OPEN CALL #1

TECHNICAL GUIDELINES CL3E INFORMATION

Revision: V1

COVER PAGE

Document Revision History

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1 CLUSTER 3E: EDGE INTELLIGENCE FOR GRID RELIABILITY

1.1 CLUSTER OVERVIEW

Cluster Title	**Cluster 3E: Edge Intelligence for Grid Reliability**
Domain	Energy, utilities, sustainable power systems
Locations	Western Greece + University of Patras (UOP) Laboratory
Objective	Advance edge-based real-time energy management for grids with high renewable penetration, enabling sub-second control decisions without cloud latency

The **Cluster 3E** pilot activities focus on the integration, monitoring, intelligent operation and interoperability of Distributed Energy Resources (DERs) and flexible loads within active electricity distribution networks. These infrastructures, ranging from PVs, wind, and biogas generation units to fast Electric Vehicles (EV) charging stations, and households, demonstrate the transition from centralized to decentralized, two-way energy systems. Cluster 3E showcases how cloud-edge architectures, IoT-enabled sensing, and AI-based predictive analytics can mitigate the challenges of high-DER penetration—such as grid congestion, overvoltage, thermal limit violations, and stochastic supply variations—while maintaining grid stability, flexibility, and resilience. It specifically targets biogas production and the EV charging domains, leveraging a suite of advanced technologies for edge-based health monitoring and production / consumption forecasting, which can provide valuable input to the distribution grid operator, forming a bi-directional flow of information.

The **Cluster 3E** pilot activities are organized around three complementary use cases **(UC#3E.1–3E.3 of Figure 1)** deployed in different physical and operational environments across Western Greece that collectively demonstrate a fully connected, decentralized, two-way energy system with high presence of DERs and flexible loads.

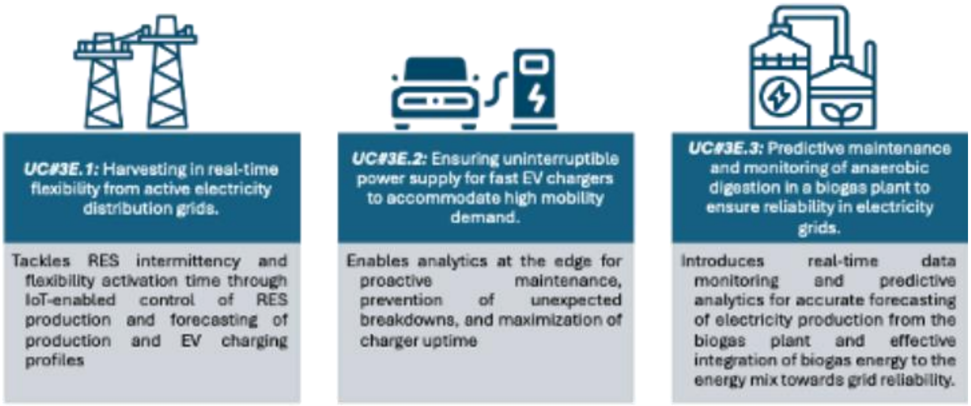

Figure 1- Cluster 3E Use Cases breakdown.

1.2 AVAILABLE INFRASTRUCTURE & TECHNICAL CAPABILITIES

To operate the Cluster3E activities, the COP-PILOT architecture forms an interconnected experimentation environment linking a biogas plant, and a set of EV charging stations, both equipped with sensing and edge processing units, with a simulated distribution grid and advanced distribution managements system. Secure interconnection is realized through the Secure Integration Fabric (SIF) and multi-cloud orchestration, while information exchange among different domains is performed through FIWARE-enabled data domains. This geo-distributed experimentation environment allows the efficient demonstration and validation of activities in a decentralized DER-rich distribution grid to enable real-time coordination and data sharing between DERs and the operator for efficient power grid operation.

