HSLU Lucerne University of Applied Sciences and Arts

Engineering and Architecture
B.Sc.. Energy and Environmental Systems Engineering
Bachelor-Thesis

Energy and impact analysis of an intensive aircraft painting process

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1. Introduction, Goals and Research Questions

The study focuses on improving energy efficiency in the painting and drying processes at PILATUS Aircraft Ltd. by analyzing electricity and heat consumption of the OZ2. It addresses the growing importance of sustainable production systems and aims to identify inefficiencies in these energy-intensive processes.

The main objectives are:

- Evaluating energy consumption of different operational modes
- Developing optimization strategies for energy use
- Assessing the environmental footprint of the processes
- Providing actionable sustainability improving recommendations

2. Method Overview and Materials

The methodology of the study is structured into several steps, as illustrated in the diagram. Data from the painting processes is collected and processed in a dashboard to analyze current and cumulative values for electricity and heat consumption. The energy analysis is conducted on annual, seasonal, and operational levels, focusing on various operating modes. This approach provides a comprehensive understanding of energy use patterns and identifies inefficiencies. The results support actionable recommendations aimed at reducing energy consumption, saves costs and CO_2 emissions, forming the foundation of the bachelor thesis and future investments.

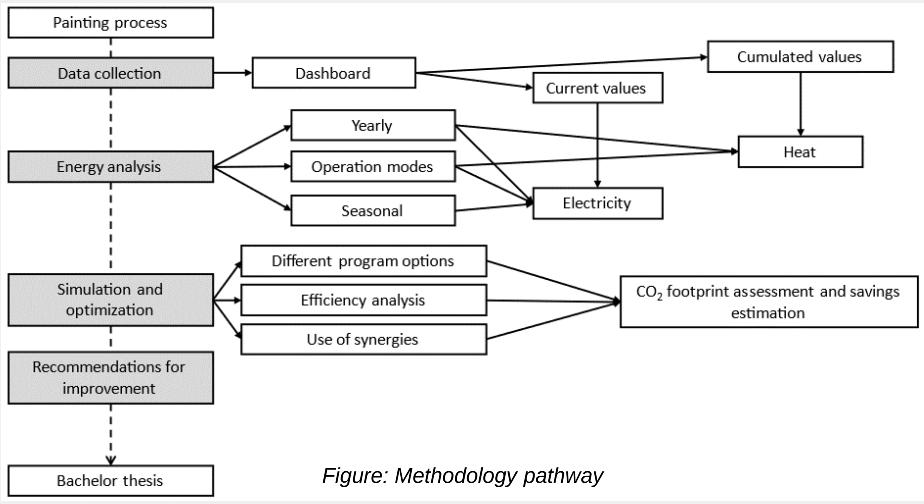

Figure: Methodology pathway

The analysis used Excel to consolidate active and reactive energy data and to display consumption trends over time.

The annual energy consumption totaled 1'340 MWh for electricity with heating and ventilation systems being the primary drivers and 2'463 MWh for heat, almost twice as high.

Figure: PC24 in paint shop (Pilatus, 2018)

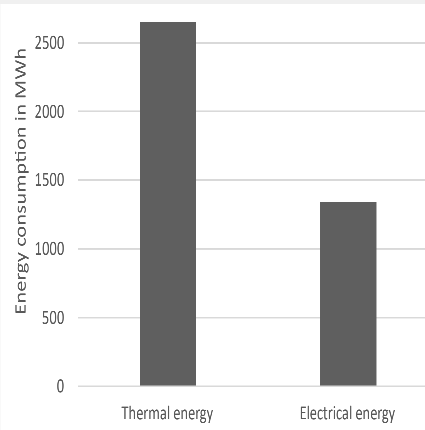

Figure: Electrical and thermal demand

3. Results and Discussion

The lacquering mode was identified as the most energy-intensive, consuming 313 kWh, costing 24.23 CHF and emitting 7.77 kg CO2-equivalents per hour. In comparison, sanding mode reduced energy consumption by 49% and preparation modes by 30%, respectively. Optimized ventilation systems could achieve energy savings while integrating heat recovery systems or implementing heat pumps could reuse heat in adjacent processes reducing energy consumption, cutting costs and emissions. There is no impact on the quality of the paint finish whether heat up to 50°C is applied or if the process is simply slowed down.

