Teaching Case Study

It's Just Air? Think Again.

Analysing the design of pneumatic systems with a focus on energy efficiency and operating cost reduction in an automated production workstation

Proposal Sheet

By

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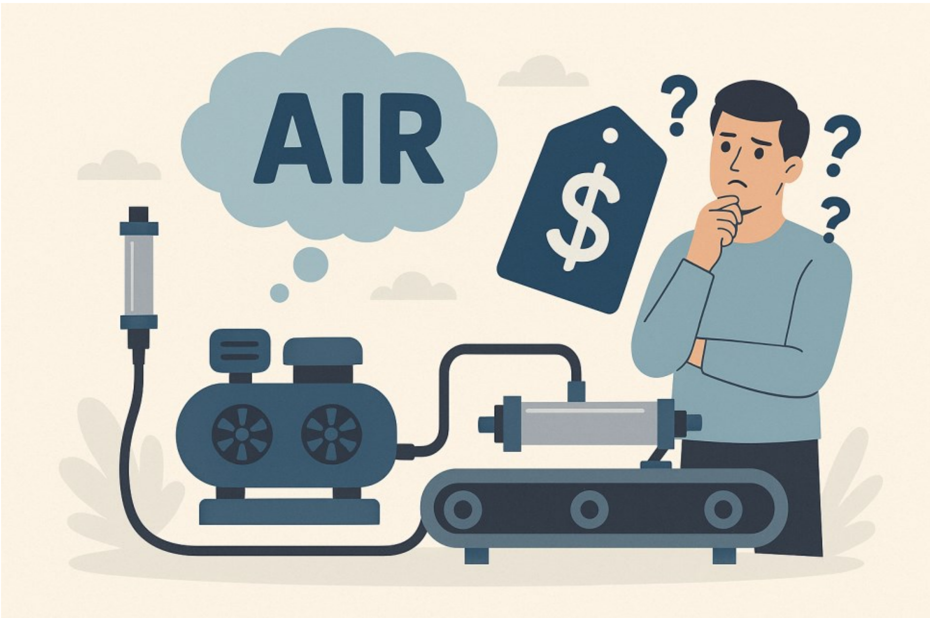

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CONTENT

1 GENERAL INFORMATION 2
2 ABSTRACT 3
3 PEDAGOGIC GOALS & PREREQUISITES 3
4 SUSTAINABILITY GOALS 4
5 CASE DESCRIPTION 4
6 CASE PACK COMPONENTS 6

1 GENERAL INFORMATION

Activity Sector	Industrial Automation and Energy Efficiency		
Key words	Pneumatic system design, Energy efficiency, Compressed air losses, Pressure drop analysis, Industrial automation, Sustainable manufacturing, Pneumatic actuators, Air consumption optimization, System performance evaluation, Energy-saving strategies.		
Author(s) / Institution / Country	Marek Płaczek, Silesian University of Technology (Poland)		
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

The students are working in an engineering company specializing in the design and implementation of automated assembly stations and handling systems for the light industry. As Junior Engineers, they have been assigned the task of developing a concept for a pneumatic system for a new production workstation that is expected to perform repetitive operations (such as sliding, lifting, or clamping) in a continuous three-shift mode.

In response to rising energy costs, the management of the company has decided to compare two design approaches:

1. a standard version, developed without particular emphasis on energy efficiency, and
2. an optimized version, designed with a focus on minimizing compressed air consumption and operating costs.

The project requires students to analyze both approaches from technical and economic perspectives. They are expected to select working pressures, choose appropriate pneumatic actuators and valves, design the compressed air distribution system, and determine pressure drops and compressor requirements. Furthermore, students will estimate the annual air consumption and electricity costs associated with generating compressed air in both system variants.

The analysis aims to highlight the impact of design decisions on energy efficiency, operating expenses, and investment costs. In addition, students are encouraged to propose further improvements to enhance the energy performance of the system.

This assignment reflects real-world industrial challenges where engineering decisions must balance technical feasibility with cost efficiency and environmental responsibility.

