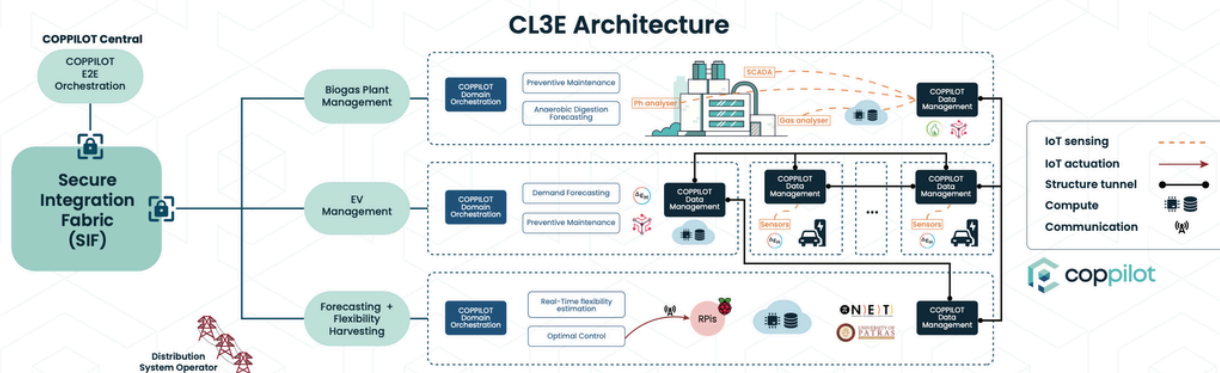


Use Case Overview Diagram



Ambition, Mission and Objectives

- Enable real-time integration of distributed renewable energy sources and flexible loads within active distribution grids using edge intelligence and secure orchestration.
- Demonstrate scalable, automated energy services across laboratories, EV charging networks, and biogas plants, improving reliability, flexibility, and operational efficiency.
- Transition from fragmented, reactive energy operations to proactive, data-driven, and interoperable grid management models that support resilience and decarbonisation.

Description

Smart & Resilient RES-Rich, Cross-Sector Coupled Distribution Grids focuses on enhancing energy system resilience and efficiency in Western Greece through coordinated edge–cloud intelligence. The cluster integrates active distribution grids, EV charging infrastructure, and a biogas power plant into a distributed yet interconnected ecosystem. Using advanced ICT, IoT sensing, and predictive analytics, it enables real-time flexibility harvesting, predictive maintenance, and energy forecasting. The cluster demonstrates how cross-sector orchestration can reduce operational costs, improve reliability, and support low-carbon, renewable-rich distribution networks.

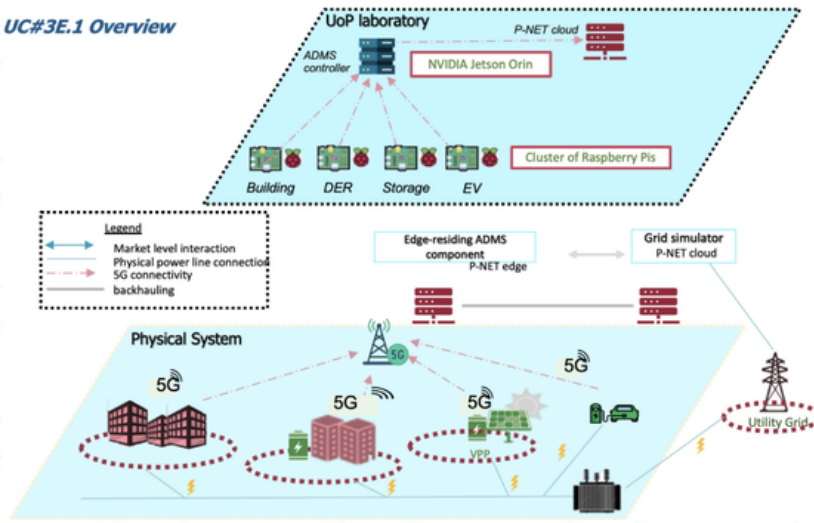
Pathway to Execution

Execution depends on synchronising energy-sector business goals with distributed digital infrastructure. Business alignment focuses on measurable outcomes such as grid resilience, reduced downtime, lower operational costs, and improved flexibility market participation. Technically, this requires interoperable cloud-edge architectures, low-latency connectivity, and secure orchestration of analytics and control services across heterogeneous assets. Continuous coordination between grid operators, infrastructure owners, and technology providers ensures that real-time analytics, predictive maintenance, and flexibility control are deployed reliably, scaled across sites, and translated into operational and economic value.

