Integrated Measuring and Data Analysis Framework for Sustainable Manufacturing

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INTRODUCTION

Electricity generation is responsible for 87% of global CO2 emissions, with industrial sectors consuming 38% of this energy. Despite rapid growth in renewable energy sources, per capita energy consumption and **CO2 emissions continue to rise**. As a result, there is an urgent need for environmental traceability within manufacturing processes to:

- Assess the environmental impact of energy consumption.
- Comply with international regulations and emission targets.
- Inform consumers of production sustainability.
- Foster cleaner production practices to mitigate climate change.

MATERIALS AND METHOD

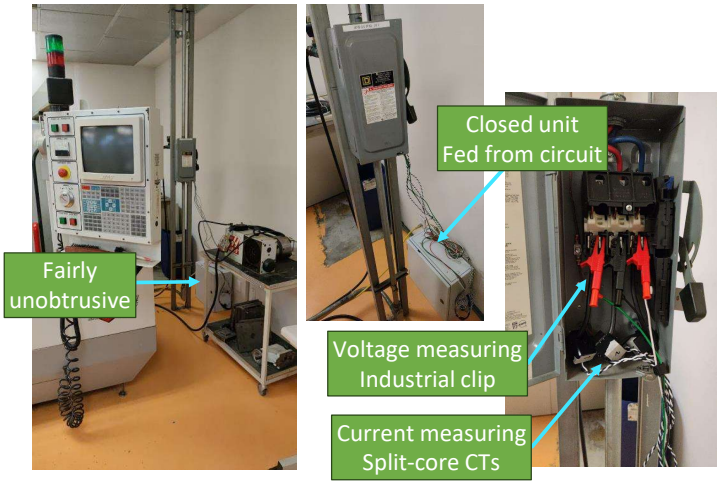
Our approach is designed to support sustainable manufacturing through a combination of instrumentation, data analysis, and process optimization. We provide:

- **Instrumentation Plans**: Customized to the specific needs of each manufacturing facility, ensuring that key energy consumption points are monitored.
- **Instrument Leasing**: Accessible solutions for case studies, allowing companies to test measurement and monitoring systems without the need for large upfront investments.
- **Comprehensive Data Analysis**: Detailed reports that highlight areas of inefficiency and energy waste.
- **Process Modeling and Digital Twin Implementation**: Advanced tools to model and simulate processes, allowing for optimization before real-world implementation.

Key Features:

- 3 measuring units, each monitoring up to 3 circuits.
- Max power capacity of 200 kVA @480V and 250 A per circuit.
- Sampling rate of 1 second for high-precision data.
- Remote monitoring capabilities via Ethernet, WiFi, and 4G for real-time data access.

Tested on a CNC cell case study for one week



RESULTS AND DISCUSSION

The implementation led to significant insights and improvements in the CNC cell's energy usage. Key results include:

- Process Optimization: Tailored instrumentation identified inefficiencies and energy overuse in **specific time slots**, allowing for planning adjustments (tool penetration was too deep into the material).
- Energy Savings: The ability to monitor and act on energy consumption patterns reduced overall energy use, minimizing **operational costs** and **equivalent emissions**.

Discussion

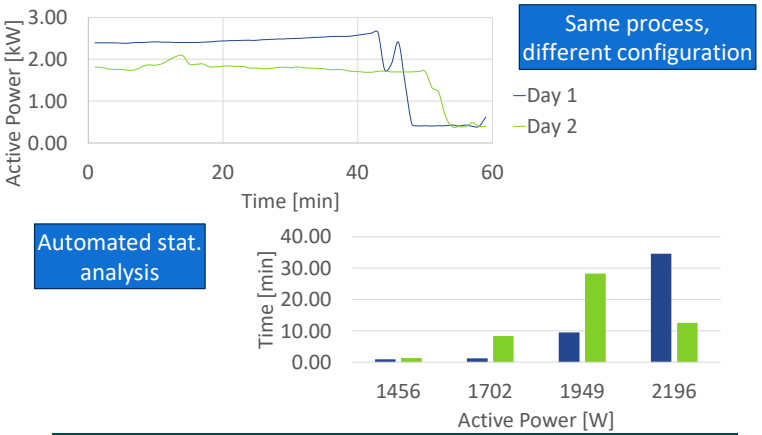
- The remote monitoring system enabled real-time analysis of the CNC cell's performance, facilitating proactive **decision-making**.
- One could **compare** processes performance **and adapt** resources allocation, scheduling, configurations, and forecast production.
- Quick setup and commissioning ensured minimal disruption to existing operations.
- This approach can be **scaled** across other industrial processes.

CONCLUSIONS

This project demonstrates that environmental traceability and data-driven process optimization can lead to **meaningful reductions** in energy consumption.

- Tailored instrumentation uncovered areas for process improvement, driving both operational **efficiency** and **energy savings**.
- Integrated data analysis, paired with process insights empowers industries to make **informed decisions** that support sustainable innovation.

This integrated approach can serve as a model for other industrial sectors. Here, the **machining settings** were found not only to be more energy demanding but also unnecessarily harsh on the CNC.



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✓ [Accepted] L. Ibarra, A. Romero, R. Galluzzi, "Recursive Estimation of Statistical Metrics over Large Datasets or Real-Time Signals," accepted in 2024 50th Annual Conference of the IEEE Industrial Electronics Society (IECON)