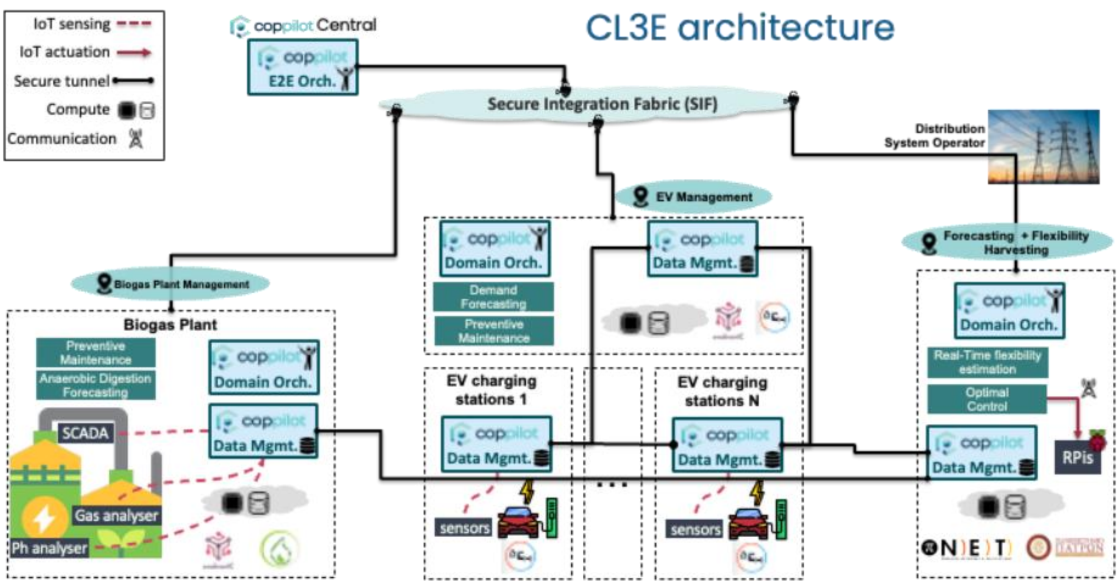

Figure 2- Cluster 3E – end-to-end architecture

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Cluster 3E includes the following domains:

- Flexibility Harvesting Domain
- Biogas Plant Domain
- EV Management Domain
- EV Charging Stations Domain

For each of the domains, we list below the current infrastructure components and their availability to be utilized by applicants.

Table 1: Infrastructure components provided by the Cluster 3E Flexibility Harvesting domain.

Infrastructure type	Description
Physical compute infrastructure	1x Supermicro CloudDC SuperServer SYS-120C-TN10R 1x Cluster of RPis to host DERs simulators 1x NVIDIA Jetsson Orin Nano – 6-core Arm Cortex-A78AE, 8GB Module
Virtual compute infrastructure	On-demand automated Kubernetes Cluster creation capability. Open Call Tenant's quota (shared with EV Management domain): • 50 vCPUs • 80 GB RAM • 240 GB Storage • 1 NVIDIA RTX A6000 48GB (Available for 7 days in total, 4 hours per session – Available through Kubernetes) • Network interface with Internet access FIWARE Orion-LD Context Broker
Physical network infrastructure	MikroTik CRS354-48G-4S+2Q+RM Managed L2 Switch 1 Gbps fibre internet connectivity

Virtual network infrastructure	N/A
Physical IoT infrastructure (or data sources)	N/A
Virtual IoT infrastructure (or data sources)	Simulated DER and aggregated measurements from other domains
Infrastructure Availability for COP-PILOT and Open Calls	The infrastructure is fully available to offer compute capability as-a-Service (aaS) through a streamlined process. It can also offer a powerful GPU to support AI workloads.

Table 2: Infrastructure components provided by the Cluster 3E Biogas Plant domain.