Cluster 3E Use Case Summary

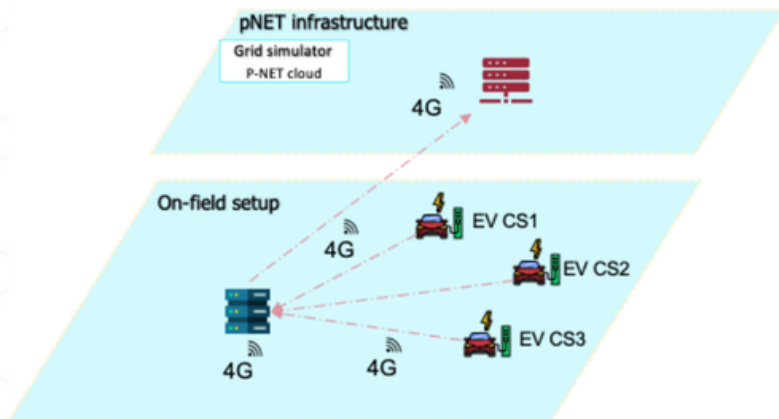
UC 3E.1

UC#3E.1 Overview



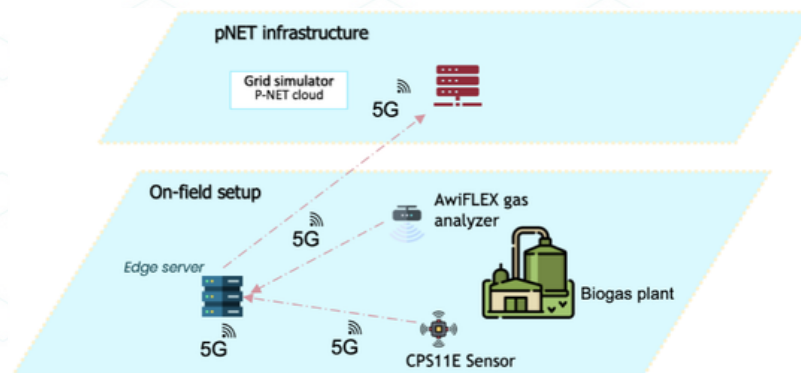
Description This use case shows a cloud-edge platform enabling real-time, low-latency flexibility management in active distribution grids.

UC 3E.2



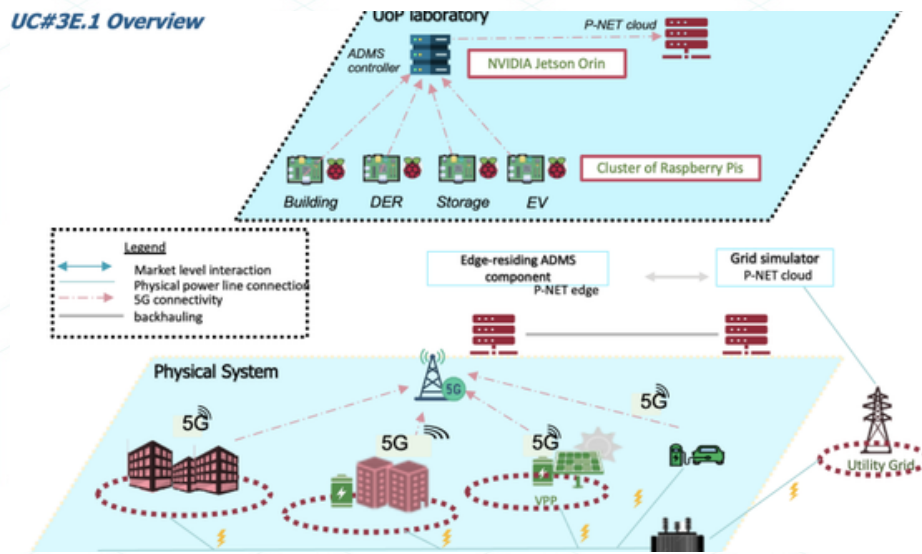
The use case uses edge-enabled analytics and AI to monitor EV fast-charger health, forecast demand, reduce downtime, and optimize power use.

