

# Challenging students with open multidisciplinary problems: A case study concerning sustainable technologies

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Process Technologies for Carbon Neutral Fuels (PTCNF) is a Master's degree course at the University of Padova, which is offered to students in Chemical and Process Engineering, Energy Engineering, and Materials Engineering. The course is structured around four core modules, covering biofuels, carbon capture, utilisation and storage, hydrogen technologies, and decarbonisation strategies for 'hard-to-abate' industries. Despite being an elective course, PTCNF has consistently attracted strong student engagement, with over 100 exams registered annually. Apart from a clear interest for the topics, we believe that its success can be largely attributed to its innovative examination methodology.

*Teamwork example*

Imagine 1.5 million people living in a group of islands with no commercial or industrial interaction with the mainland due to an embargo from foreign countries. The archipelago is composed of 3 islands of similar size [...]. There are no carbon-based fossil fuels, and nuclear energy cannot be deployed as an outcome of a referendum. The climate is warm subtropical [...].

- They need steel, cement, and chemicals.
- They need food, but freshwater is scarce [...]
- They are all pescatarian.
- They need urban transportation to move within the islands and ships to move among the islands.
- Battery technology cannot be exploited due to ongoing trade sanctions.
- Fossil fuels can be smuggled from the mainland at 5 times their current market cost in Europe.

Figure 1. Teamwork example.

Students are organised into multidisciplinary teams and asked to develop an action plan to address a high-level open problem, integrating sustainability criteria and the technologies covered in class (Figure 1). Assessment is based on a mix of six components derived from the group project: three project presentations (preliminary, intermediate, and final presentations), one project report, one individual feedback assessment ('blind' peer review), and one response to feedback. Through this approach, students engage in strategic analysis, teamwork, and critical evaluation of energy challenges. Additionally, they assess competing proposals by other groups, fostering a collaborative and analytical learning environment.

The evaluation criteria include: (i) the ability to analyse and synthesise complex and broad energy issues, (ii) teamwork and collaboration, (iii) communication and presentation skills, and (iv) critical analysis and constructive feedback on peer projects. This assessment methodology not only enhances students' technical knowledge on cutting-edge decarbonisation technologies, but also develops essential skills in problem-solving, multidisciplinary collaboration, and professional communication.

**Keywords:** *Teaching sustainability, Multidisciplinary teamwork, Chemical and Process Engineering, Process Technologies for Carbon Neutral Fuels*