Infrastructure type	Description
Physical compute infrastructure	1x NVIDIA Jetson Orin Nano – 6-core Arm Cortex-A78AE, 8GB Module
Virtual compute infrastructure	FIWARE Orion-LD Context Broker
Physical network infrastructure	N/A
Virtual network infrastructure	Teltonika TSW200
Physical IoT infrastructure (or data sources)	AwiFlex gas Analyzer, CPS11E Ph sensor
Virtual IoT infrastructure (or data sources)	N/A
Infrastructure Availability for COP-PILOT and Open Calls	Fully available for Open Call projects to deploy the necessary application components for the validation. Access to data (from sensors, or analytics) will be performed through the local FIWARE Orion-LD Context Broker

Table 3: Infrastructure components provided by the Cluster 3E EV Management domain.

Infrastructure type	Description
Physical compute infrastructure	1x Supermicro CloudDC SuperServer SYS-120C-TN10R 2x NVIDIA Jetson Orin Nano – 6-core Arm Cortex-A78AE, 8GB Module
Virtual compute infrastructure	On-demand automated Kubernetes Cluster creation capability. Open Call Tenant's quota (shared with Flexibility Harvesting domain): • 50 vCPUs • 80 GB RAM • 240 GB Storage • 1 NVIDIA RTX A6000 48GB (Available for 7 days in total, 4 hours per session – Available through Kubernetes) • Network interface with Internet access FIWARE Orion-LD Context Broker
Physical network infrastructure	MikroTik CRS354-48G-4S+2Q+RM Managed L2 Switch 1 Gbps fibre internet connectivity Teltonika TSW200
Virtual network infrastructure	N/A
Physical IoT infrastructure (or data sources)	N/A
Virtual IoT infrastructure (or data sources)	Historical data from EV charging stations Power consumption forecasting results
Infrastructure Availability for COP-PILOT and Open Calls	Available for Open Call projects to deploy necessary application components for the validation. Access to data (from sensors, or analytics) will be performed through the local FIWARE Orion Context Broker.

Figure 2 illustrates the end-to-end architecture of the Cluster 3E – Edge Intelligence for Grid Reliability, demonstrating how edge analytics and inter-domain data information exchange are beneficial for DER owners and the power grid.

The system connects IoT sensing with AI powered analytics at the edge: 1. pH sensors and gas analysers' measurements are used for monitoring of the anaerobic digestion process at biogas plants and preventive maintenance activities) and 2. current sensors at EV charging stations feed edge analytics for power production estimation and real-time health monitoring. Secure information exchange between sensors and apps, and between the different domains is enabled by FIWARE and SIF. Trusted data from DERs is communicated with the PNET domain where sophisticated energy related algorithms can be tested on top of a private cloud infrastructure and a cluster of edge devices simulating DERs behaviour.

The Cluster 3E testbed provides access to operational data from biogas plants and commercial EV chargers as well as to developed applications outcomes (biogas and EV analytics, distribution grid simulator). Applicants will receive technical onboarding, data access credentials, and integration support from Cluster3E and COP-PILOT consortium partners during experimentation.

Note for Open Call applicants

Open Call projects interested in Cluster 3E activities have the following integration capabilities:

Open Call projects may bring and deploy a new domain within Cluster 3E, introducing and complementary DERS, or services; or

They may host and validate their solution within one of the existing Cluster 3E domains, leveraging its infrastructure, data environment, and demonstration use cases.

1.3 CLUSTER 3E TECHNOLOGIES, STANDARDS, AND (OPEN-SOURCE) COMMUNITIES

To support the three distinct use cases of Cluster 3E, a set of different software components has been developed. Table enumerates the different components, and provides information on their open-source status, relevant standards, and underlying technologies.

