Zerynth

UNIVERSITÀ DI PISA

# AI for Industry

Daniele Mazze Prof. Università di Pisa &
co-founder Zerynth

# Industry 4.0

18th century
Industry 1.0
Mechanical production.
Machinery powered by steam and water

1784
First mechanical chassis

19th century
Industry 2.0
Mass production assembly lines that require labor and electricity

1870
First assembly line: slaughterhouses in Cincinnati

20th century
Industry 3.0
Automated manufacturing using electronics and information technology

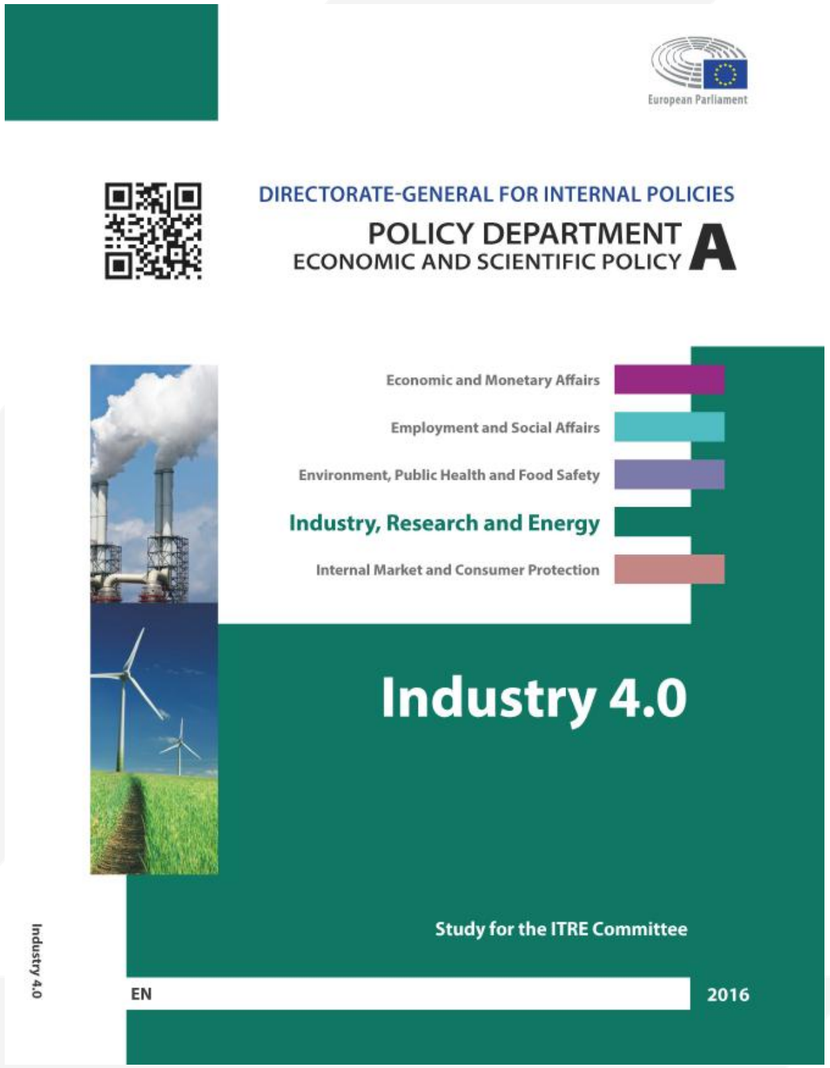
1969
First programmable logic controller (PLC)

21st century
Industry 4.0
Smart manufacturing integrated with IoT, cloud technology and big data

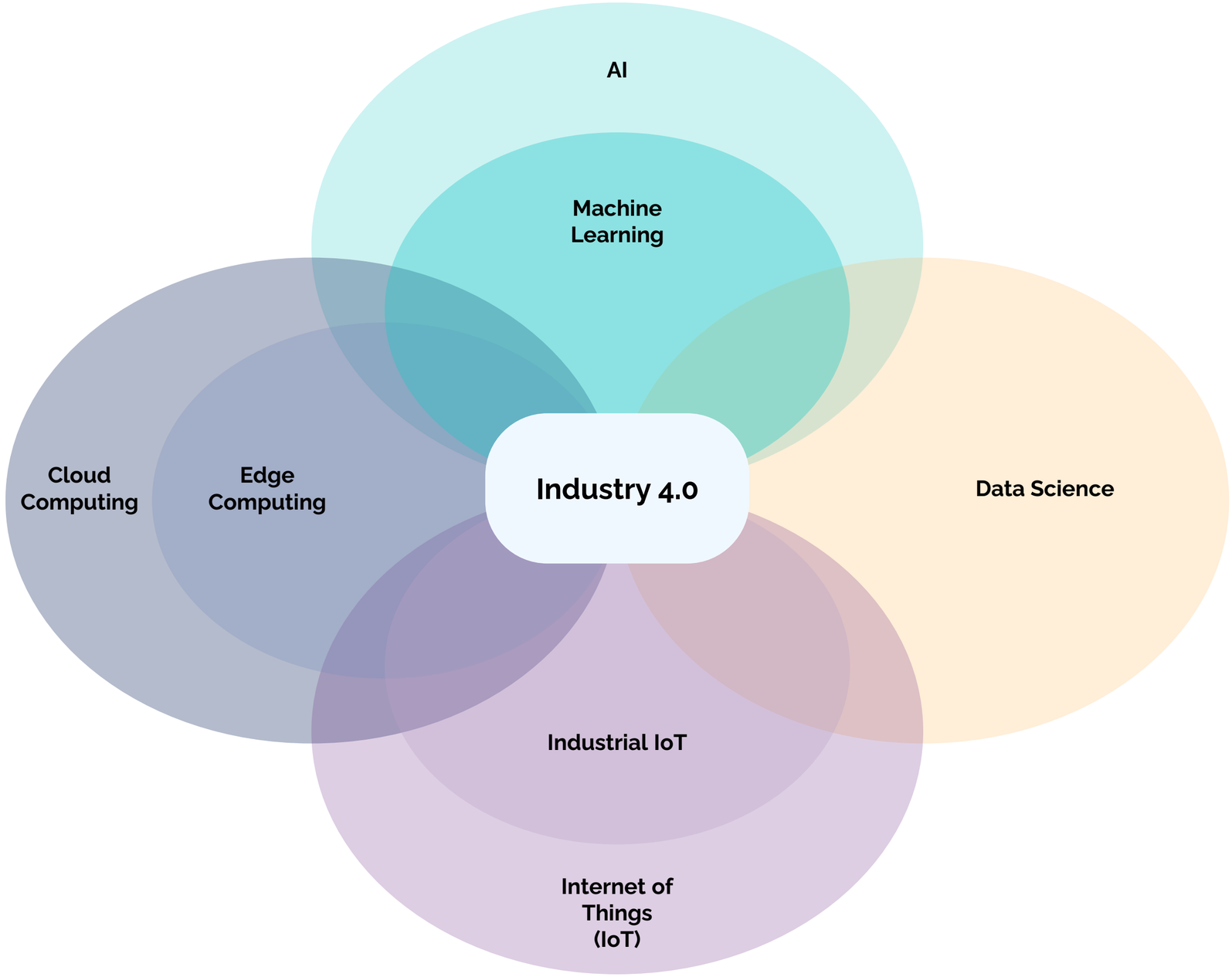
Today
Degree of technological complexity that grows exponentially

# THE INDUSTRY 4.0

- Industry 4.0 describes **the organisation of production processes based on technology and devices autonomously communicating with each other along the value chain:** a model of the **'smart' factory of the future** where computer-driven systems monitor physical processes, **create a virtual copy of the physical world** and make decentralised decisions based on self-organisation mechanisms. The concept takes account of the increased **digitalisation of manufacturing industries where physical objects are seamlessly integrated into the information network**, allowing for decentralised production and real-time adaptation in the future.
- Industry 4.0 was **initially developed by the German government** to create a coherent policy framework to maintain Germany's industrial competitiveness.




From: Industry 4.0 Study for the ITRE Committee - www.europarl.europa.eu/RegData/etudes/STUD/.../IPOL_STU(2016)570007_EN.pdf



# More connected machines. Still low productivity.

**In countries like Italy, labor productivity remains among the lowest in Europe.**

Billions invested in Industry 4.0 — but most SMEs saw little real impact.

**Machines were connected, but data was not transformed into decisions.**

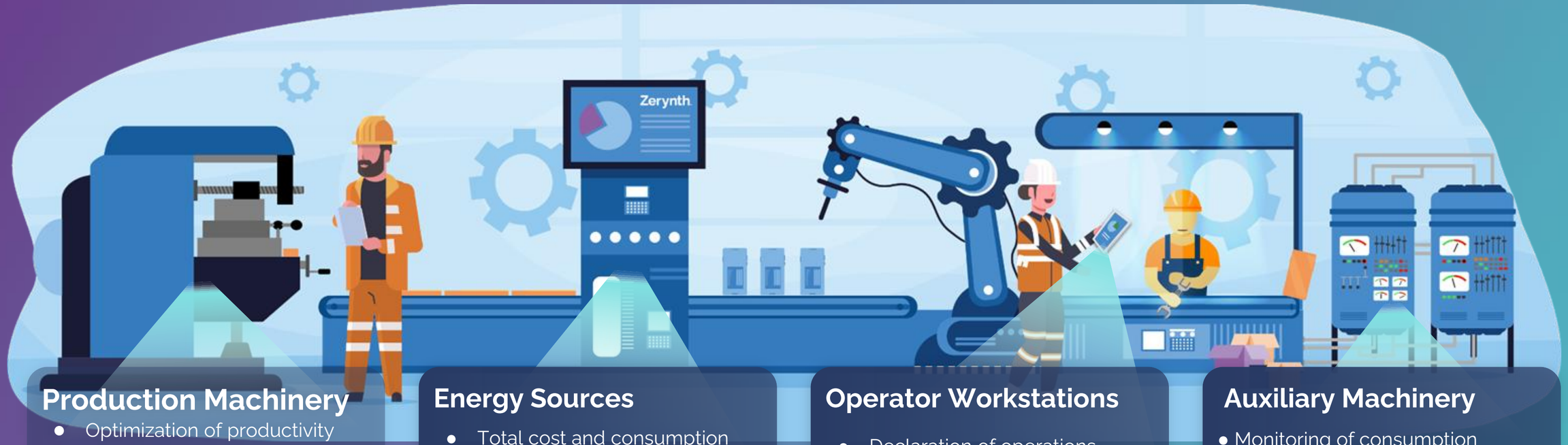
**Without intelligence, connectivity is not enough.**

*Bettiol, M., Capestro, M., Di Maria, E., & Ganau, R. (2023). Is this time different? How Industry 4.0 affects firms' labor productivity. https://doi.org/10.1007/s11187-023-00825-8

# Current Challenges in Manufacturing

- **Reactive monitoring:** Problems are noticed too late, causing inefficiencies and downtime.
- **Manual data entry:** High risk of errors and slow reporting.
- **Delayed, static reports:** Decisions based on outdated information.
- **No real-time insights:** Inconsistent analysis limits agility.
- **Lack of support for operators:** Knowledge is hard to access when needed.

