Combined AI and Data solutions for AUTOMATION

# Challenge 4.1

## Smart energy management of unplanned machine downtime

# 4 Combined AI and Data solutions for AUTOMATION

## 4.1 Smart energy management of unplanned machine downtime

### Challenge and context

In high-volume and energy-intensive industrial parts production, a significant share of energy losses occurs during unplanned machine downtime, such as micro-stoppages, quality control stops, disruptions caused by tool malfunctions, or other unexpected interruptions. Unlike planned non-production periods, these events are often unmanaged from an energy perspective, leading to machines and auxiliary systems remaining in fully powered states while no value-adding operations take place.

This challenge focuses on industrial production cells for parts manufacturing, where machines operate in cyclical modes and rely heavily on auxiliary and spatially distributed energy consumers, such as tool tempering units and compressed air systems. These subsystems remain in standby and continue to consume energy even when production cycles have stopped unexpectedly, resulting in unnecessary energy use, increased operational costs, and higher environmental impact.

LTH currently operates several production cells where machine cycle information is available at PLC or sensor level; however, automated energy-aware control of auxiliary energy consumers during unplanned downtime is not yet implemented. Operators intervene manually or not at all, and auxiliary systems often remain in full operation during downtime.

The challenge addresses the need to automatically detect machine cycles, identify unplanned downtime events in real time, determine appropriate energy mitigation strategies and dynamically transition machines and auxiliary equipment into appropriate standby or off modes. On the other hand, the estimated preparation time to continue production should be predicted and orchestrated control of auxiliary systems should be performed at process startup, without compromising production readiness or product quality once production resumes.

### Use case and expected solution

The expected solution should provide an automated energy management system that continuously monitors machine cycle signals, production states, and energy consumption within an industrial production cell and provides an orchestrated control of most significant consumers linked to the observed operation. The solution shall include a smart tool tempering unit for aluminium diecasting process capable of individual monitoring and control of each tempering circuit within the diecasting tool and integration capability for real-time measurement, visualization and regulation with aim to integrate it within the demonstrated system.
Based on this information, the system shall:

1. Automatically detect machine cycle starts, normal cycle operation, cycle interruptions, and unplanned downtime events using real-time data.
2. Distinguish between short micro stoppages and longer unplanned downtime to select appropriate energy saving strategies.
3. Dynamically control machine operation states (e.g. run, standby, off mode) during unplanned downtime.
4. Specifically optimize the operation of energy intensive auxiliary systems, with a focus on Tool tempering unit (TTU) and Air Management System (AMS).

### Specification for use case

The solution will use data driven methods, combining rule-based logic with AI or machine learning techniques, to learn normal cycle behavior, automatically detect deviations, and continuously improve

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downtime classification and energy saving decisions. Moreover, it should provide a reliable indicator of the estimated time needed for re-activation of the auxiliary systems.

The developed solution should be demonstrated in the industrial environment, where communication with the auxiliary systems should be resolved using standard communication protocols (OPC-UA, MODBUS, etc.). Finally, the control of auxiliary services (TTUs and AMS) shall operate autonomously, without reliance on manual operator input, while remaining fully compatible with production control systems, safety constraints, and quality requirements.

## Expected solution

The expected solution should be demonstrated and validated under real production conditions with varying unplanned downtime scenarios. The solution should provide the following functionalities:

- Machine cycle detection from PLC signals, sensors, or energy signatures.
- Realtime identification of unplanned downtime events.
- Integration of monitoring and automated control of compressed air pressure and airflow, including supply of IoT-enabled AMS.
- Integration of automated control of TTU and supply of suitable TTU for the pilot.
- Energy aware control interfaces for production cell supporting standby and off modes.
- Orchestrated and on-time management of startup phases.

## Key Performance Indicators

Key Performance Indicators (KPIs) should be defined as clear, objective criteria that demonstrate the relevance and impact of the proposed solution, covering at least two of the following dimensions—resource optimisation, Green Deal objectives, and social impact—and must be SMART (Specific, Measurable, Achievable, Relevant and Time-bound), ensuring they remain quantifiable throughout the project.
The demonstrated solution will enable LTH to significantly reduce nonproductive energy consumption in parts production cells while maintaining production flexibility and responsiveness. The impact of the developed solution will evaluate changes compared to the baseline conditions (operation without the energy management system).

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