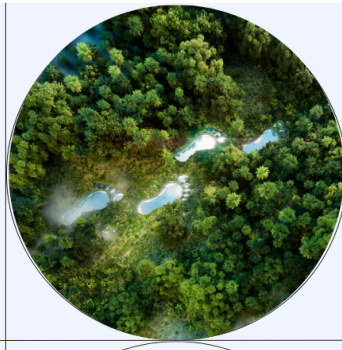
Power-to-X Module

as Part of Sustainability Week



Course description

This three-day workshop introduces Power-to-X (PtX) as a key technology in the green transition. Through short inputs, experiments with electrolysis, and group discussions, students explore how renewable energy can be converted into fuels like hydrogen.

The workshop combines scientific understanding with societal perspectives, as students evaluate the potentials and challenges of PtX in relation to climate, economy, and energy systems. Through collaborative poster work and presentations, they develop and communicate their own informed perspectives.

Contents and description of learning activity	This three-day learning activity was developed as part of the Sustainability Week at Techcollege HTX, where students engage with real-world sustainability challenges. The module introduces students aged 16–20 to Power-to-X (PtX) as an emerging technology in the green transition. The focus is primarily scientific, but the activities also integrate technological and social science in order to provide students with a broader understanding of sustainability solutions. The learning activity is designed for students with varying academic backgrounds, including students with limited confidence in science. Therefore, emphasis is placed on conceptual understanding, practical experimentation and dialog. Day 2 included a visit to the energy department of Aalborg

	University. That can be changed to a company working with PtX or other activities where students work more with the scientific background (physics, chemistry or social science).
Target audience	The learning activity is designed primarily for students aged 15–19, but it can be adapted to other age groups and educational contexts. It is particularly intended for mixed-ability student groups, including learners who may not have strong backgrounds or high confidence in science subjects. The learning activity is flexible and can be adjusted to the target group in terms of academic level, duration, and depth. Scientific content can be simplified or expanded, experiments can be made more or less advanced, and discussion topics can be adapted depending on whether the audience is general education students, vocational students, or more science-oriented learners. This makes the activity transferable and scalable across different educational settings.
Structure and framework	The presentations are supposed to be very short (five minutes per presentation) and meant as input for the students. It is not supposed to be long lectures!

Day 1

1. Presentation: What is Power-to-X?
    a. Electric power
        i. Electricity is energy produced by movement of electrons
        ii. Electric power is the rate of transfer of electric energy
    b. In math X is a variable or placeholder for an unknown number
    c. In Power-to-X it is a chemical compound
    d. Several possibilities (X is variable)
    e. In other words: Power-to-X is a technology where:
    f. **Electric power is converted to energy stored in chemical compounds**
2. Discussion in groups:
    a. What is electricity used for by you and others?
    b. How does the need for electricicty change during the day/year?
3. Energy production in your country
    a. How is electricity produced in your countries?
    b. Are the technologies CO2 neutral? Are they renewable?
    c. What are the pros and cons for each technology?
    d. Use: How is EU electricity produced and sold? - Consilium
4. Watch: How can we heat with the sun at night? - Hydrogen as future energy storage
5. Make hydrolysis experiment in lab (converting water to H_2 and O_2)
6. Discussion: What happened and why?
    a. What did you observe?
    b. What is the energy source? What is the energy used for?
    c. Where are the energy stored after the electrolysis?
    d. Why are the volume of produced hydrogen the double compared to produced oxygen?
7. Presentation:
    a. **Direct electrification** is the most energy-efficient option, but not everything can be electrified.
    b. Only when there is a surplus of renewable energy does it make sense to produce X, because energy is lost when electrical energy is converted into chemical energy.
    c. From green energy, **green dihydrogen** can be produced via PtX. It can either be used directly as a fuel or chemical
    d. Or it can be further converted into other fuels or chemicals—both of which represent forms of **indirect electrification**.
8. Fuel cell presentation:
    a. Transforms chemical energy back to electric energy
    b. Reverse electrolysis!
    c. The fuel reacts with oxygen, the product depends on the fuel:
    d. H_2: Only water
    e. Any carbonbased fuel: water and CO_2
    f. The reaction releases a lot of energy.