UC 3E.3



Use case 3E.3 uses real-time monitoring and predictive analytics to improve biogas plant reliability, stabilise output, and reduce unplanned downtime.

Harvesting in Real-Time Flexibility From Active Electricity Distribution Grids



Description

This use case demonstrates a cloud–edge platform for real-time flexibility management in active distribution grids under laboratory conditions. It integrates continuous flexibility estimation with optimal control of distributed energy resources, including loads, generation, and storage. Real-time telemetry is processed at the edge to enable low-latency decisions, while cloud services support analytics training and orchestration. By emulating realistic grid scenarios, the use case validates automated, data-driven flexibility services such as voltage regulation and demand response, providing a scalable blueprint for future field deployment.

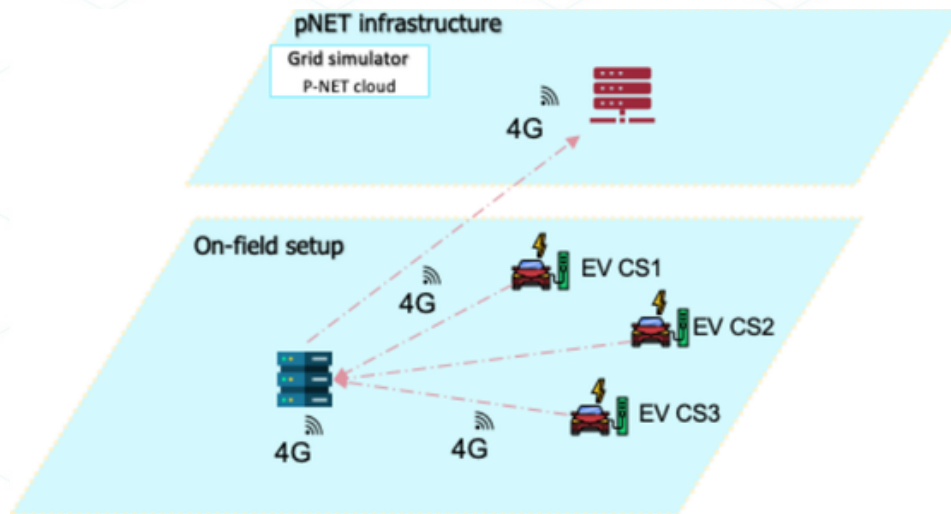
Functional Requirements

The system must continuously estimate available grid flexibility from distributed energy resources with a short refresh cycle and monitor grid constraints in real time. It must dynamically coordinate DERs to deliver flexibility services, executing analytics and control logic on edge devices to ensure sub-second responsiveness. Reliable, low-latency communication between far-edge, edge, and cloud layers is required, using standard energy protocols for interoperability. The platform must also support realistic grid simulation and seamless orchestration of microservices across the cloud–edge continuum.

Market Business Requirements

From a market perspective, the solution must reduce the cost and complexity of flexibility deployment for distribution system operators by enabling automated, real-time control rather than manual intervention. It should support scalable integration of additional DERs and grid areas without major infrastructure changes, improving return on investment. The platform must enhance operational efficiency and reliability, enabling new flexibility-based services and local energy market participation. By lowering entry barriers and supporting standardized interfaces, the use case strengthens commercial viability and adoption potential across diverse grid environments.

Ensuring Uninterruptible Power Supply For Fast EV Chargers



Description

This use case focuses on improving the reliability and intelligence of highway EV DC fast-charging infrastructure through edge-enabled analytics. It combines high-resolution sensing with local AI to monitor charger health and forecast demand in real time. By deploying predictive maintenance and per-charger load forecasting directly at the edge, the system minimizes downtime, optimizes power allocation, and enhances user experience. The solution strengthens charging network resilience, supports grid-aware operation, and contributes to the broader objective of accelerating large-scale EV adoption.

