Eros4NRG: Zero Trust IoT Analytics for Smart Energy

Martel Innovate

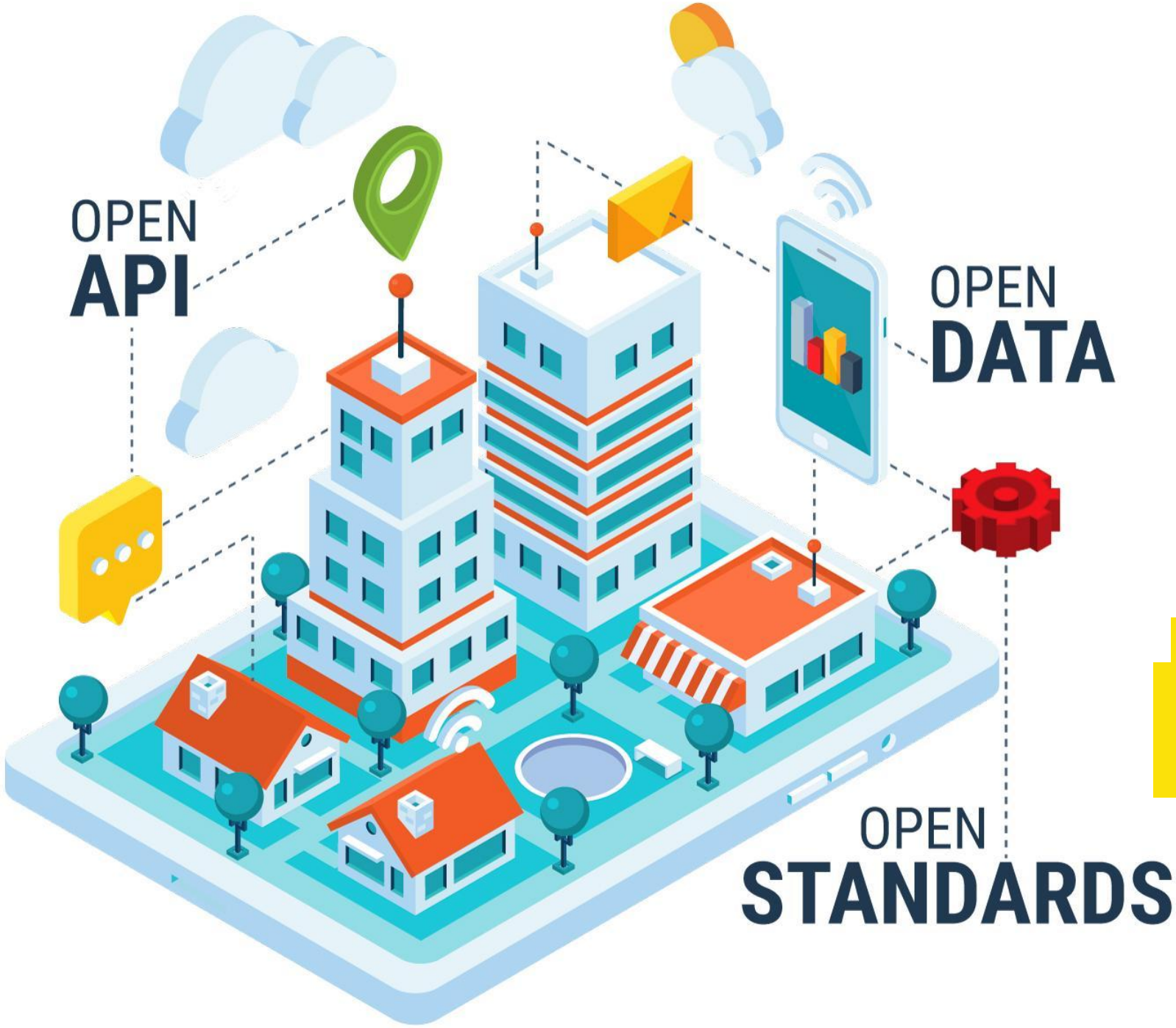
MARTEL INNOVATE R&D PILLARS: IoT, AI, CLOUD

Technologies

- Microservices orchestration and mash solutions: Kubernetes and Istio
- Timeseries data bases: Crate, Timescale
- AI and data analytics solutions: Kubeflow, Nuclio, Spark, …
- Open Source IoT stacks: FIWARE
- IoT standards: Lorawan, AMQP, COAP
- Infrastructure as Code & DevOps: Argo / Flux