3 PEDAGOGIC GOALS & PREREQUISITES

This Teaching Case Study aims at the following pedagogic goals:

- Enable students to discover and identify relevant technical, environmental, and economic indicators to compare different pneumatic system designs and justify engineering decisions.
- Understand that compressed air, despite being "just air," represents a significant cost and energy burden in industrial applications, and that its optimization directly contributes to lower operational costs and environmental impact.
- Develop the ability to present, justify, and defend a proposed solution to various stakeholders, such as a supervisor, client, or project manager, using technical and financial arguments.
- Raise awareness of how energy efficiency can be integrated into the engineering design process through proper component selection, system layout, and process analysis.
- Develop students' ability to present and defend engineering solutions in a professional context — before a supervisor, project manager, or client — using clear technical reasoning and economic justification.
- Encourage critical thinking and interdisciplinary problem-solving by connecting mechanical design, energy management, and sustainability goals in an industrial automation setting.

The following prerequisites are recommended:

- Basic knowledge of pneumatic systems, including the function and selection of actuators, valves, and compressors, to understand the case in a practical context.
- Basic understanding of industrial automation and production process organization (engineering studies) to relate system design decisions to operational efficiency and cost-effectiveness.

4 SUSTAINABILITY GOALS

This Teaching Case Study allows students to understand how industrial pneumatic systems — when thoughtfully designed — can contribute to broader sustainability goals by reducing energy waste, lowering operational costs, and minimizing environmental impact.

The TCS highlights the often-overlooked fact that compressed air is one of the most energy-intensive utilities in manufacturing environments. By comparing a standard and an energy-optimized pneumatic system, students learn how intelligent engineering decisions — such as lowering operating pressure, reducing leakages, selecting efficient actuators, and optimizing system layout — can lead to measurable reductions in electricity use and CO_2 emissions.

Furthermore, the case study emphasizes the importance of sustainable engineering practices in the context of modern industry and supports the achievement of several Sustainable Development Goals (SDGs), particularly:

- **SDG 7 – Affordable and Clean Energy**, by encouraging the reduction of unnecessary energy consumption through system optimization,
- **SDG 9 – Industry, Innovation and Infrastructure**, by promoting innovation in pneumatic system design that aligns with responsible resource use,
- **SDG 12 – Responsible Consumption and Production**, by demonstrating how energy efficiency contributes to sustainable production systems.

This case also fosters an understanding of lifecycle thinking in engineering design, showing that sustainability begins at the concept stage and extends through daily operations.

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: 6.0 h 4.5 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		5 / 31
Number of pages: Teachers' note:		19
Diffusion licence		See cover page

6 CASE PACK COMPONENTS

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 It's Just Air? Think Again (2025) – Proposal Sheet.pdf	8
Company agreement	Agreement of the company to use their internal information and data	SCABEE TCS It's Just Air? Think Again (2025) – Company agreement EMT.pdf	3
Base scenario	The document for students including the mission and all necessary information.	SCABEE TCS It's Just Air? Think Again (2025) - Base Scenario.pdf	36
Nomograms	Documents that should be printed and made available to students for the purpose of carrying out exercises.	SCABEE TCS It's Just Air Think Again (2025) – Nomograms.pdf	3
Analysis form (student, beginner)	A spreadsheet designed to support the analysis and comparison of pneumatic system configurations with a focus on energy efficiency. It includes forms and calculation tools to estimate pressure drops, air consumption, and system losses, enabling decision-making without requiring advanced technical skills. The document structure and sheets are protected against unintentional deletion or modification. The unlock password is "SUT".	SCABEE TCS It's Just Air? Think Again (2025) - Analysis form (student, beginners).xlsx	9
Teacher's note	Document for teachers to guide them through the Teaching Case Study.	SCABEE TCS It's Just Air? Think Again (2025) - Teacher's note.pdf	19
Analysis forms (teachers)	Excel file with completed analysis forms to help teachers in the evaluation phase. This document can also be helpful when teachers want to update data or enter parameters for their region. The document structure and sheets are protected to avoid unintentional deletion or modification. The password to unlock is "SUT".	SCABEE TCS It's Just Air? Think Again (2025) - Analysis form (teachers).xlsx	9
Evaluation (report)	Suggestion for the evaluation of the submitted presentation document/report	SCABEE TCS It's Just Air? Think Again (2025) - Evaluation report.docx	1