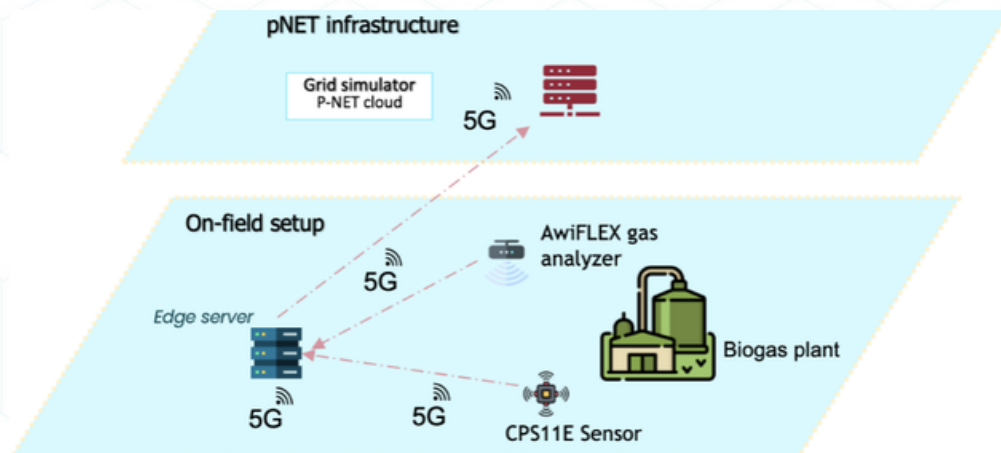
Functional Requirements

The system must collect and process high-resolution voltage and current data from inductive sensors at each charging point in real time. It must execute predictive maintenance algorithms at the edge to detect early signs of hardware degradation and generate timely alerts. The platform must also forecast short-term energy demand per charger to support dynamic power management. Reliable, low-latency communication between sensors, edge devices, and orchestration layers is required, along with automated service deployment and operator notification through centralized dashboards.

Market Business Requirements

From a market perspective, the solution must reduce operational costs by shifting maintenance from reactive to predictive and by minimizing unplanned charger downtime. It should increase charger availability and customer satisfaction, strengthening operator competitiveness in a rapidly growing EV market. The architecture must support scalable deployment across large charging networks with minimal integration effort, enabling fast time-to-market. By improving energy efficiency and grid coordination, the use case also creates value for utilities and supports sustainable, commercially viable EV charging services.

Predictive Maintenance and Monitoring of Anaerobic Digestion In A Biogas Plant



Description

This use case improves the reliability and output of the Preveza biogas plant by adding continuous monitoring and predictive maintenance to the anaerobic digestion (AD) process. Real-time sensing tracks key stability indicators such as pH, temperature, feedstock conditions, and gas composition, while analytics anticipate equipment wear and process deviations early enough to plan interventions. The system also forecasts electricity production so grid operators can better schedule dispatchable renewable power. Overall, it reduces unplanned downtime, stabilises biogas quality, and increases plant contribution to grid resilience.

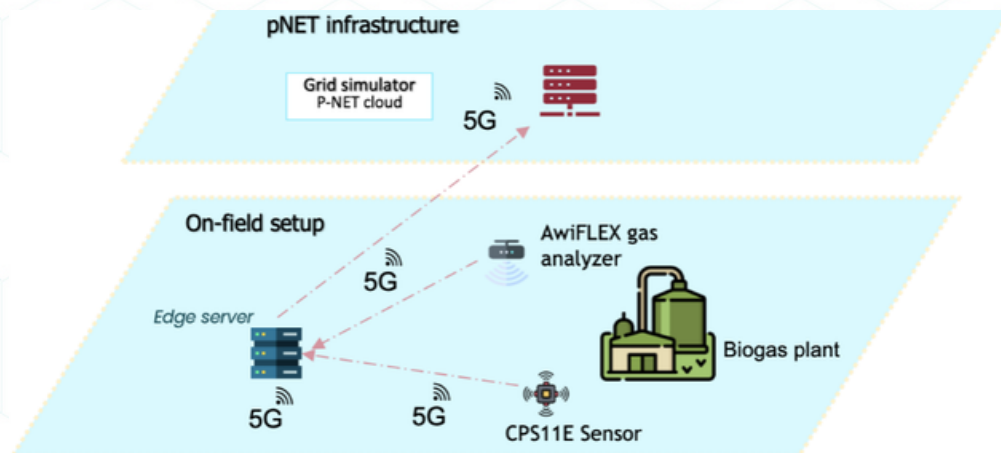
Functional Requirements

The system must continuously collect and process AD telemetry, including CH₄, CO₂, O₂, H₂S and pH, and integrate plant sensors with an edge gateway via Modbus. It must execute edge microservices for (i) process forecasting and (ii) predictive maintenance with at least 24 hours lead time for fault risk. When anomalies are detected, it must generate automated alerts and deliver insights through an operator dashboard showing real-time trends and diagnostics. All data transfers between sensors, gateway, and edge server must be encrypted and handled securely end to end.