Research topics

- Dynamic serverless orchestration of AI pipelines
- Context-aware Machine Learning Operation
- Self-privacy aware data
- Enablement of dynamic cloud-edge ecosystems
- Energy-optimized cloud-edge native orchestration



ORCHESTRA *CITIES*

BY MARTEL INNOVATE

AN OPEN PLATFORM

OrchestraCities Main Features

OPEN SOURCE SOFTWARE, OPEN APIS AND OPEN DATA MODELS

MULTIDIMENSIONAL DATA AT SCALE: SCENARIO, LOCATION AND TIME

MODULAR AND SCALABLE CLOUD SERVICES

SHARING OF DATA AND METRICS AMONG CITIES

COST-SHARING AMONG CITIES

REALTIME CITY MONITORING

Eros4NRG Concept

- Eros4NRG aims to enhance Nemo Project Smart Energy Trial through the integration of new plugins and software components.
- **Enhance Data Trust & Transparency:** Analyse and secure IoT/Edge data.
- **Optimize Energy Data Management and Secure Sharing:** Establish Cutting Edge data storage solutions that fosters semantic connections between dynamic information and metadata.
- **Streamline Energy Operations & Data Decision Making:** Optimise energy operations by providing state-of-the-art explainable ML/AI components for Nemo Energy Trial.

Eros4NRG Challenges

- **Challenge #1 - Unreliable Energy IoT/Data Sources:** Inaccurate data in energy ecosystems (Buildings, PVs, EVs) that affect ML operations and training.
- **Challenge #2 - Lack of Organization and management of Energy Data:** Static data elements, like energy entity attributes, environment, geolocation, and device fleets, are frequently overlooked, leading to information loss and diminished analytics quality.
- **Challenge #3 - Involve stakeholders in cross-value chain services:** Enhancing AI/ML model explainability and translating machine learning predictions into user-friendly language, will make them more comprehensible to non-technical stakeholders, consequently contributing to the end user interaction with the smart energy analytics domain.

Eros4NRG Objectives 1/2

- **Obj. 1 - Increase Data Trust and Transparency in Energy Analytics Services:** Conduct data inspection and anomaly detection to identify anomalous data sources.

- **Obj. 2 - Improve Data Self Explainability, Management and Secure Sharing:** Eros4NRG enhances data management through metadata extraction, separating static energy entity details and IoT/Edge device inventories from dynamic data. It improves semantic connections and data ecosystems for enhanced data protection, secure sharing, and access control.

Eros4NRG Objectives 2/2

- **Obj. 3 - Deploy Abnormal Aware Energy Analytics:** On top of checked-in data (high-quality) train AI/ML models to optimise energy grid behaviour.

- **Obj. 4 - Introduce AI/ML Models Explainability:** Eros4NRG aims to deploy Explainability components that will be responsible for the machine learning interpretation to facilitate high level users on the decision making towards more energy efficient operations.

Eros4NRG Expected Outcomes

Outcome ID	Outcome Name	Start/End TRL
#1	Zero Trust Data Services	3/5
#2	Collaborative Data Enclaves	3/5
#3	xAI Enabled One-Stop-Shop for Energy	3/5

Outcome #1 - Zero Trust Data Services

- **Zero Trust Data Services** (TRL 3/5):
  - verify IoT/Edge data sources by applying anomaly detection
  - decision making if IoT/Edge data source adoption (based on anomaly detection results) we will isolate abnormal data sources
  - data pipelines will operate over the checked-in data to perform curation, data modelling, anonymisation of sensitive data.
  - Metadata decomposition functionality is important to disaggregate static information from dynamic information.
    - Static information (building entities like N# of building floors, N# of rooms inside each floor, IoT/Edge entities inside each room and what are measuring)
    - Dynamic Information will be the timeseries generated by the IoT/Edge sources

Outcome #2 - Collaborative Data Enclaves

- Eros4NRG aims to move from conventional data warehousing techniques and exploit the potential of static information (energy physical entities) in order to reduce computational load and enhance querying capabilities.
  - **Data Lake:** Will contain the raw and the clean buckets, where in the first raw data after capturing will be stored and on the other data after anomaly detection will be stored.
  - **Dynamic Data Enclave:** Dynamic Information (Tms) will be stored there after metadata decomposition.
  - **Graph Data Enclave:** Static Information will be stored to innovate graph databases where graph data models will be exploited to depict energy related static information. Semantic links over the dynamic enclave will be applied.
  - **Secure Data Catalogue:** Will offer advanced querying functionalities to expose the stored information in Data Enclaves (Dynamic, Graph) to authorised users, components (role-based access control)

