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# D4.2 Vocational Training Content

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# 1 Introduction

This report presents a list of vocational training contents that might be interesting for engineers. The topics have been chosen based on reports, presenting which fuel cell and hydrogen technologies will enter the market within 2020-2050. The training contents has been also defined based on those technologies that will have the most significant impact on the job market for students and engineers. However, there is a gap in the training landscape of fuel cell and hydrogen topics.

# 2 Vocational training content

The market demand for fuel cell and hydrogen technologies increased across the sectors. Therefore, there will be an increasing need for vocational training to provide job specific technical training in the trades across Europe. It can be noted that the application with the highest number of positions for engineers is the fuel cell electric vehicles. Also in the European Hydrogen Roadmap, it is affirmed that the largest employment potential is due to automotive industry [1]. Hydrogen production is expected to have a significant impact on job positions for engineers to be employed [2]. This consideration must be taken into account in the development of the vocational training contents.

Based on a survey from KnowHy, “safety” related to the fuel cell and hydrogen technologies is a main topic of interest for industries. This indicates the importance of vocational training course development for such topic [3]. Safety aspects are important from several points of view such as:

- Risk of explosion
- Handling of chemicals (particles, nanoparticles…)
- Electric power safety

Based on the emerged stakeholders need, TeacHy will provide a vocational training that enables engineers to safely operate fuel cell systems with a clear understanding of the real risk connected to their current and future work. The courses would be designed to introduce fuel cell and hydrogen technology to students across Europe, educating the engineers and professionals. A list of vocational training contents is given in Table 1.

Table 1: List of Vocational Training Contents which might be interesting for engineers.

| Recommended contents (initial list) | Course duration (Inc. 40% optional practical training) | | Fees (€) | |
|---|---|---|---|---|
| | Face to Face | Online | Face to Face | Online |
| Introduction to fuel cells | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |
| Hydrogen (production, storage, handling), fuels | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |
| Hydrogen safety | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |
| Low temperature systems (PEM) | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |
| High temperature systems (SOFC) | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |
| Energy system and storage | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |
| Fuel cell electric vehicles | 2-5 days | 4-6 weeks | 1500-2000 | 1000-1500 |

| 1 | **Course Title** | **Introduction to fuel cells** |
|---|---|---|
| 2 | Rationale for Introduction | The Introduction to fuel cell course aims to introduce Fuel Cell and Hydrogen Technologies to students and engineers and provide them with the basic science behind the processes involved. This will be useful for both students progressing into the area of energy generation/storage, as well as those aiming at getting involved in the fuel cell field itself. |
| 3 | Module Description | The module will cover the Fuel Cell technologies and their science<br>• electrochemistry/thermodynamics/energy analysis tools<br>• applications of fuel cells<br>• low temperature fuel cells, materials, designs, fuels, and systems<br>• high temperature fuel cells, materials, designs, fuels, and systems<br>• hydrogen and fuel cell safety issues<br>• environmental analysis, market introduction, economy, and policy framework |

| 1 | Course Title | Hydrogen (production, storage, handling), fuels (P2G, P2X) |
|---|---|---|
| 2 | Rationale for Introduction | This module aims to introduce hydrogen (technologies) production and fuels to students and provide them with the basic science behind the processes involved. This will be useful for both students progressing into the area of hydrogen production and its utilisation in energy generation/storage, as well as those aiming at getting involved in the FCH field itself. |
| 3 | Module Description | • Hydrogen and fuel cells, introduction, definitions<br>• Fossil hydrogen production, Nuclear hydrogen<br>• Renewable hydrogen, electrolysis<br>• Renewable hydrogen, non-electrolysis<br>• Hydrogen separation and purification<br>• Compression and liquefaction of hydrogen<br>• Solid state and chemical compounds of hydrogen<br>• Hydrogen storage<br>• On-board hydrogen storage<br>• Hydrogen infrastructure and HRS<br>• Supply chains and transport of hydrogen<br>• Fuels, power to gas<br>• Fuels, power to X<br>• Safety handling of hydrogen |