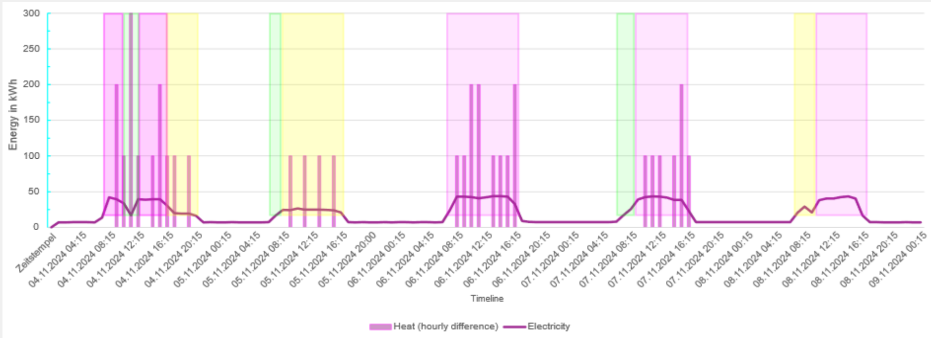

Figure: Program recording of Q6.1 BEA 2 in a hangar over a week (energy demand)

Operation mode	Total Energy	Total costs	Energy saved	Emissions per hour
Pink (lacquering)	131 kWh/h	34.23 CHF/h	-	7.77 kg CO2-e
Yellow (sanding)	67 kWh/h	17.03 CHF/h	48.9 %	3.82 kg CO2-e
Green (preparation)	91 kWh/h	24.69 CHF/h	30.5 %	5.69 kg CO2-e

Table: Savings on energy (electricity and heat together) and emissions

Electricity demand peaks in summer due to cooling and ventilation, while heat consumption rises in winter to meet increased heating requirements.

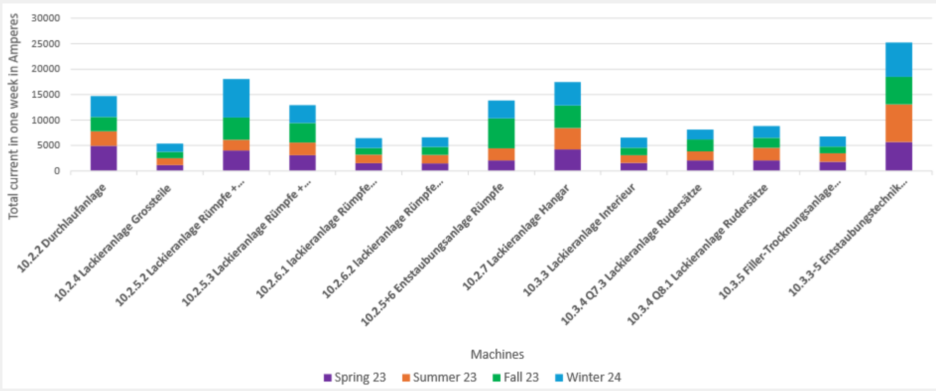

Figure: Seasonal detailed current use in specific weeks

4. Conclusion and Recommendations

This analysis reveals inefficiencies and optimization opportunities. Heat use, nearly double that of electricity, dominates energy consumption, with seasonal variations showing higher heating demands in winter and electricity peaks in summer. Lacquering is the most energy-intensive process, while sanding and preparation modes offer savings of up to 49%. Recommendations include integrating heat recovery systems, optimizing ventilation and adopting renewable energy and monitoring systems. These measures aim to improve energy efficiency, reduce emissions and support sustainable industrial practices.

References

Rippert Anlagentechnik GmbH & Co. KG. (2024). Anlagenbeschreibung für Pilatus Flugzeugwerke AG.

Industry Partner:
Pilatus Aircraft Ltd

PILATUS

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