Market Business Requirements

The solution must lower total operating cost by reducing reactive maintenance, preventing avoidable failures, and minimising revenue loss from outages. By increasing uptime and stabilising electricity output, the plant becomes a more dependable, dispatchable renewable asset—improving its value to grid operators and strengthening participation in a decarbonised energy mix. The architecture should be replicable across similar biogas facilities with limited retrofit effort, supporting a scalable predictive-analytics service model. Improved yield and reduced methane leakage risk also strengthen ESG performance and stakeholder confidence in biomass-based energy.

Predictive Maintenance and Monitoring of Anaerobic Digestion In A Biogas Plant



Description

This use case improves the reliability and output of the Preveza biogas plant by adding continuous monitoring and predictive maintenance to the anaerobic digestion (AD) process. Real-time sensing tracks key stability indicators such as pH, temperature, feedstock conditions, and gas composition, while analytics anticipate equipment wear and process deviations early enough to plan interventions. The system also forecasts electricity production so grid operators can better schedule dispatchable renewable power. Overall, it reduces unplanned downtime, stabilises biogas quality, and increases plant contribution to grid resilience.

Functional Requirements

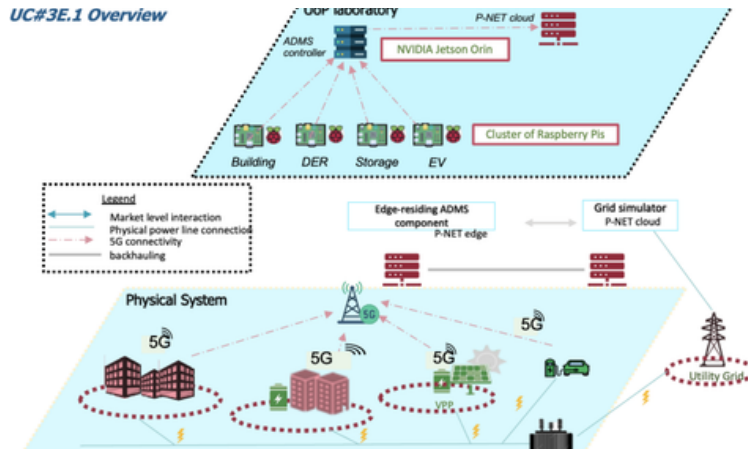
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Use Case 3E.1

Ensuring Uninterruptible Power Supply For Fast EV Chargers



Description

This use case demonstrates a cloud–edge platform for real-time flexibility management in active distribution grids under laboratory conditions. It integrates continuous flexibility estimation with optimal control of distributed energy resources, including loads, generation, and storage. Real-time telemetry is processed at the edge to enable low-latency decisions, while cloud services support analytics training and orchestration. By emulating realistic grid scenarios, the use case validates automated, data-driven flexibility services such as voltage regulation and demand response, providing a scalable blueprint for future field deployment.

Functional Requirements

The system must continuously estimate available grid flexibility from distributed energy resources with a short refresh cycle and monitor grid constraints in real time. It must dynamically coordinate DERs to deliver flexibility services, executing analytics and control logic on edge devices to ensure sub-second responsiveness. Reliable, low-latency communication between far-edge, edge, and cloud layers is required, using standard energy protocols for interoperability. The platform must also support realistic grid simulation and seamless orchestration of microservices across the cloud–edge continuum.

Market Business Requirements

From a market perspective, the solution must reduce the cost and complexity of flexibility deployment for distribution system operators by enabling automated, real-time control rather than manual intervention. It should support scalable integration of additional DERs and grid areas without major infrastructure changes, improving return on investment. The platform must enhance operational efficiency and reliability, enabling new flexibility-based services and local energy market participation. By lowering entry barriers and supporting standardized interfaces, the use case strengthens commercial viability and adoption potential across diverse grid environments.