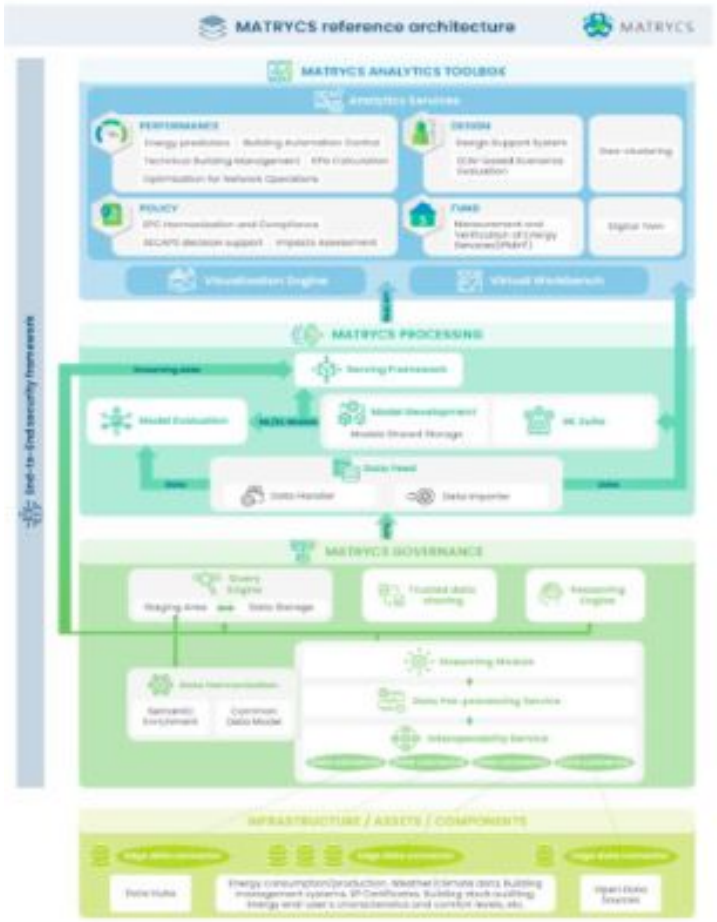
Outcome #3 - xAI Enabled One Stop Shop for Energy

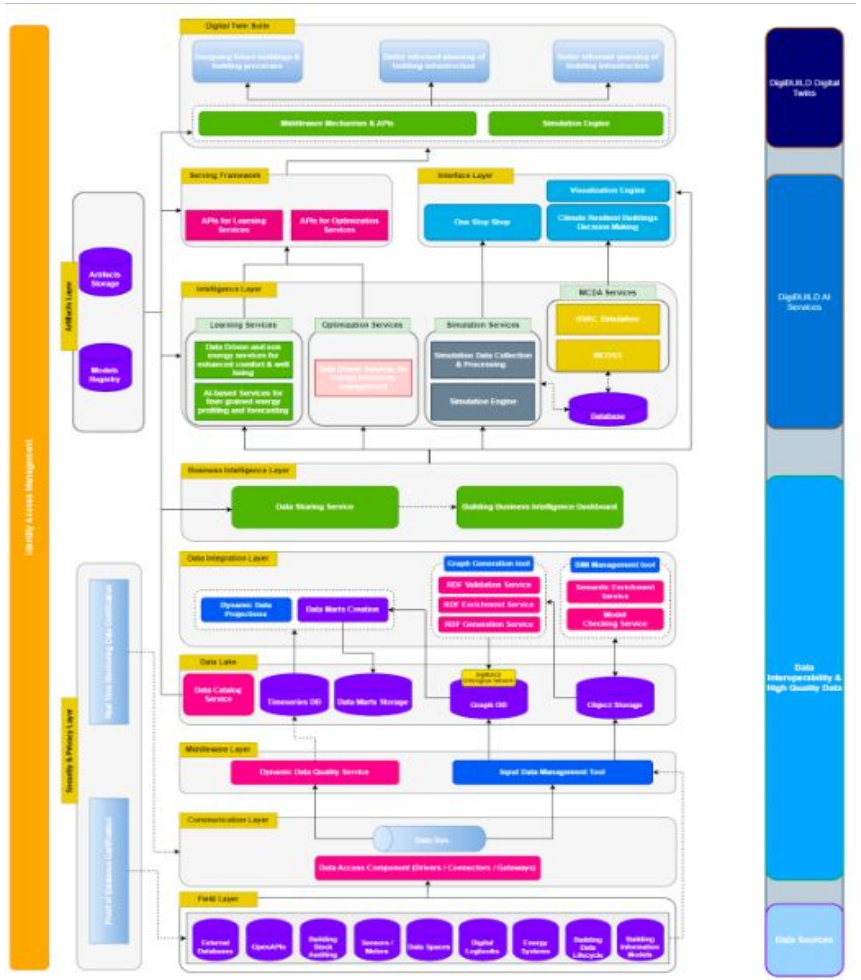
- **xAI Analytics Suite:** AI/ML Algorithms and techniques to optimize Energy Operations in EMOT and ASM pilots with a focus in EV, Buildings and PV systems.
  - EV load forecasting; Buildings energy consumption; PV Energy Consumption; Flexibility analysis involving 3 entities (EVs, Buildings and PV Systems)
  - trained models will be explainable and interpreted so end users will be able to make data-driven decisions.
- **Visual Analytics & Monitoring:** Visualizations, charts and reports over Eros4NRG Data Enclaves.

