

SENSE-CPS: Smart and Sustainable Engineering for Industrial CPS

This special session showcases **applied engineering solutions** for Cyber-Physical Systems (CPS) and IoT, with a focus on practical prototypes, real-time monitoring, edge intelligence, and student-driven innovation.

Session Scope

- IoT sensing and monitoring
- Edge computing architectures
- Industrial dashboards and HMI
- Smart energy and environmental monitoring

Context

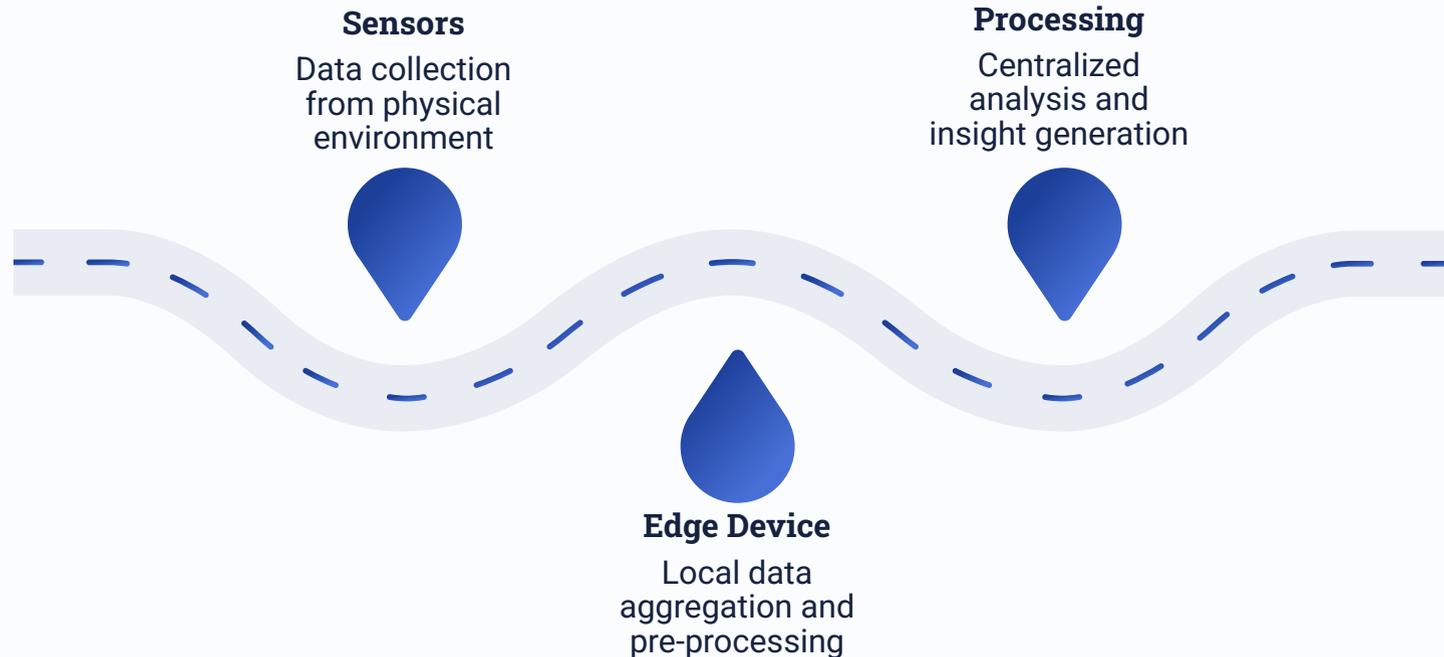
1. Growing importance of CPS and IoT in industrial applications
2. Demand for low-cost, scalable, energy-efficient solutions
3. Need for hands-on engineering experimentation

This session highlights how **small-scale prototypes and student-led projects can explore real-world CPS challenges and validate emerging architectures.**

Overview of Accepted Contributions

Three papers were accepted in the SENSE-CPS session, each addressing a distinct application domain while sharing a common CPS pipeline architecture.

1	2	3
Wastewater Potability Edge-Based IoT and AI Framework for Water Quality Classification	Craft Beer Monitoring A CPS IoT System for Precision Brewing	Smart Building Energy Edge-Centric IoT System for Building Energy Management



All three works share common technical themes: IoT sensing, MQTT-based communication, edge computing, and dashboard-based monitoring on low-cost embedded platforms.



PAPER 1

Edge-Based IoT and AI Framework for Wastewater Potability Classification

Traditional water monitoring relies on **laboratory testing** or **cloud-based processing**, introducing latency. This paper proposes an edge-centric water quality monitoring platform with local AI inference.

System Architecture

- Arduino sensor node
- MQTT communication
- Raspberry Pi edge gateway
- Local AI inference + Web dashboard

ML Models Evaluated

Logistic Regression

k-Nearest Neighbors

Naïve Bayes

Random Forest ✓ Best

Random Forest achieved the best performance for water potability classification, proving that **real-time ML inference can be performed directly at the edge**.

Craft Beer Monitoring: A CPS IoT System for Precision Brewing

Problem

Small-scale breweries rely heavily on **manual monitoring**, leading to inconsistencies in fermentation processes.

Key Contribution

Demonstrates how **low-cost CPS architectures can support precision fermentation monitoring** for small-scale producers.

Proposed Solution

- Cyber-Physical IoT monitoring system
- Sensors: Temperature, pH, Flow
- ESP32 embedded device
- MQTT communication
- Cloud dashboard (Blynk)

5-Layer IoT Architecture

- Physical sensing → Embedded hardware → Communication → Cloud processing → Application dashboard



Edge-Centric IoT System for Smart Building Energy Management

Traditional Building Management Systems are **centralized and cloud-dependent**, limiting resilience. This paper proposes an edge-centric BEMS platform that brings intelligence closer to the building.



Hardware Layer

ESP32 sensor nodes with MQTT communication and Raspberry Pi edge gateway



Data & Visualization

InfluxDB + Grafana dashboards with React frontend for real-time monitoring



Smart Features

Multi-zone monitoring, occupancy-aware energy management, and weather-informed predictive control of lighting and HVAC

📄 **Key Contribution:** Demonstrates how **edge autonomy improves resilience and scalability** in building energy systems.



Session Takeaways



Edge-Centric Architectures

All three works adopt edge-first CPS designs for resilience and low latency



Low-Cost Platforms

ESP32 and Raspberry Pi enable accessible, scalable IoT deployments



MQTT Communication

Lightweight, distributed messaging infrastructure across all systems



Real-Time Dashboards

Decision support through live visualization in every application domain

Accessible IoT technologies combined with edge intelligence enable **practical Cyber-Physical Systems that address real-world sustainability and efficiency challenges** – from brewing to water quality to smart buildings.