# Industrial Data Sources




## Production Machinery

- Optimization of productivity and OEE calculation
- Preventive and predictive maintenance
- Order tracking and processing cycles

## Energy Sources

- Total cost and consumption analysis
- Environmental impact analysis of processes
- Energy balance analysis
- Self-consumption and energy self-sufficiency analysis

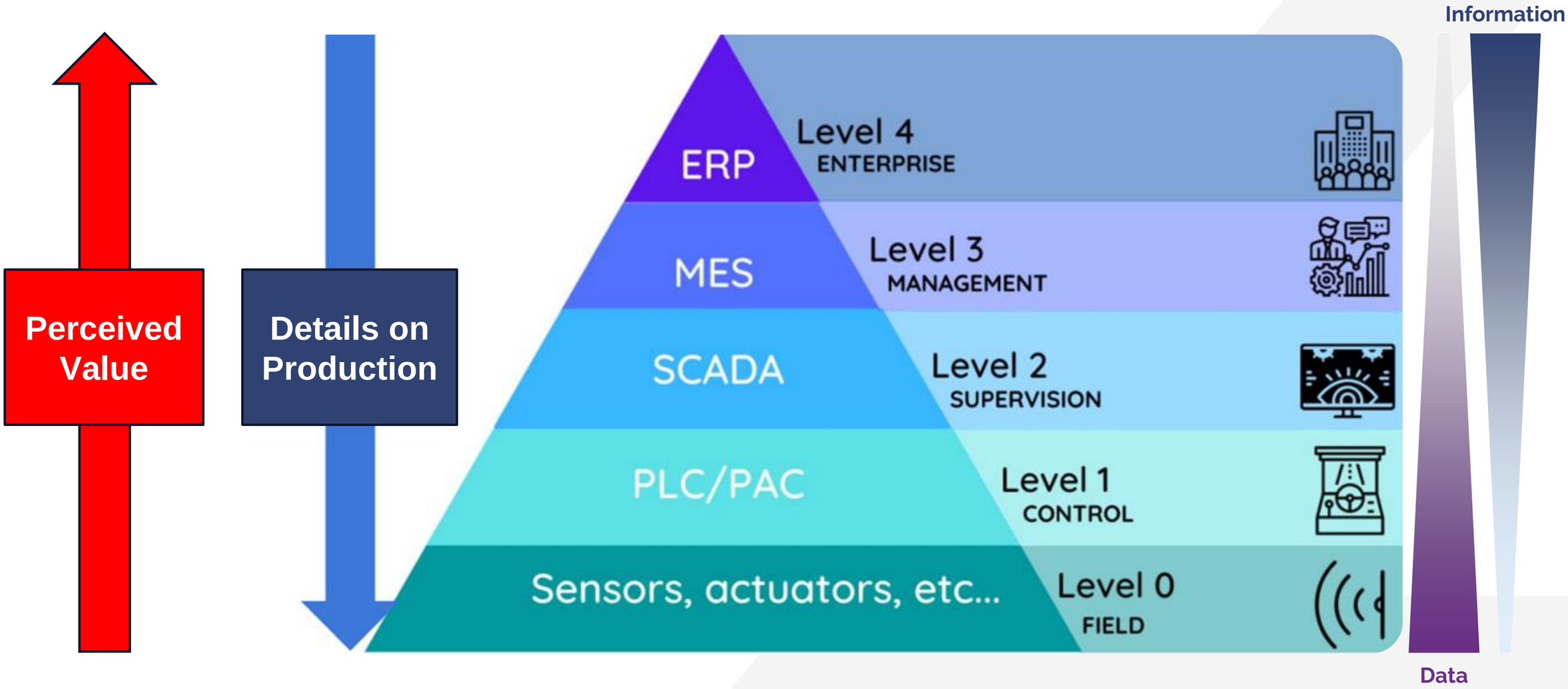
## Operator Workstations

- Declaration of operations
- Downtime causation
- Data entry for production data

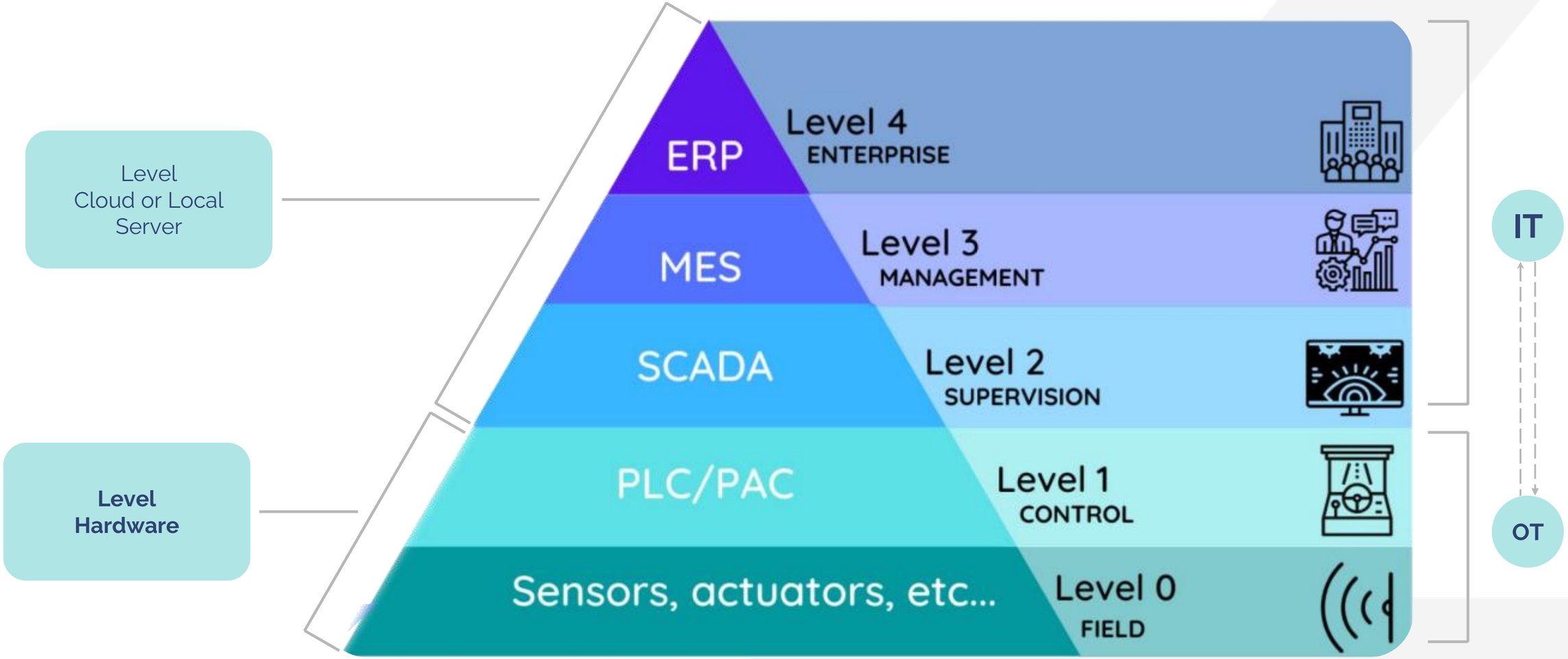
## Auxiliary Machinery

- Monitoring of consumption
- Anomaly identification and alarm notifications
- Preventive and predictive maintenance

# Industrial Automation Pyramid (3.0)



# Industrial Automation Pyramid (3.0)



# OT e IT

# Operation Technology

**Operational Technology (OT) is the set of hardware and software systems used to monitor and control industrial processes and physical devices, such as PLCs and sensors, with the aim of managing operations in real time and optimizing the efficiency of physical processes.**

# Operation Technology

**In OT, only what physically exists is digitized,** ensuring a direct correspondence between digital variable and reality. **PLCs (Programmable Logic Controllers)** transform sensor signals into digital variables through dedicated hardware, acting as true digitizers of physical reality.

**The PLC programmer implements an algorithm that, at each cycle, reads the signals from the sensors and modifies the state of the actuators,** acting directly on the machine. This process is based on physical models that could be replicated in the past with analog circuits and discrete components.

# Information Technology

**Information Technology (IT) refers to the hardware, software, and infrastructure systems used to manage, process, and store data and information. It includes systems such as ERP, MES, and SCADA that support enterprise asset management, manufacturing process optimization, and operations monitoring.**

**E.g. an MES system that collects and analyzes real-time data from production to optimize the efficiency and quality of the production process.**

# IT vs OT

The conceptual difference between IT and OT is based on the type of data and operational logic:

**Information Technology**
It manages abstract data (conceptual variables): symbols and digital information (e.g. databases, ERP).

**Operation Technology**
It manages real data (physical variables): concrete measurements and processes (e.g. sensors, PLCs).

**Symbol Grounding Problem**
Difficulty in translating concrete data from OT into abstract symbols in IT and vice versa, to give them concrete meaning.