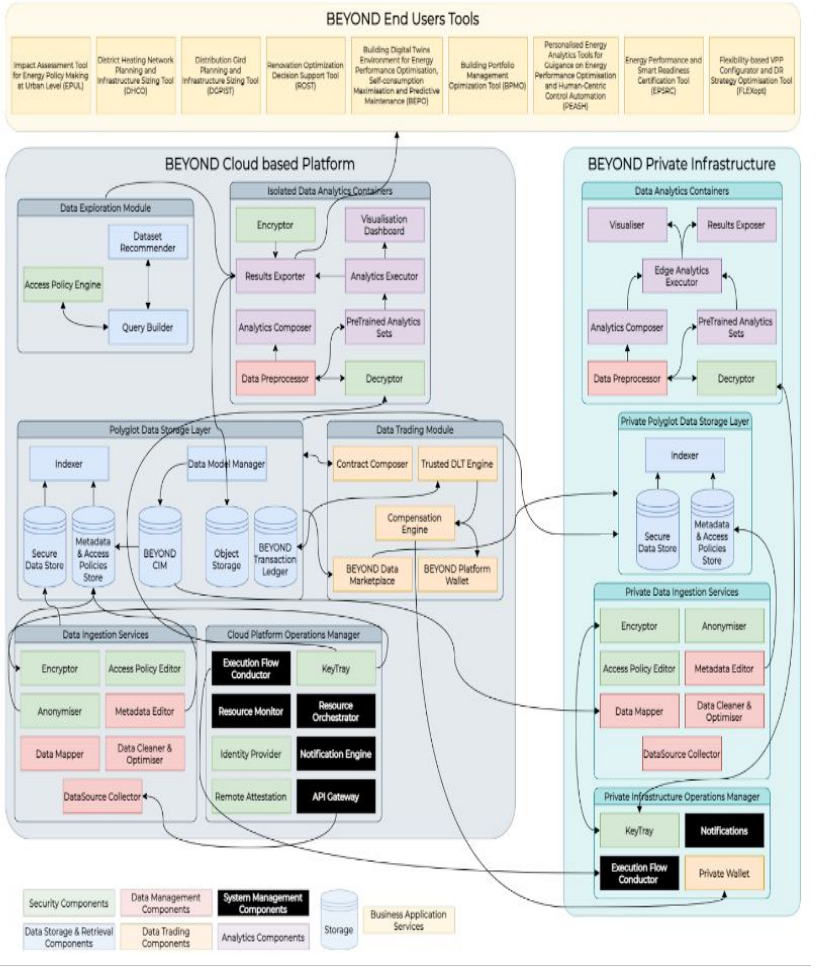
Eros4NRG Integration with NEMO

- **NEMO Cybersecure & Federated MLOps:** Eros4NRG will leverage its functionalities to store, version and serve at REST trained models.
- **Nemo meta-Orchestrator**: Eros4NRG will integrate the functionality of this components to exploit workflow orchestration to trigger Eros4NRG data pipelines and training/re-training of models belonging in Eros4NRG Analytics Suite.
- **NEMO Unified Access Control:** will be integrated with Eros4NRG data catalogue to enable role-based authorization in EROS Data Enclaves and Data Catalogues, also to be integrated with Eros4NRG One-stop-shop for Energy.