Table 4 Cluster 3E Technologies, Standards and (Open-Source) Communities

Component	Open Source	Standard / Reference Framework	Main Technologies
IoT Agents	Yes	FIWARE IoT Agents	NGSI-LD, MQTT, HTTP, AMQP
Context Broker	Yes	FIWARE Orion-LD Context Broker	NGSI-LD
Context Data Storage	Yes	FIWARE Orion-LD	MongoDB
Data Ingestion & ETL	Yes	FIWARE QuantumLeap	Apache Flume, NGSI-LD
Short-Term Historic Storage (STH)	Yes	FIWARE QuantumLeap	QuantumLeap with CrateDB as time-series DB
Persistent Data Storage	Yes	—	TimeScale DB, Quantumleap
Analytical Database (BDA)	Yes	—	MySQL, PostgreSQL
Long-Term Historic Storage (Lakehouse)	Yes	Delta Lake ACID table format for data lakes	Delta Lake tables on object storage for energy time-series

Real-Time Data Ingestion Platform (RTDIP)	Yes	LF Energy RTDIP ingestion framework for time-series	RTDIP pipelines for Delta Lake
OCPP Server/Client	Yes	OCPP v2.0.1 JSON	OCPP Python library, OCPP v2.0.1 over JSON, Python
DLMS/COSEM Server	Yes	DLMS/COSEM	Gurux.DLMS library, DLMS/COSEM, Java
IEC 61850 Communication Stack	Yes	IEC 61850 standard	IEC61850 MMS, C
Identity & Authorization Management	Yes	OAuth 2.0 Authorization protocol (RFC 6749)	keycloak
Authorization & Policy Enforcement	Yes	FIWARE AuthZForce	XACML
Secure Context APIs	Yes	NGSI-LD + OAuth 2.0	REST APIs
Visualization & Dashboards	No	—	Custom ReactJS, Python streamlit framework
Data Models	Yes	Smart Data Models	NGSI-LD, JSON

1.4 OPEN CALL CHALLENGES & INNOVATION OPPORTUNITIES

The following challenges represent examples of potential topics that applicants may address under **Cluster 3E.**

1. Edge Intelligence for predictive Maintenance in RES

Deploy edge AI models to detect early anomalies in RES units such as PV inverters, wind turbines, etc. The challenge involves developing lightweight ML models that can run locally with limited compute, ensuring real-time diagnostics. Solutions must integrate with COP-PILOT SIF and use FIWARE data models for information exchange. Solution providers can use GPU-accelerated edge devices for hosting and validating their solutions

2. Flexibility modelling and harvesting techniques from residential feeders

Modelling the flexibility potential of residential loads (heat pumps, EV chargers, appliances, rooftop PV) under different operating and comfort constraints. Participants must design algorithms that quantify available flexibility and propose control schemes (e.g., demand response, peak shaving). Algorithms must be fitted into edge-hosted simulators and communicate their results via standardized interfaces and or FIWARE data models.

3. Industrial users (e.g., factories) offering surrogate or analytical models mapping flexibility potential to be exposed to DSOs.

Participants must develop surrogate or analytical models that map industrial processes (e.g., factory equipment cycles, thermal loads) to flexible capacity that can be reliably offered to DSOs. This requires capturing operational constraints, production dependencies, and acceptable load-shifting windows. The challenge involves building interpretable models that DSOs can trust and embed in grid management tools. The models shall be hosted on edge devices (RPis) and participate as a new type of DER in UC#3E.1. Participants can also offer a new domain (as EV management and

Biogas Plant domains) that will be interconnected with the Flexibility Harvesting Domain and provide flexibility potential. Secure data sharing via SIF/FIWARE is essential, as is testing integration with the distribution grid simulator.

4. Edge AI analytics tor EV Charging stations or Biomass plants or DSOs

Participant must develop and deploy edge AI models running directly on edge gateways (NVIDIA Jetson or other) to perform real-time analytics on local sensor data for predictive maintenance, anomaly detection, and optimization. Biogas sensors can offer data related to methane, oxygen, carbon and hydrogen concentration in the digesters, as well as production of the CHP units. EV charging stations sensors offer high frequency measurements of current, voltage, power factor and harmonics.