# Industrial IoT

**The Industrial Internet of Things (IIoT) is a network of connected devices and sensors that collect and exchange data within an industrial context. IIoT acts as a bridge between operational technology (OT) and information technology (IT), seamlessly uniting the physical and digital worlds.**

**This allows companies to monitor and optimize production processes in real time, improving efficiency, quality and safety, and to make decisions based on concrete data thanks to the integration of physical devices with advanced digital systems.**

# Industrial IoT

> The Industrial Internet of Things (I-IoT) was primarily heralded as a way to improve operational efficiency. But in today's environment, companies can also benefit tremendously by seeing it as a tool to find growth in unexpected opportunities.
> In the future, successful companies will use I-IoT to capture new growth through three approaches:
>
> 1. Increase revenues by increasing production and creating new hybrid business models
> 2. Leveraging smart technologies to fuel innovation
> 3. Transform their workforce.

***Paul Daugherty, Prith Banerjee, Walid Negm e Allan E. Alter. Cop***
https://www.accenture.com/us-en/_acnmedia/Accenture/next-gen/reassembling-industry/pdf/Accenture-Driving-Unconventional-Growth-through-IIoT.pdf

# Limitation of Industry 3.0 Stack (Pyramid)

Systems only exchange data with the immediately adjacent layers.

PLCs are not connected to the internet.

PLC firmware is generally not available or updated by companies.

The same machines may have PLCs from different suppliers depending on the geographical region.

Each PLC uses different interfaces, creating integration complexity.

Custom solutions for data collection from PLCs are not scalable.

# New IIoT approach

*Filling the gap between IT & OT*

## OT - Operation Technology

PLC

Signals Input/Output


IIoT Device (Gateway)

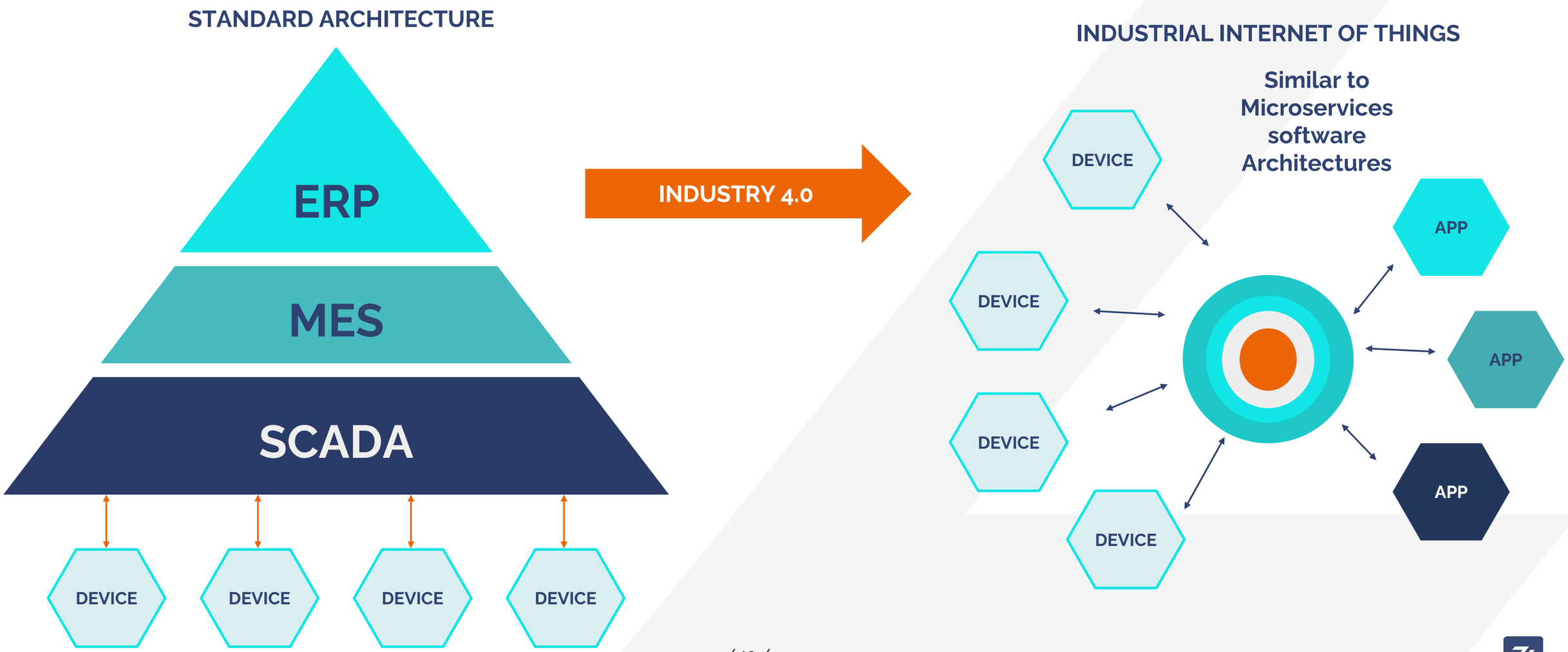
## IT - Information Technology

ERP

MES

SCADA

# Integration with Management Systems



# DIGITAL TWIN

- A digital twin is a **digital replica of a physical entity.**
- By bridging the physical and the virtual world, data is transmitted seamlessly allowing the **virtual entity to exist simultaneously with the physical entity.**
- Digital twin refers to a digital replica of physical assets, **processes, people, places, systems and devices that can be used for various purposes.**

# Industrial IoT

Application Layer

Device & Connectivity Layer

Power Sources

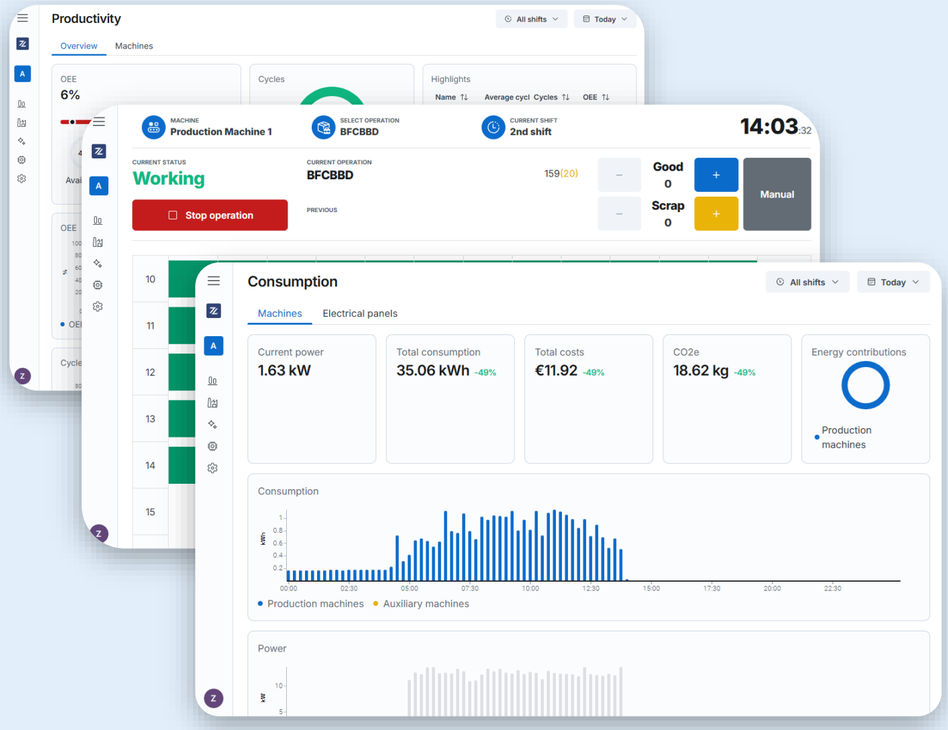
Production Machines

IoT Device

Cloud Platform

Auxiliary Machines

Data Processing Layer




**Data visualization and integration into external management systems (MES, ERP...)**

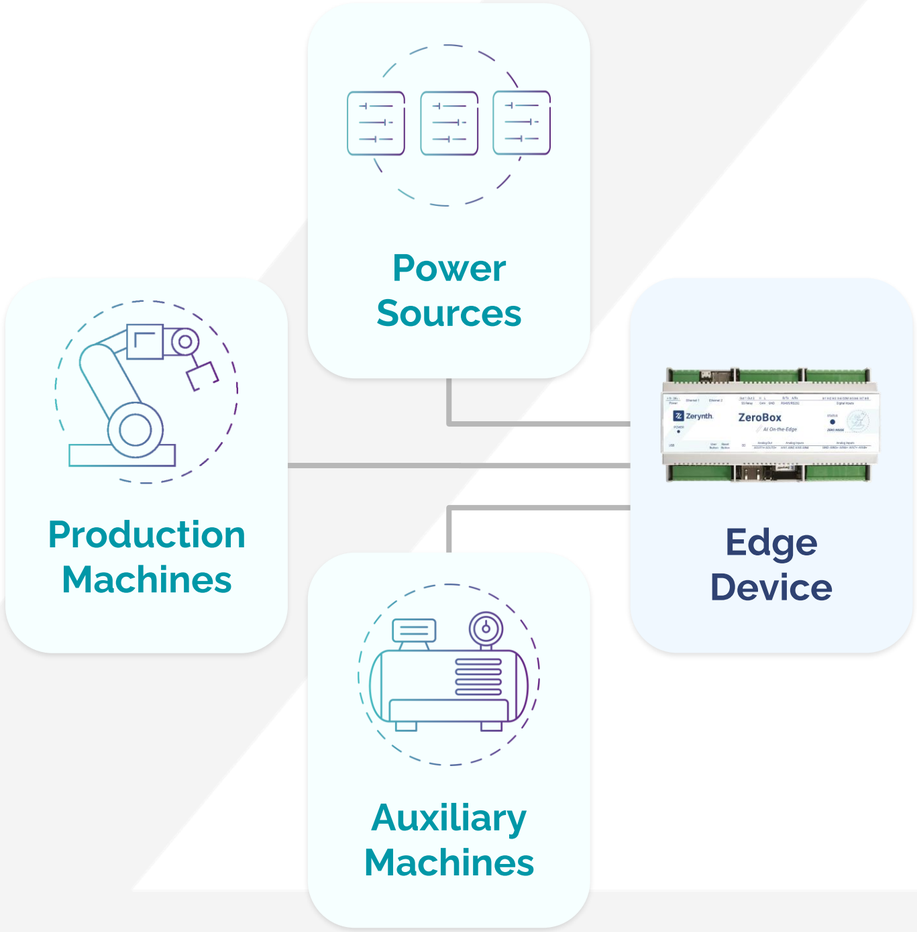
# Edge Computing For IIoT

Edge computing is a practice that involves **processing data as close as possible to its source** (leveraging IoT Edge Devices), to:

- Reduce latency and
- conserve bandwidth
- make decisions in real time.