9. Group work: social science
    a. Climate perspective
        i. How can PtX contribute to reducing CO_2 emissions?
        ii. Which sectors are difficult to electrify directly (e.g. aircraft, ships, heavy industry)?
        iii. Why can PtX be relevant here?
    b. Economic perspective
        i. Why can PtX create new jobs?
        ii. Why can it be an advantage for a countries like Denmark, Spain, France and Austria to produce hydrogen?
        iii. What does energy independence mean, and why can it be politically important?
    c. Business perspective
        i. Why can it be attractive for companies to invest in green technology?
        ii. What are the risks of investing in PtX?
10. Group work: Pros and cons(possible arguments)
    a. PtX can store excess wind and solar energy.
    b. Energy is lost in the process.
    c. PtX can be used in airplanes and ships.
    d. The plants are expensive to build.
    e. Can create green jobs.
    f. Requires a lot of renewable energy.
    g. Can reduce dependence on oil and gas.
    h. The technology is still under development.
    i. Perspective questions
    j. Is PtX a solution or only part of the solution?
    k. Who pays for the expansion of PtX?
    l. Feel free to add more arguments
    m. Would you prioritize batteries or PtX if you were Minister of Energy? Why?
11. Make a poster
    a. Must explain why researchers, politicians and companies are interested in power-to-X.
    b. Must explain the basic principle of Power-to-X including electrolysis
    c. Must explain the advantages and disadvantages of the technology.

Day 2

1. What did we work with yesterday (discussed in groups and afterwards as a class).
2. Visiting the energy department of Aalborg University. A professor gives a lecture, where he explains the need for PtX, newest research and how the future could be.
3. Demonstration: a standard engine fed with ethanol

Day 3

1. Finish posters
2. Each group makes a short presentation.
3. Class discussion:
    a. What do you think about PtX?
    b. What do you think about the last three days learning activity? Anything you would like to be a part of your normal school activities?

Outcome

This learning activity enables students to develop a multidisciplinary understanding of Power-to-X and the broader challenges and opportunities connected to sustainable energy production. Through a combination of science, technology, societal perspectives, and creative communication, students gain insight into both the potential of green technologies and the complexity of the energy transition.

Students strengthen their understanding of key scientific concepts such as electrolysis, energy conversion, and hydrogen as an energy carrier, while also exploring economic, political, and environmental dimensions of the topic. The activity supports systems thinking by helping students see how scientific solutions are connected to societal choices and priorities.

An important learning outcome is that students engage critically with current energy challenges, including limitations related to efficiency, infrastructure, and renewable energy supply. At the same time, the activity promotes a constructive perspective: while the challenges are significant, there is reason for optimism when innovation and sustainable priorities are combined.

The activity also develops transversal competences such as collaboration, problem solving, communication, and inquiry-

	based learning through experiments, group work, and presentations. For teachers and schools, the activity offers a flexible interdisciplinary model for integrating sustainability and green transition topics into teaching. As part of the school's Sustainability Week, where other students work with different sustainability themes, the activity contributes to a broader whole-school approach and strengthens students' awareness that sustainable development requires action across many fields.
Teaching materials	• **How is EU electricity produced and sold? - Consilium** https://www.consilium.europa.eu/en/infographics/how-is-eu-electricity-produced-and-sold/ • **How can we heat with the sun at night? - Hydrogen as future energy storage** https://www.youtube.com/watch?v=_Aq8bOYo53I&t=1s • Guide to make electrolysis in lab.
Organisation	Group work, discussions, of hands-on activities, visiting University, short teacher presentations.