable **data-driven decision-making** and innovation.
- **Platform Highlights**:
  - **Data collection & harmonization** with external data enrichment.
  - Secure **data sharing** via a user-friendly marketplace.
  - **AI-driven analytics**: Pre-trained models or custom-built algorithms.
- **Architectural layers** supporting energy systems for:
  - **Buildings**, **communities**, and **energy market stakeholders**.
  - Integration with **software tools** for analytics and management.

QUESTIONS

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