Edge computing now also enables the use of **Machine Learning and AI algorithms directly on devices,** transforming them into intelligent nodes capable of autonomous analysis and local learning.

Despite the benefits, the challenges are not trivial – **more complex device management and more data security risks.**



# Cloud Computing For IIoT

Cloud computing is conceptually opposed to edge computing – it offers **scalable computational resources and centralized storage**, supporting **complex analytics and long-term data analytics**.

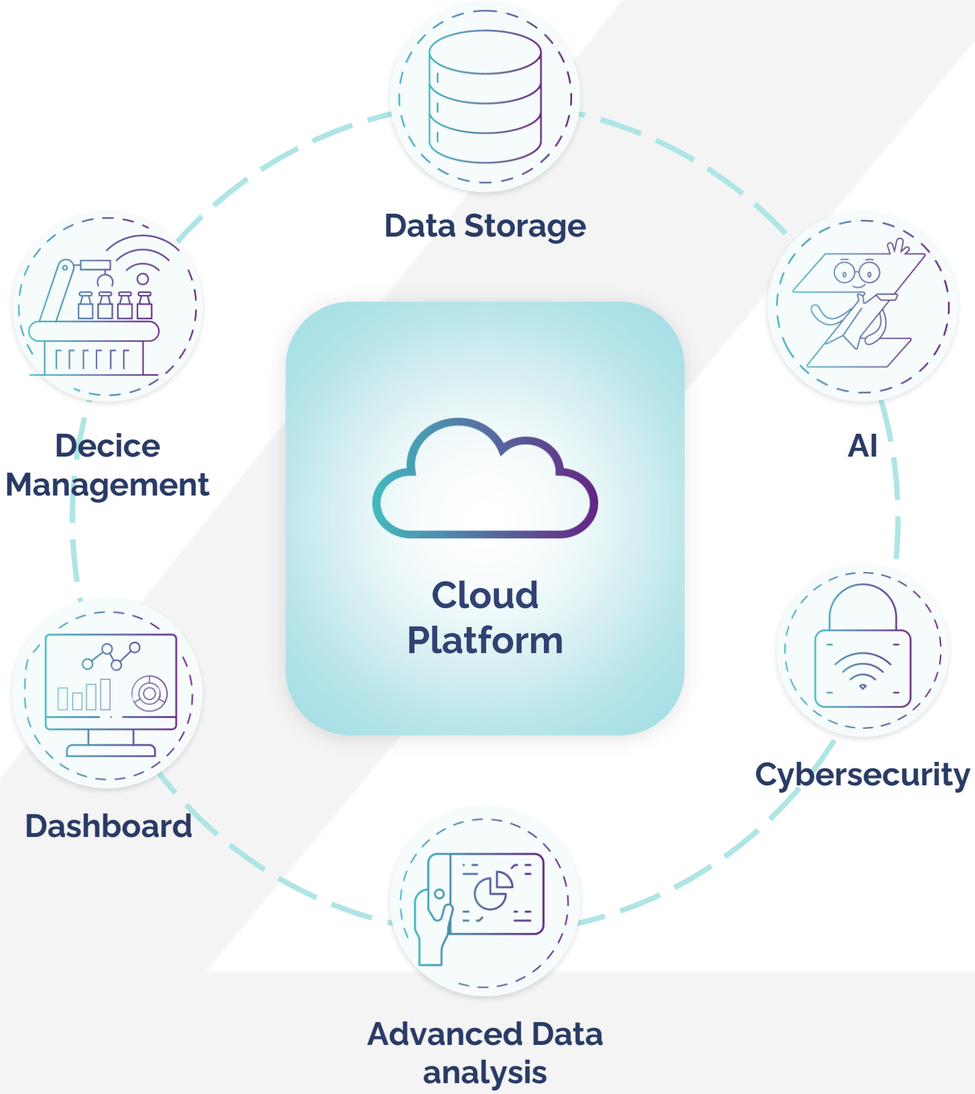
Cloud platforms analyze data from IIoT devices, enabling comprehensive **insights and optimization strategies.**

Advantages over the edge include:

-More power = support for advanced analytics

-Comprehensive insights (historical data analysis)

scalability



# Synergy between Edge and Cloud Computing

The **integration of edge and cloud computing creates a dynamic and distributed computing environment,** leveraging the strengths of both technologies (low latency edge, cloud computing power)

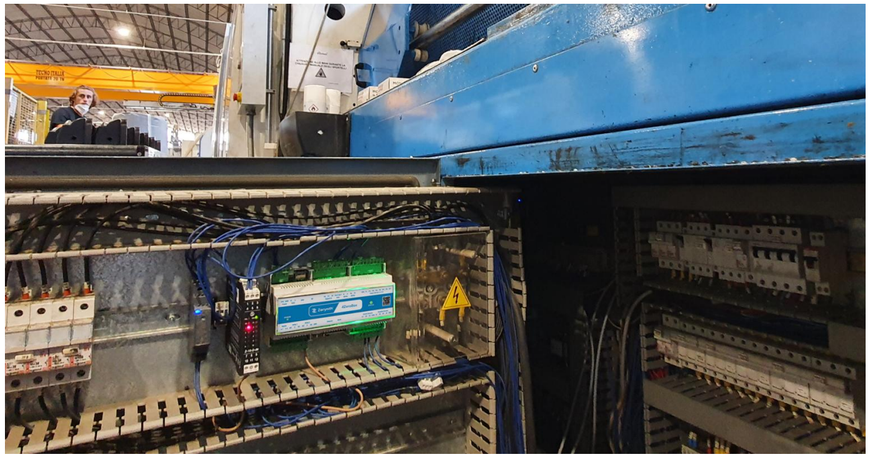
**A hybrid edge-cloud model combines immediate data processing at the edge, with comprehensive analytics in the cloud,** delivering agility and analytical capabilities.

Case studies across multiple industries demonstrate improvements in operational efficiency, cost reduction, and predictive maintenance capabilities with **hybrid edge-cloud IIoT solutions.**

# Case Studies

Zerynth x Armal

**Increased visibility into the production cycle and energy consumption in a plastic molding company with industrial machinery of various types, ages, and brands.**



## INDUSTRY:

plastic

## ASSET:

injection molding presses

## RESULTS

| | |
|---|---|
| 20 years | Age of machines to be digitalized |
| -40% | Power consumption reduction |
| 4 months | Return on investment |

## CHALLENGES

- Optimize the energy consumption of the entire production line.
- Automatically calculate the quantity of products produced per machine.
- Reduce defective components, machine downtime, and maintenance costs

## SOLUTION

**Real-time monitoring of production and energy consumption**

https://zerynth.com/customers/case-studies/

Zerynth® x vitesco TECHNOLOGIES

**IIoT System for Real-Time Machinery Monitoring with Retrofit Implementation. Predictive Maintenance Enabled through the Development of AI Data Analysis Algorithms.**

## INDUSTRY:

automotive

## ASSET:

assembly line testing machinery

## RESULTS

| | |
|---|---|
| up to 70% | Machine Downtime Reduction |
| 24 h | Malfunction prediction in Pneumatic Valves |
| €€€ | Savings from false-negative scrap detection |

## CHALLENGES

- Optimize the quality of your production process.
- Reduce downtime of the fuel injector assembly line testing machinery.
- Remotely monitor the status of each machine in the line.
- Minimize false negative results.
- Decrease the need for diagnostics and manual intervention.

## SOLUTION

**Real-time machinery monitoring and predictive maintenance with 24-hour advance malfunction prediction**

https://zerynth.com/customers/case-studies/

Zerynth® x LEF YOUR DIGITAL REVOLUTION

**Remote monitoring of both old and new-generation industrial machinery, asset management for machines not connected to the internet, production optimization, and maintenance.**


## INDUSTRY:

industrial

## ASSET:

lathes, saws, CNC machines, milling machines

## RESULTS

| | |
|---|---|
| 100% | Brownfield and greenfield coverage |
| 3h | Connection of 4 machines at 2 different sites |
| 24/7 | Real-time and remote monitoring |

## CHALLENGES

- Digitalizing in a non-invasive way both old and new-generation machinery.
- Permanently reducing components and anomalies with minimal installation time.
- Breaking free from vendor lock-in and gaining a comprehensive view of the active machine park

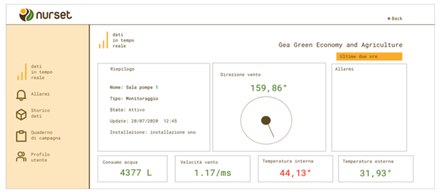
## SOLUTION

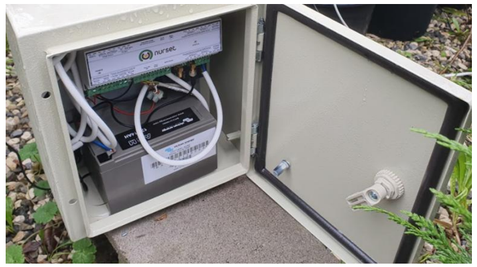
**Complete retrofitting and seamless integration of modern and legacy machinery**

https://zerynth.com/customers/case-studies/

Zerynth x Pierucci agricoltura

**IoT platform for monitoring crops (salinity, humidity, substrate temperature, irrigation timing) and tracking system consumption and functionality (water and electricity consumption, fertilizer levels).**


## INDUSTRY:

agriculture

## ASSET:

nursery fertilizers

## RESULTS

| | |
|---|---|
| x2 | Optimization of cultivation growth |
| -20% | Decrease in water usage and power consumption |
| 30% | Reduction in on-site visits |

## CHALLENGES

- Increase productivity through fertilizer usage optimization.
- Reduce manual operations to lower cultivation costs.
- Decrease water and energy consumption.

