Teaching Case Study

Smarter scheduling. Less energy.

Improving the energy efficiency of the thermoforming process in the manufacture of acrylic bathtubs

Proposal Sheet

By

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CONTENT

1 GENERAL INFORMATION

Activity Sector	Manufacturing – Energy-intensive discrete production		
Key words	Thermoforming; Production planning; Energy optimisation		
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Public	Initial and alternative education ☒ Beginners ☒ Intermediaries ☐ Experts	Continuing education ☒ Beginners ☒ Intermediaries ☐ Experts	
Domain(s)	☐ CSR ☒ Economics ☐ Entrepreneurship ☐ Finance ☐ HRM ☐ Information Systems ☐ Law ☐ Marketing & Sales ☐ Political Sciences ☐ Strategy ☐ Supply chain & logistics	☐ Arts, Architecture, Design, Ergonomics ☐ Education Sciences ☐ Geography & Urban planning ☐ Information & communication Sciences ☐ Literature & language Sciences ☐ Medical Sciences ☐ Physical activities & Sport Sciences ☐ Psychology, Sociology, Philosophy, Demography	☐ Biology & Neurosciences ☐ Chemistry, Biochemistry ☐ Earth & Universe Sciences ☐ Electrical, Electronics ☒ Energetics ☐ Mathematics & Computer Science ☒ Mechanical Engineering ☐ Physics ☒ Processes
UN SDG	☒ 9 Industry, Innovation, and infrastructure ☒ 12 Responsible consumption and production		
Place in the Circular Economy Model	☐ Raw materials ☐ Sustainable design ☒ Production ☐ Distribution ☐ Consumption Reuse Repair ☐ Collection ☐ Waste management ☒ Residual waste		

2 ABSTRACT

This Teaching Case Study addresses the problem of improving energy efficiency in an energy-intensive production process through decisions related to production planning and scheduling. The analysed system represents a discrete manufacturing environment. It concerns the production of acrylic bathtubs and is characterized by a multi-stage technological process with a dominant resource of high energy consumption: the thermoforming oven.

The case study was inspired by analytical challenges identified in industrial projects carried out by InterMarium, a company specializing in the analysis and improvement of production and logistics systems. In these projects, significant variability in energy consumption was repeatedly observed despite stable production volumes and unchanged technological conditions, indicating the crucial role of planning and scheduling decisions in optimization activities. The Teaching Case Study focuses on the impact of production sequencing on oven utilization, energy consumption, and the timeliness of delivery completion. Production orders are grouped into shipment packages with defined due dates, while transitions between different product types on the oven require sequence-dependent changeovers. Although the production technology and manufacturing volumes remain unchanged, different scheduling decisions lead to significantly different levels of energy losses and due-date performance.

Students are expected to analyse a baseline schedule and design alternative scheduling scenarios using analytical tools based on spreadsheets. By evaluating key performance indicators related to oven energy consumption and shipment package tardiness, students analyse the trade-offs between energy efficiency and customer-oriented objectives. The case study demonstrates that significant energy savings can be achieved without technological changes, solely through improved planning and scheduling decisions.

3 PEDAGOGIC GOALS & PREREQUISITES

This Teaching Case Study aims to achieve the following **pedagogical goals**:

- enable students to analyse a multi-stage, energy-intensive production process and examine how planning and scheduling decisions influence the performance of the entire system,
- enable students to understand that production sequencing decisions can significantly affect energy consumption, even when production technology and output volumes remain unchanged,
- enable students to understand that improvements in energy efficiency can be achieved through organizational and planning decisions without modifying the production technology,
  enable students to evaluate alternative scheduling scenarios using key quantitative performance indicators related to energy consumption and due-date performance,
- prepare students to present and defend a data-driven scheduling strategy that balances energy efficiency objectives with due-date requirements,
- prepare students to present and defend a structured recommendation for improving production planning practices based on analytical results.

The following **prerequisites** are recommended:

- basic knowledge of production systems and manufacturing processes,
- familiarity with the fundamental concepts of production planning and scheduling,
- understanding of basic performance indicators used in operations management,
- ability to work with spreadsheet-based analytical tools,
- basic quantitative and analytical skills.