Relevant EU-funded projects in Energy (MATRYCS, DigiBUILD, BEYOND)

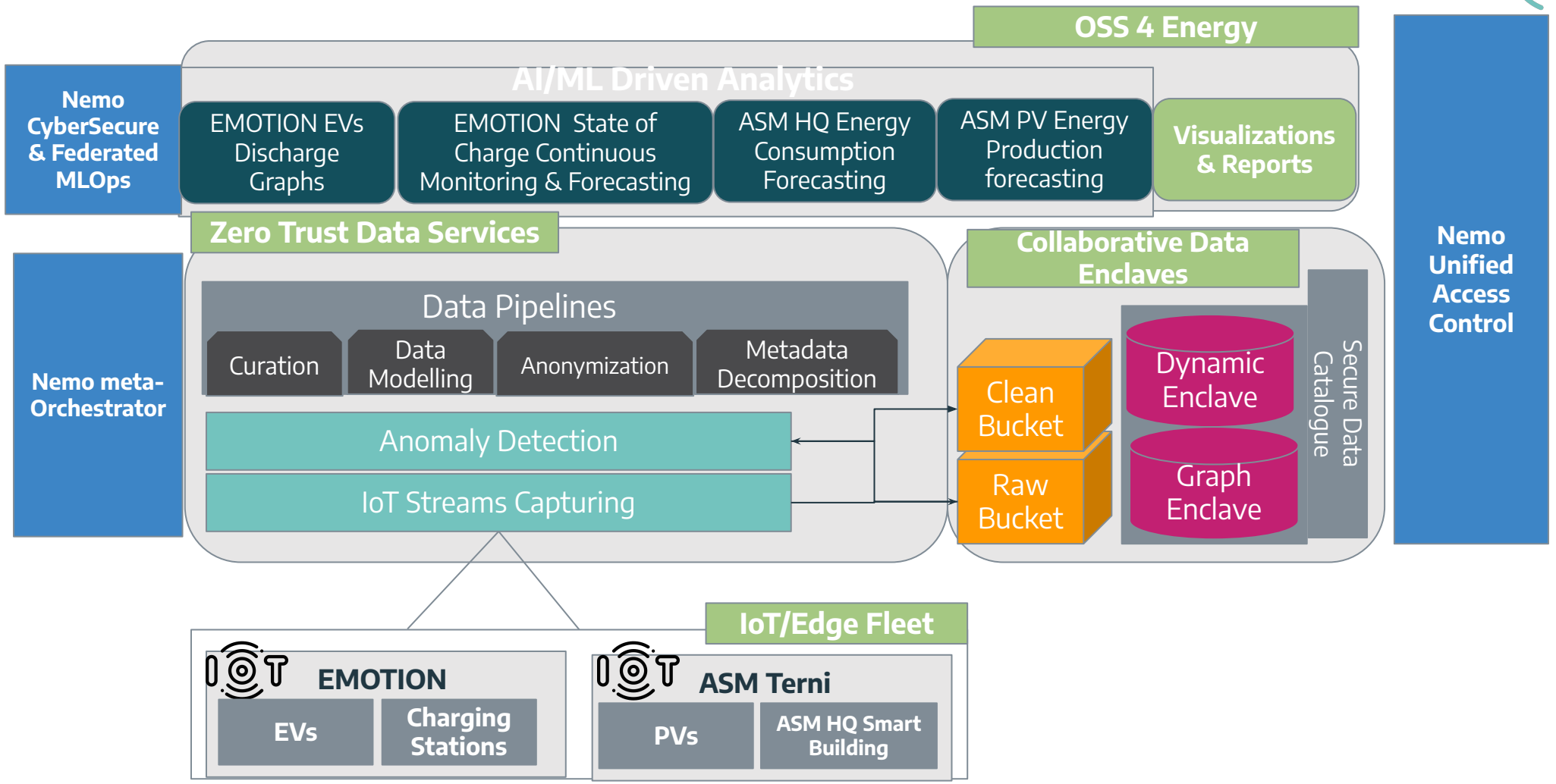






Eros4NRG Design Process

Eros4NRG Conceptual Architecture



Core Technologies

- **Programming Languages**: Python 3.10
- **Queuing Systems**: Apache Kafka, RabbitMQ, ZeroMQ
- **API core Libraries**: FastAPI, Flask
- **ETL Pipelines**: Prefect, Apache Airflow, Pandas, Scikit-Learn
- **Data Storages:** MinIO, TimescaleDB, Neo4j
- **Analytics Suite**: Keras, Tensorflow, Darts, Scikit-Learn
- **Visualization Engine**: Apache Superset
- **Service Mesh**: Istio, Jaeger
- **Cloud Native Infrastructure**: K8S, microK8S

Eros4NRG Team

- Albert Seubers - Project Manager
- Amjad Majid - Technical Manager
- Panagiotis Kapsalis - Software Engineer
- Favian Gozali - Software Engineer
- Aletta D’Cruz - D&C Specialist

Thanks for your attention