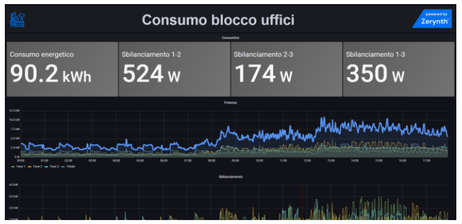
## SOLUTION

**Real-time monitoring of crop health parameters, water, and energy consumption**

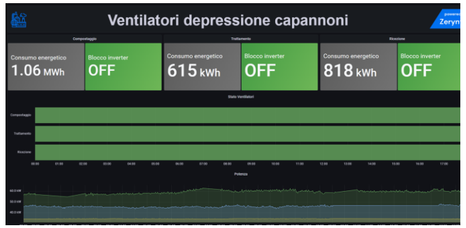
https://zerynth.com/customers/case-studies/

Zerynth® x Esa Spa ELBANA SERVIZI AMBIENTALI

**IoT technology for monitoring ventilation systems, waste storage processes, door openings in warehouses, energy consumption, and the proper functioning of the facility.**








## INDUSTRY:

environmental services

## ASSET:

electrical panels, ventilation systems, tanks, storage facilities

## RESULTS

| | |
|---|---|
| 24/7 | Odor emissions monitoring from plants |
| 9 | Monitored and interconnected systems |
| 100% | Compliace with sustainability report |

## CHALLENGES

- Monitor energy consumption.
- Mitigate odors inside the facilities.
- Purify and treat air from the warehouses.
- Monitor the level of liquid waste tanks.
- Monitor environmental parameters in the facilities.

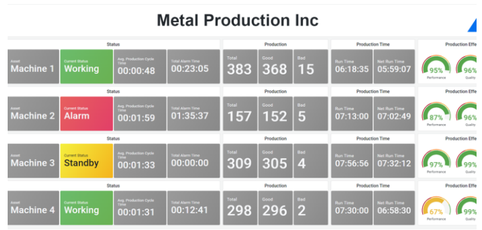
## SOLUTION

**Monitoring of energy consumption, waste storage processes, and the proper functioning of the facilities.**

https://zerynth.com/customers/case-studies/

# Zerynth x Metal Industry

**Interconnection and monitoring of production, machine states, setup times, and energy consumption of all machinery within the industrial facility of a metalworking company.**





## INDUSTRY:

metal Industry

## ASSET:

lathes, milling machines, boring machines, grinding machines, welding machines, sandblasting machines

## RESULTS

| | |
|---|---|
| 35 | Machines connected in two plants |
| -10% | Set-up times decrease |
| -15% | Downtime reduction |

## CHALLENGES

- Monitor machine status, setup times, and downtime.
- Track production progress and ensure greater data accessibility.
- Enhance integration between machine data and the existing management system in the company.

## SOLUTION

**Interconnection of heterogeneous machinery for monitoring machine states and production**

https://zerynth.com/customers/case-studies/

# Zerynth x Manufacturer of components for the fashion industry

**IoT technology for streamlining production processes through real-time order tracking, product quality monitoring, and machinery maintenance management.**


## INDUSTRY:

fashion

## ASSET:

injection molding machines, machines that apply fasteners, machines that apply sliders

## RESULTS

- Complete visibility on production and calculation of OEE
- Visibility on the quality of produced parts
- Support for maintenance management

## CHALLENGES

- Monitor diverse types of legacy machinery with custom production for each individual customer.
- Track orders in real-time along the production chain.
- Estimate the quality of produced parts.
- Reduce waste and machine downtime.
- Gain visibility into the entire production line, energy consumption, and costs.
- Support maintenance management.

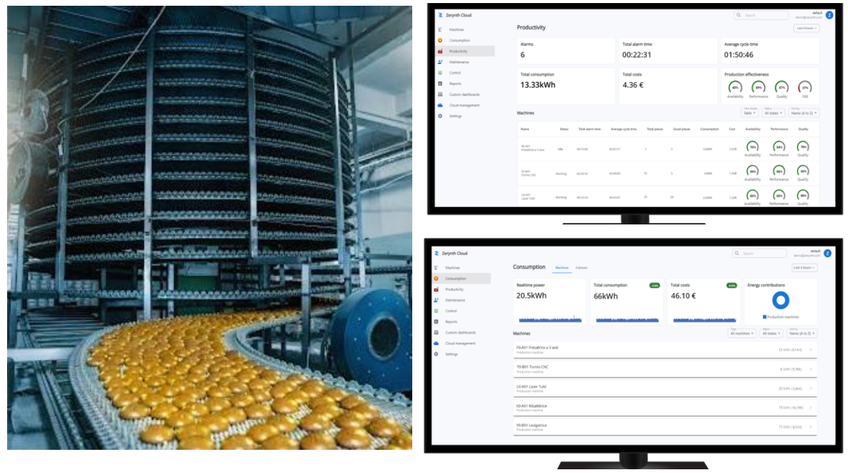
## SOLUTION

**Order tracking, visibility into the production process, monitoring of energy costs, and machinery maintenance management**

https://zerynth.com/customers/case-studies/

Zerynth x Erlacher

**Optimization of production processes, interconnection of machinery with the management system to obtain the 4.0 tax credit in the food industry.**






## INDUSTRY:

food

## ASSET:

cannoli filling machine, mixer and packaging machine

## RESULTS

- Production traceability
- Industry 4.0 paradigm
- Interconnection with Odoo

## CHALLENGES

- Enable real-time machine data monitoring.
- Interconnect machinery to meet the 5+2 requirements for obtaining tax benefits under the Industry 4.0 tax credit.
- Achieve full visibility into production processes.

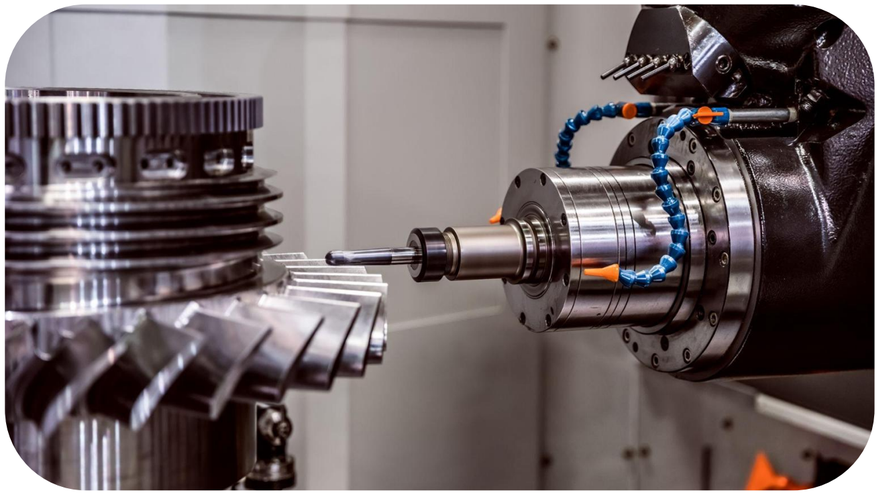
## SOLUTION

**IoT solution for improving production efficiency and integration with the Odoo management system**

https://zerynth.com/customers/case-studies/

Zerynth® x PROJECT AND MANUFACTURING

**Optimization of production processes and visibility into job orders in the metalworking industry.**



## INDUSTRY:

metal industry

## ASSET:

lathe, frees, welders

## RESULTS

- **Real time and remote visibility on production**
- **Productive processes automation**
- **Integration between production and planning**

## CHALLENGES

- Monitor setup times and machine downtime.
- Track production progress.
- Ensure greater data accessibility.
- Enhance integration between machine data and the existing management system in the company.

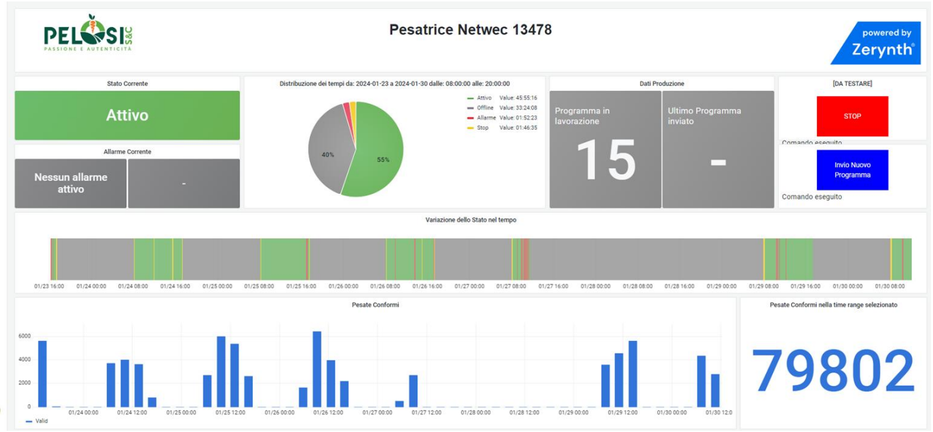
## SOLUTION

**Production monitoring and complete visibility into manufacturing processes: seamless integration between production and planning**

https://zerynth.com/customers/case-studies/

Zerynth x PELOSI S&C

**Pelosi, a company specializing in the processing and packaging of carrots, sought assistance from Zerynth to streamline the production processes of their Industry 4.0-ready machinery, eligible for industry 4.0 benefits.**




## INDUSTRY:

Food

## ASSET:

Palletizer, Weigher, Sorter, Pallet, Legger

## RESULTS

- Product Quality Visibility
- Monitoring of Processes
- Interconnection for Industry 4.0

## CHALLENGES

- Gain visibility into the quality of carrots from suppliers.
- Implement a reliable traceability system to effectively manage prices based on the quality of carrots and optimize overall investment.
- Manage resources more consciously.