Instantiation of Use Case

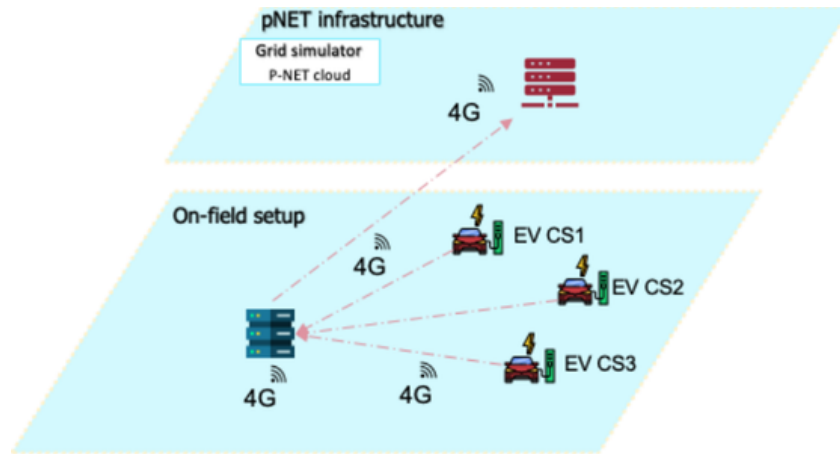
Use Case 3E.1 focuses on real-time flexibility management within UoP's laboratory environment, utilizing a cloud-edge computing infrastructure and the COP-PILOT platform to orchestrate distributed energy resources. Sensor data from far-edge devices — alongside real DER and load data from Use Cases 3.2 and 3.3 — flows through FIWARE IoT Agents into the Orion Context Broker and MongoDB, where AI models drive flexibility estimation and optimal DER control. Overseen by the COP-PILOT domain orchestrator, the system operates through secure 5G/6G communication channels and standardized protocols including IEC 61850.

The real benefit in the use case

Leveraging the COP-PILOT system, fragmented isolated algorithms are unified into a real-time orchestration platform, improving cross-site coordination across distributed energy resources. It enriches flexibility estimation algorithms with real operational data from active field deployments, improving their accuracy. Most importantly, it enables bidirectional communication between system operators, DERs, and controllable loads, transforming grid interaction from passive monitoring into an active, closed-loop control environment.

Use Case 3E.2

Ensuring Uninterruptible Power Supply For Fast EV Chargers



Description

This use case focuses on improving the reliability and intelligence of highway EV DC fast-charging infrastructure through edge-enabled analytics. It combines high-resolution sensing with local AI to monitor charger health and forecast demand in real time. By deploying predictive maintenance and per-charger load forecasting directly at the edge, the system minimizes downtime, optimizes power allocation, and enhances user experience. The solution strengthens charging network resilience, supports grid-aware operation, and contributes to the broader objective of accelerating large-scale EV adoption.

Functional Requirements

The system must collect and process high-resolution voltage and current data from inductive sensors at each charging point in real time. It must execute predictive maintenance algorithms at the edge to detect early signs of hardware degradation and generate timely alerts. The platform must also forecast short-term energy demand per charger to support dynamic power management. Reliable, low-latency communication between sensors, edge devices, and orchestration layers is required, along with automated service deployment and operator notification through centralized dashboards.

Market Business Requirements

From a market perspective, the solution must reduce operational costs by shifting maintenance from reactive to predictive and by minimizing unplanned charger downtime. It should increase charger availability and customer satisfaction, strengthening operator competitiveness in a rapidly growing EV market. The architecture must support scalable deployment across large charging networks with minimal integration effort, enabling fast time-to-market. By improving energy efficiency and grid coordination, the use case also creates value for utilities and supports sustainable, commercially viable EV charging services.

Instantiation of Use Case

Use Case 3E.2 focuses on high-performance EV fast charging reliability, utilizing high-resolution inductive sensors and NVIDIA Jetson-based edge AI units to enable predictive maintenance and demand forecasting. Sensor data flows through FIWARE IoT Agents into the Orion Context Broker and MongoDB, where AI models are trained and inferred to detect anomalies and forecast load. Overseen by the COP-PILOT domain orchestrator, the main goal is to maximize charging network uptime through local edge processing and seamless scalability.