| 1 | Course Title | Hydrogen Safety |
|---|---|---|
| 2 | Rationale for Introduction | This module seeks to develop in students the knowledge and skills in the fundamentals of hydrogen safety applicable to existing and foreseeable hydrogen, fuel cell systems and infrastructure. The students will learn scientific and engineering principles of hydrogen safety to understand the origin and phenomenology of hydrogen safety problems. The study of hydrogen safety engineering principles will be underpinned by online engineering tools and case studies. |
| 3 | Module Description | The course consists of 12 lectures:<br>Lecture 1: Introduction to hydrogen safety<br>Lecture 2: Hydrogen properties and hazards, comparison with other fuels<br>Lecture 3: Regulations, Codes and Standards (RCS) and hydrogen safety engineering<br>Lecture 4: Unignited releases<br>Lecture 5: Ignition of hydrogen mixtures<br>Lecture 6: Microflames<br>Lecture 7/8: Jet fires - Part 1 &2<br>Lecture 9: Hydrogen permeation<br>Lecture 10: Compatibility of metallic materials with hydrogen<br>Lecture 11: Materials for hydrogen technologies<br>Lecture 12: Case studies |

| 1 | **Course Title** | **Low temperature system (PEFC)** |
|---|---|---|
| 2 | Rationale for Introduction | Aims to explain the operating principle, performance, and application of PEFCs to the students, engineers and other technical people. This will be useful for both students progressing into the area of energy generation/storage, as well as those aiming at getting involved in the fuel cell field itself. |
| 3 | Module Description | • Fuel Cell - Introduction<br>• Fuel Cell – Principle of Operation<br>• Fuel Cell Performances<br>• Different types of Fuel Cell<br>• PEFC Technology<br>• Fuel Cell Power System<br>• Power Fuel Cell Module Hybridizing<br>• Power Electronics<br>• Fuel Cell Vehicle Example |

| 1 | **Course Title** | **High temperature system (SOFC)** |
|---|---|---|
| 2 | Rationale for Introduction | The “High temperature system (SOFC) aims to explain the operating principle, cell and stack designs, cell and stack performance, and applications of SOFCs to the students, engineers and other technical people. This will be useful for both students progressing into the area of energy generation/storage, as well as those aiming at getting involved in the fuel cell field itself. |
| 3 | Module Description | • Introduction to SOFCs<br>• History<br>• Thermodynamics<br>• Cell and stack designs<br>• Electrode polarizations<br>• Fuels and fuel processing<br>• Systems and applications<br>• Balance of plant components |

| 1 | **Course Title** | **Energy system and storage** |
|---|---|---|
| 2 | Rationale for Introduction | The Energy system and storage module aims to introduce energy system and energy storage to students and provide them with the basic science behind the processes involved. This will be useful for both students progressing into the area of energy generation / storage, as well as those aiming at getting involved in the hydrogen energy field itself. |
| 3 | Module Description | • The actual energy system, introduction<br>• Fossil and nuclear energy production<br>• Renewable energy<br>• Energy vectors/carriers<br>• Hydrogen as energy vector/carrier, energetic properties of hydrogen<br>• Application to Fuel Cells and Electrolysers<br>• Energy storage and technologies<br>• Hydrogen for energy storage<br>• The hydrogen economy and sector-coupling<br>• Power to gas/x and NG network<br>• Hydrogen and fuel cells as UPS systems<br>• Hydrogen and fuel cells in energy supply of householders<br>• Energy and hydrogen corridors<br>• Aspects about safety, critical infrastructures and environmental impact of the energy system |

| 1 | **Course Title** | **Fuel cell electric vehicles** |
|---|---|---|
| 2 | Rationale for Introduction | With fuel cell electric vehicles (FCEVs) such as the Toyota Mirai and Honda Clarity recently hitting the market, it is clear that there will be a growing demand for educational content centred on FCEVs. Since FCEVs are a relatively new and emerging technology, little knowledge and expertise exist in industry. This module aims to fill the gap in knowledge surrounding FCEVs which will be of particular interest to technicians and engineers operating in the transport and automotive sector. |
| 3 | Module Description | This module will aim to cover some of the following topics:<br>• The transport sectors<br>• FCEV basics<br>• High and low pressure components<br>• High voltage components<br>• FCEV architecture<br>• FCEV maintenance |

## References


[1] HyWays, “HyWays - Member States’ Report,” 2008.
[2] Expert Working Group, “Strategic Energy Technology Plan Study on Energy Education and Training in Europe,” 2014.
[3] “D1 2 Survey Analysis_Final.” .