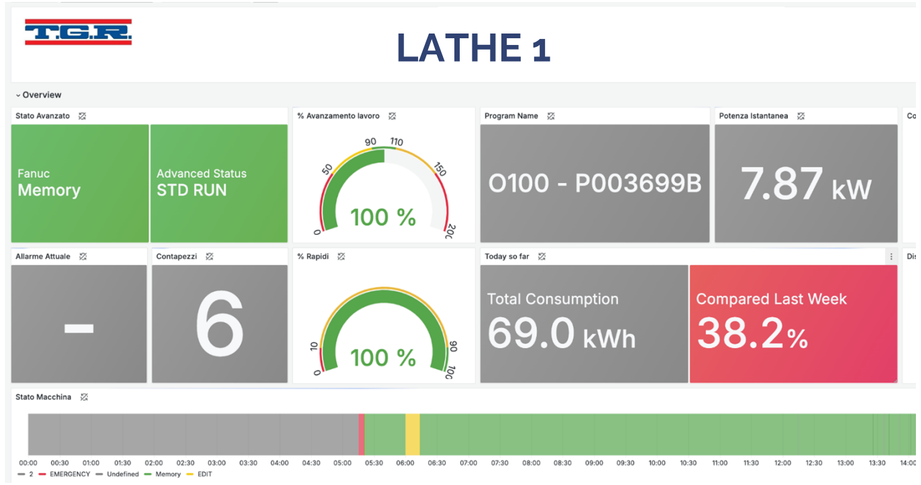
## SOLUTION

**PRODUCT QUALITY TRACKING, PRODUCTION PROCESS OPTIMIZATION, AND MACHINERY INTERCONNECTION FOR INDUSTRY 4.0.**

https://zerynth.com/customers/case-studies/

Zerynth® x T.G.R.

**T.G.R. has chosen Zerynth to monitor energy expenses and consumption, reduce overall costs and achieve complete visibility over production operations**




## INDUSTRY:

Metal manufacturing

## ASSET:

Lathes, Machining Centers, Grinding

## RESULTS

- Energy consumption optimization and operating costs reduction
- Minimization of downtime
- Integration with existing management systems

## CHALLENGES

- Obtain real-time visibility on energy consumption and production processes.
- Integrate existing management systems.
- Gain visibility on operational costs.
- Become sustainable by making the most of the resources employed.

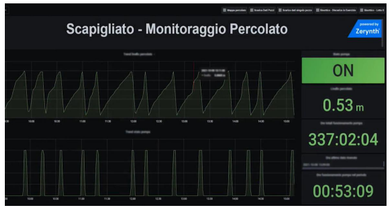
## SOLUTION

**Operational Visibility: Minimizing Downtime and Better Management of Costs and Energy Consumption**

https://zerynth.com/customers/case-studies/

Zerynth x SCAPIGLIATO la fabbrica del futuro

**IIoT System for real-time monitoring of 32 leachate wells and biogas energy production facilities. Data processing on edge devices installed in the facilities, equipped with GSM connectivity**


## INDUSTRY:

environmental services

## ASSET:

facilities consisting of leachate wells and extraction pumps

## RESULTS

| | |
|---|---|
| **<2 months** | Implementation time |
| **-12%** | Decrease in operating costs |
| **32** | Wells monitored in real-time |

## CHALLENGES

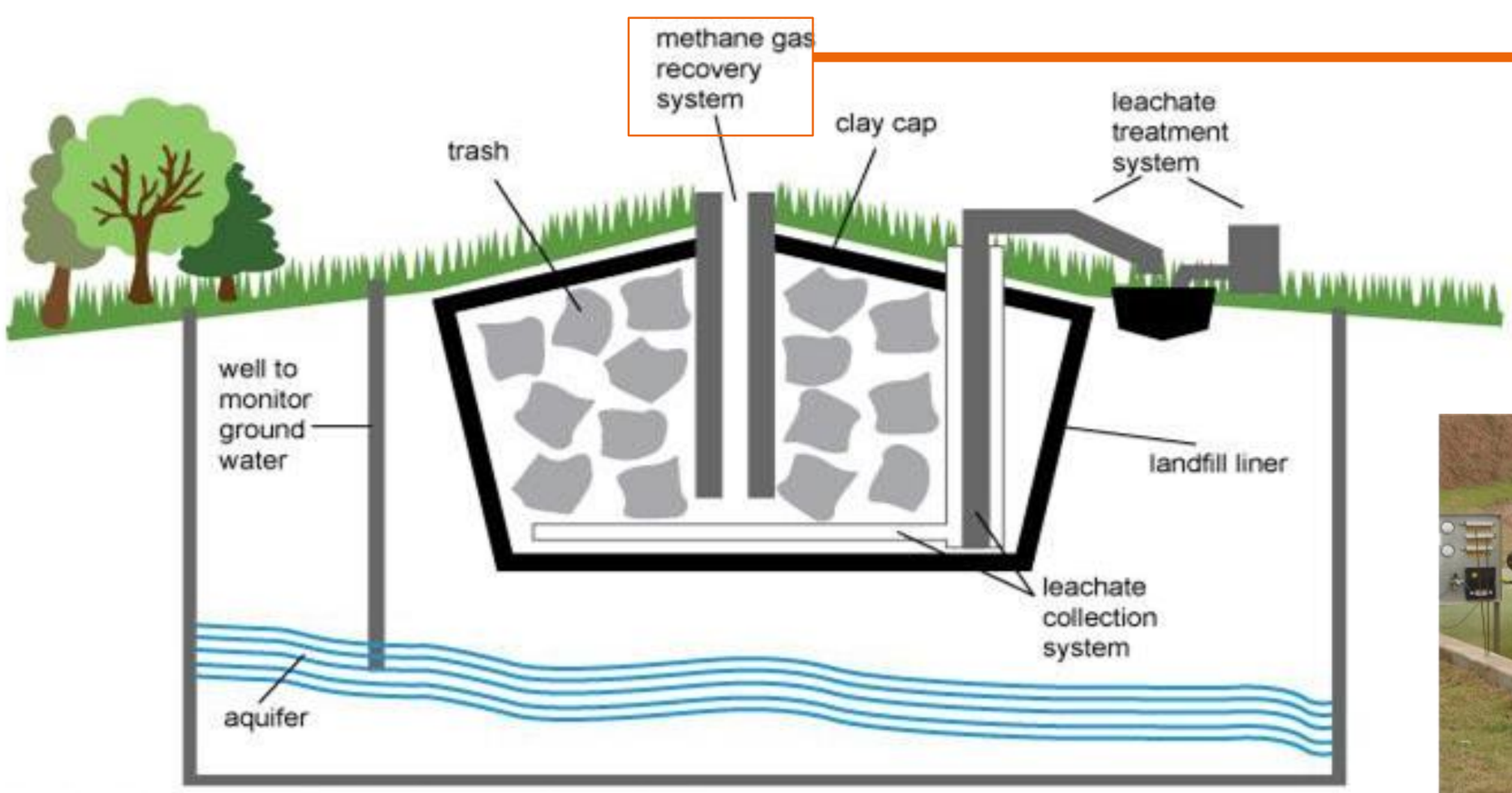
- Enhance leachate well management with remote and real-time monitoring.
- Monitor the biogas production process.
- Generate reports based on data collected from the facility.

## SOLUTION

**Remote monitoring of facilities and leachate well levels**

https://zerynth.com/customers/case-studies/

# Biogas Production in a Landfill

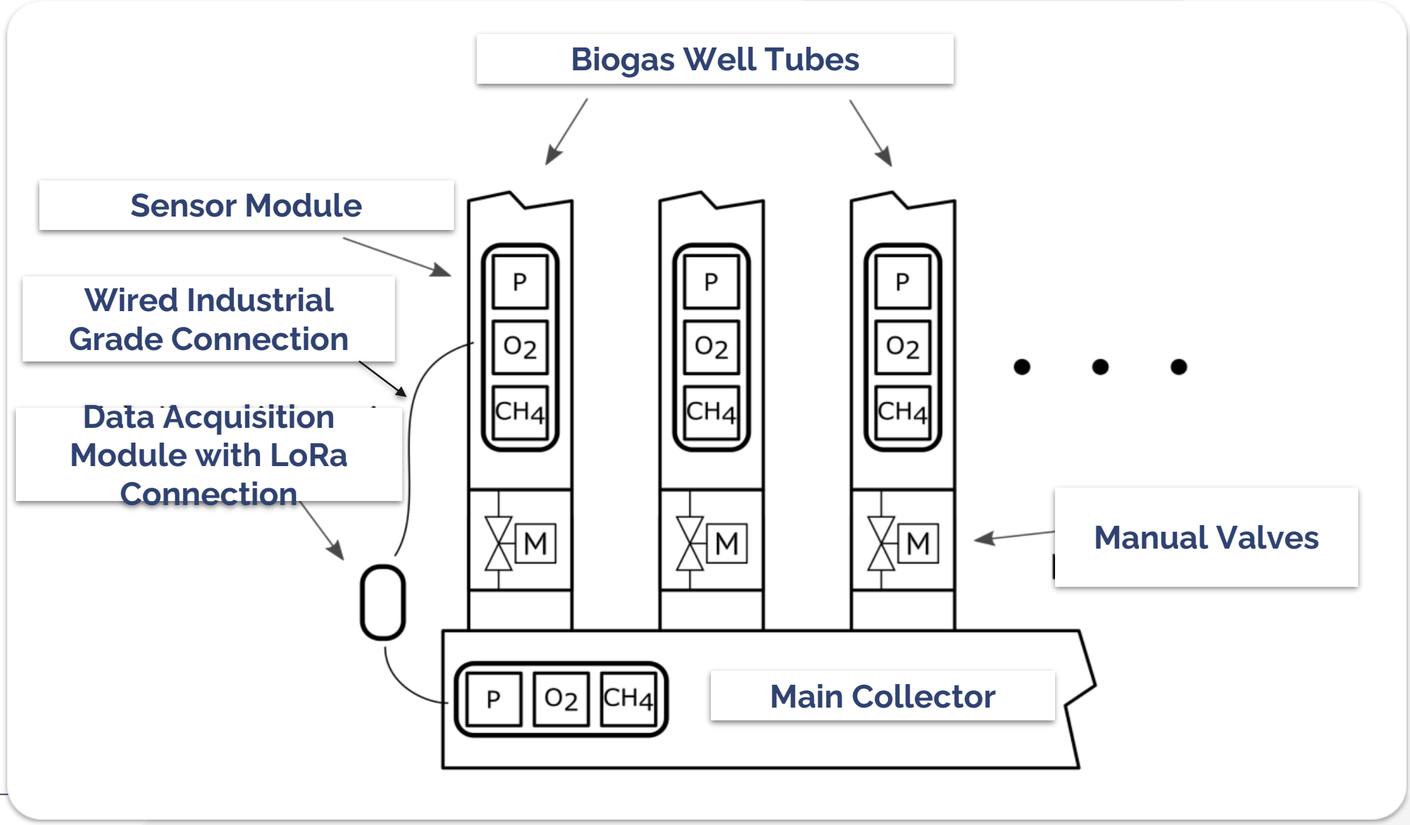



Source: Adapted from National Energy Education Development Project (public domain)