4 SUSTAINABILITY GOALS

This Teaching Case Study directly addresses sustainability challenges related to energy efficiency in industry. The main emphasis is placed on reducing unnecessary energy consumption through improvements in organizational and planning decisions, rather than through investments in new technologies or equipment.

The case study highlights the environmental and economic consequences of inefficient utilization of energy-intensive resources, such as increased energy losses during idle periods and frequent changeovers. By analysing alternative production sequences, students learn how more effective scheduling can contribute to:

- reducing energy consumption,
- lowering operational energy costs,
- decreasing the indirect environmental impact associated with energy generation.

The case study is consistent with the principles of sustainable development, demonstrating that significant improvements in energy efficiency can be achieved through better decisions and improved process organization. It supports a system-oriented approach to sustainability, in which operational efficiency, economic performance, and environmental responsibility are closely interconnected.

5 CASE DESCRIPTION

Year of the problematic	2025	
Duration for students	Preparation:	45 (90) min 45 min: reading of all related information + potentially 45 min: working through the self-learning material
	Implementation:	4,5 h 3,0 h: Analysis phase and result elaboration by students 1,5 h: Result presentations + debriefing
Languages	☒English	☒ Other: Polish (Documents addressing students only)
Use case	☒ In class	☐ Examination TCS
Category	☐ C1: Case written in collaboration with a company which has given its consent for using of its internal sources such as the company name, figures, photos, videos, and so on. Join the agreement sheet. ☒ C2: Case based on real company information and with the acceptance of the company to use its data, but names or figures (of company and persons) are modified to keep them confidential. Join the agreement sheet. ☐ C3: Case written using external public sources (annual report, websites, brochures, newspapers, …) where names or verbatims of the protagonists are used. Join the agreement sheet. ☐ C4: Case based on real company using public information without the agreement of the company (generally, the names (company and persons) are changed to anonymous ones. Impossibility to make the link between the TCS and the company. ☐ C5: Imaginary case based on teacher's experience who collected information from several companies in order to write a case study with a fictive integrative company. It can also be a compilation of different situations of several periods put together at the same time to form a pedagogic tool.	
Number of pages: Statement / Annex		50 / 13
Number of pages: Teachers' note:		16
Diffusion licence		See cover page

6 CASE PACK COMPONENTS

6.1 General documentation

Table 6.1: General TCS documents

Document name	Description	File name	# pages
Proposal Sheet	Teaching Case Study description. This file can be published to inform interested persons about the Teaching Case Study. This document	SCABEE TCS SmartScheduling (2025) - Proposal Sheet.pdf	8
Company agreement	Agreement of the company to use their internal information and data	SCABEE TCS SmartScheduling (2025) - Company agreement InterMarium.pdf	3

6.2 Student's documentation

Table 6.2: Documents for students (to be shared when TCS applied)

Document name	Description	File name	# pages
Base scenario	The document for students including the mission and all necessary information.	SCABEE TCS SmartScheduling (2025) - Base Scenario.pdf	14
Analysis form (student, beginner)	A spreadsheet containing forms to analyse various production scheduling options using the given information. The forms include predefined formulas that allow the evaluation of schedules and energy-related performance indicators without requiring advanced technical skills. The document structure and worksheets are protected against unintentional deletion or modification. Only designated input fields are editable by students. The unlock password is "SUT".	SCABEE TCS SmartScheduling (2025) - Analysis form (student, beginners).xlsx	13

6.3 Teacher's documentations

Table 6.3: Documents for teachers (not to be shared with students)

Document name	Description	File name	# pages
Teacher's note	Document for teachers to guide them through the Teaching Case Study.	SCABEE TCS SmartScheduling (2025) - Teacher's note.pdf	16
Analysis forms (teachers)	An Excel file containing completed analysis forms intended to support teachers during the evaluation phase of the Teaching Case Study. The document can also be used by teachers to update input data or adjust parameters to reflect local or regional conditions. The document structure and worksheets are protected to prevent unintentional deletion or modification. Access to protected elements is available to instructors if required. The password to unlock is "SUT".	SCABEE TCS SmartScheduling (2025) - Analysis form (teachers).xlsx	13
Evaluation (report)	Suggestion for the evaluation of the submitted presentation document/report	SCABEE TCS SmartScheduling (2025) - Evaluation report.docx	1