The real benefit in the use case

Leveraging the COP-PILOT system, reactive site-level maintenance evolves into a unified platform capable of remotely monitoring EV charging fleets at scale. It simplifies aggregation of high-resolution sensor streams across multiple stations, reducing data transfer overhead and operational costs. By enabling predictive maintenance algorithms to identify faults before they cause downtime, it shifts operations from failure response to proactive intervention, ensuring reliable service for EV drivers.



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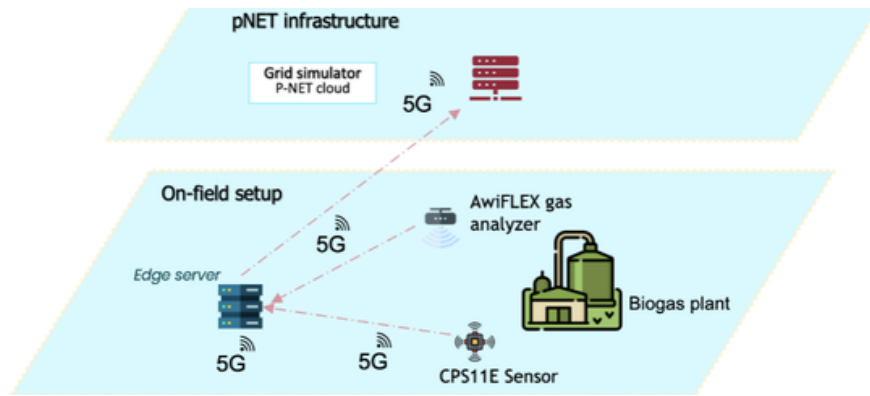
Federal Department of Economic Affairs,
Education and Research EAER
State Secretariat for Education,
Research and Innovation SERI

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Use Case 3E.3

Predictive Maintenance and Monitoring of Anaerobic Digestion In A Biogas Plant



Description

This use case improves the reliability and output of the Preveza biogas plant by adding continuous monitoring and predictive maintenance to the anaerobic digestion (AD) process. Real-time sensing tracks key stability indicators such as pH, temperature, feedstock conditions, and gas composition, while analytics anticipate equipment wear and process deviations early enough to plan interventions. The system also forecasts electricity production so grid operators can better schedule dispatchable renewable power. Overall, it reduces unplanned downtime, stabilises biogas quality, and increases plant contribution to grid resilience.

Functional Requirements

The system must continuously collect and process AD telemetry, including CH₄, CO₂, O₂, H₂S and pH, and integrate plant sensors with an edge gateway via Modbus. It must execute edge microservices for (i) process forecasting and (ii) predictive maintenance with at least 24 hours lead time for fault risk. When anomalies are detected, it must generate automated alerts and deliver insights through an operator dashboard showing real-time trends and diagnostics. All data transfers between sensors, gateway, and edge server must be encrypted and handled securely end to end.

Market Business Requirements

The solution must lower total operating cost by reducing reactive maintenance, preventing avoidable failures, and minimising revenue loss from outages. By increasing uptime and stabilising electricity output, the plant becomes a more dependable, dispatchable renewable asset—improving its value to grid operators and strengthening participation in a decarbonised energy mix. The architecture should be replicable across similar biogas facilities with limited retrofit effort, supporting a scalable predictive-analytics service model. Improved yield and reduced methane leakage risk also strengthen ESG performance and stakeholder confidence in biomass-based energy.

Instantiation of Use Case

Use Case 3E.3 focuses on improving the reliability of the Preveza Biogas Plant, utilizing high-precision instrumentation — including the AwiFLEX gas analyzer and Memosens CPS11E pH sensor — to monitor the anaerobic digestion process. Sensor data flows through FIWARE IoT Agents into the Orion Context Broker and MongoDB, where AI models support predictive maintenance and electricity production forecasting. Overseen by the COP-PILOT domain orchestrator, the goal is to transition the plant to a smart, data-driven operation.

The real benefit in the use case

Leveraging the COP-PILOT system, manual experience-dependent monitoring transitions to a smart, automated facility with continuous real-time visibility into the anaerobic digestion process. It enables accurate electricity production forecasting for better grid integration and supports circular economy goals through transparent use of organic waste resources. By anticipating equipment degradation before failures occur, it significantly reduces unplanned downtime and operational costs.



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