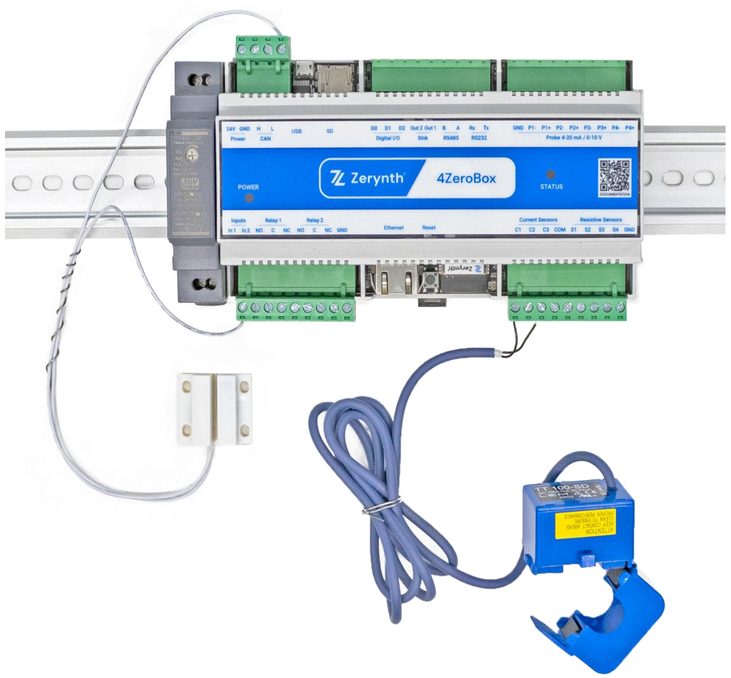
# REQUIREMENTS AND PROPOSED ARCHITECTURE

## Requirements:

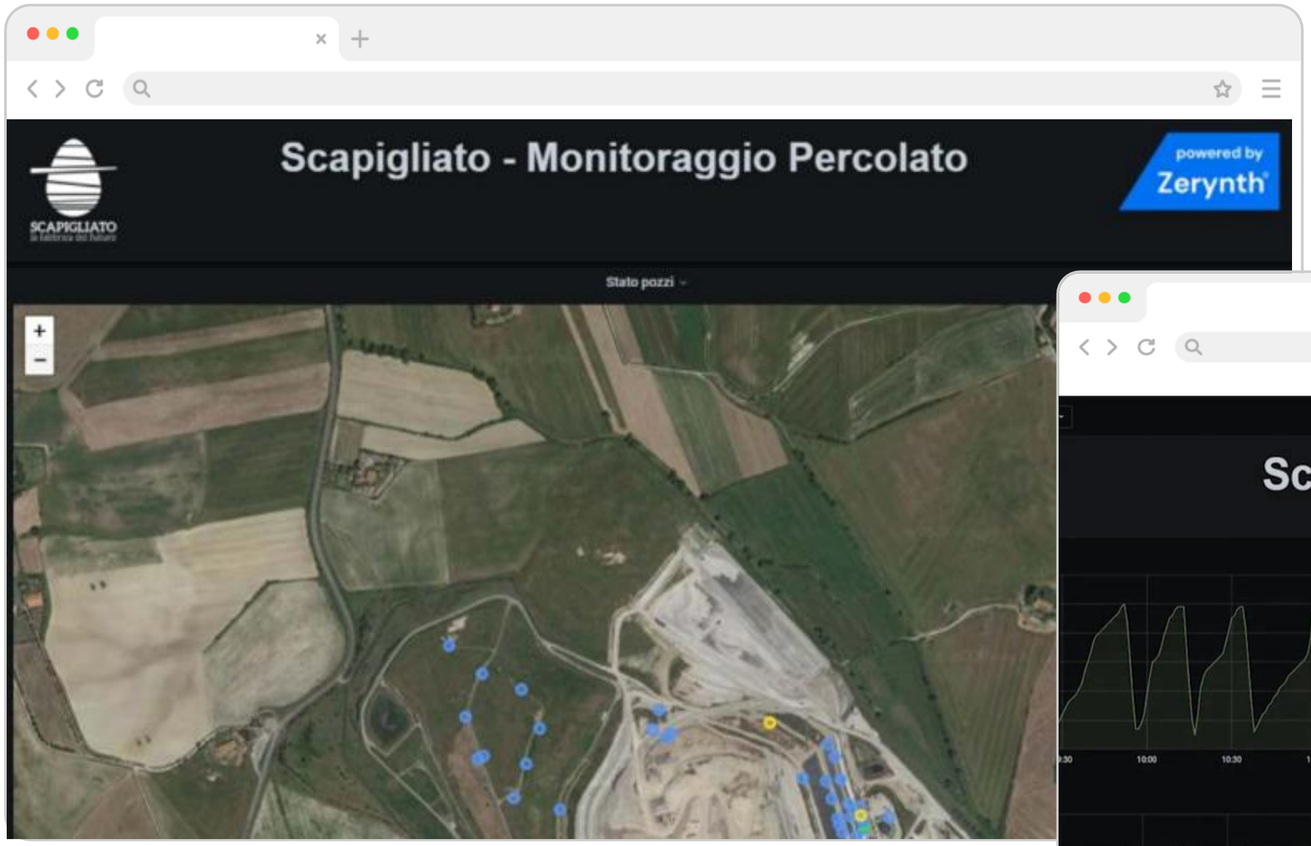
- Modular and Scalable
  - *1 data collector per sub-station*
  - *up to 20 sensor modules per sub-station*
  - *Low bandwidth long range network*
- Industrial Grade:
  - *Waterproof IP68*
  - *Certifiable (CE and Atex)*
- Connection uptime not guaranteed
  - *Local Processing*
  - *Local Storage*



Zerynth x SCAPIGLIATO
la fabbrica del futuro



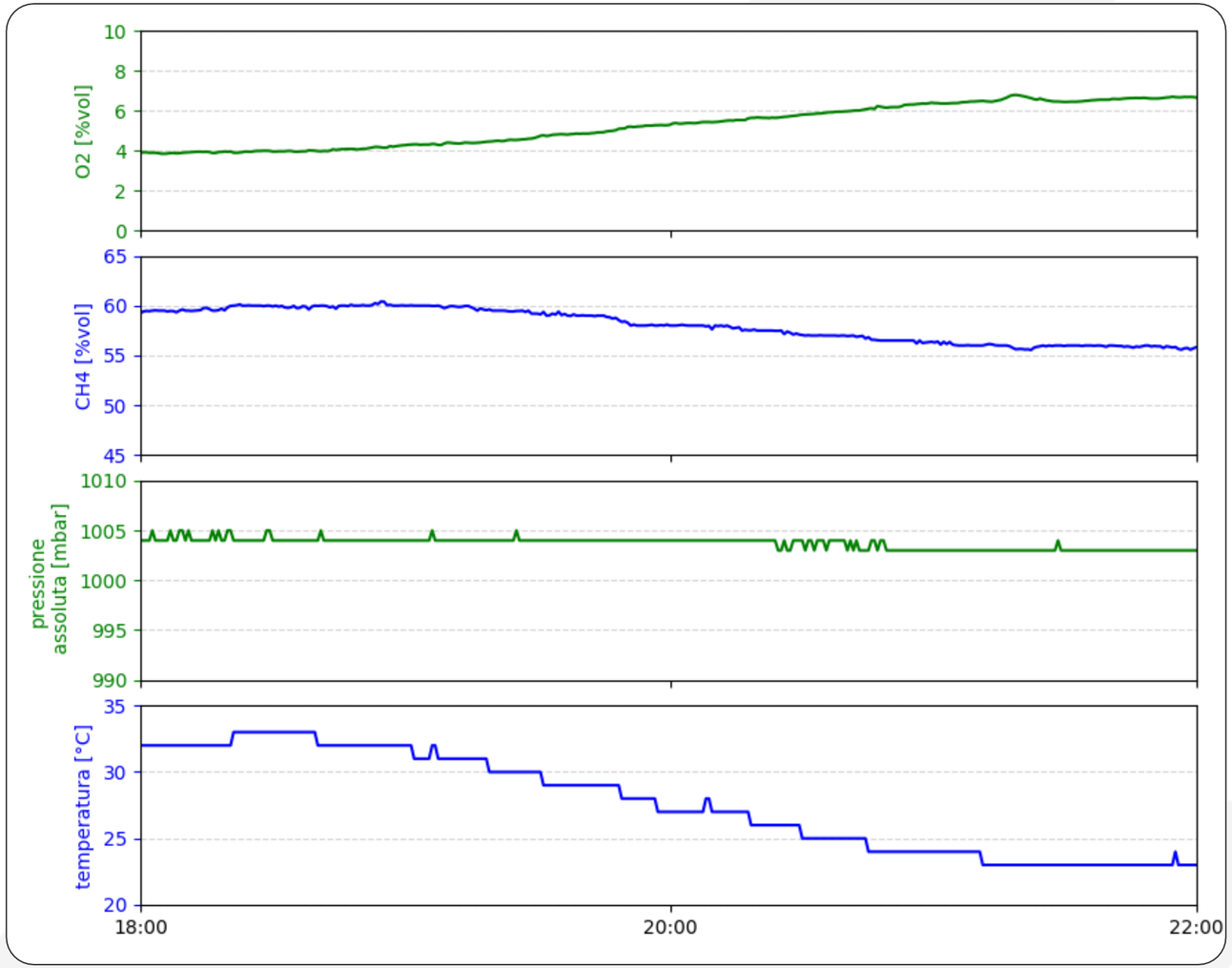

Zerynth x SCAPIGLIATO




# Prototipo Dashboard

**Allarmi:**

- CH4 concentration < 40%
- O2 concentration > 4%
- Well pressure ≥ Env. Pressure
- Collector Pressure > 900 mbar
- Gas Temperature < 10 °C



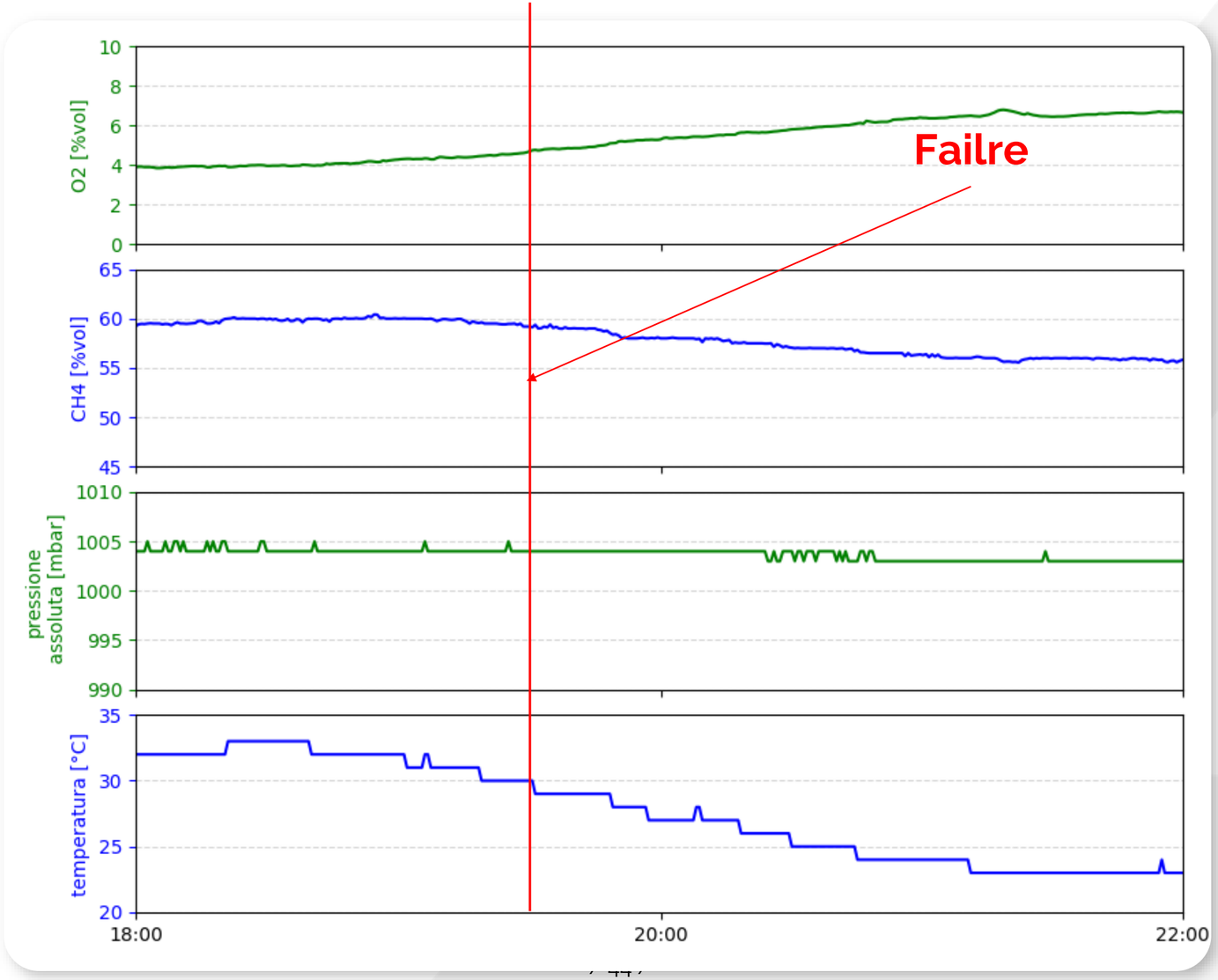
# MONITORAGGIO PRODUZIONE DI BIOGAS IN UNA DISCARICA

$O_2$

$CH_4$

Mbar

°C



# MONITORAGGIO PRODUZIONE DI BIOGAS IN UNA DISCARICA

$O_2$

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Mbar

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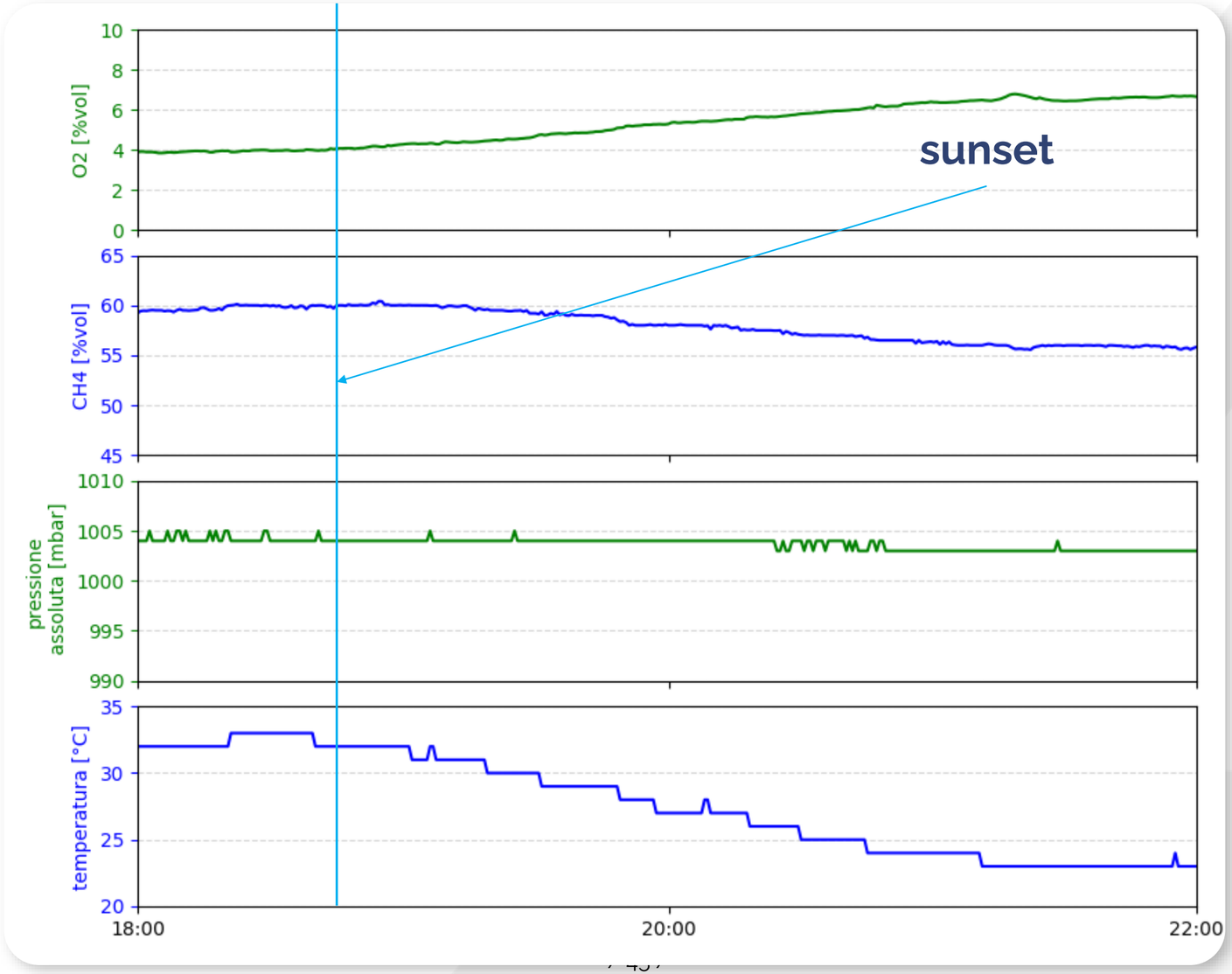


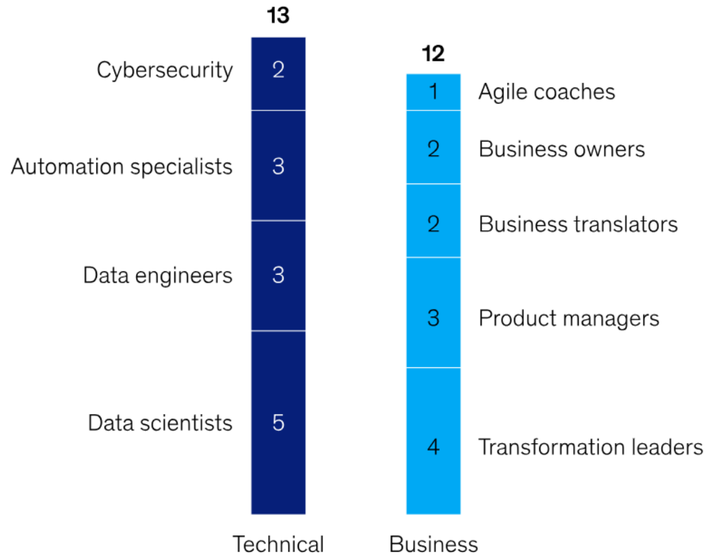
# Technology isn’t enough

…leaders recognize that **what transforms a business is not just a particular technology,** or even a unique set of use cases, **but the ability of people and processes to use technology to create value across the enterprise.**

**…For every $2 they spend on tech innovation, they earmark $3 for process debt reduction and $5 for scale and adoption.**

**…By contrast, we find that most other manufacturers spend closer to one or two times their tech investment on these same enablers.**

**Digital-transformation full-time-equivalent (FTE) roles added, by domain,** number per 1,000 total FTEs

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