Green Skills for Hydrogen

Hydrogen is a key pillar of the EU's strategy to achieve its 2050 decarbonisation goals. The rapid development of the European Hydrogen Value Chain over the coming years is expected to generate approximately 1 million highly skilled jobs by 2030, and up to 5.4 million by 2050\(^1\). This growth presents a significant economic and environmental opportunity for Europe, but it also creates considerable labour market challenges.

The European Hydrogen Skills Alliance “Green Skills for Hydrogen” is a four-year project, started in July 2022, bringing together partners from 15 European countries and funded under the EU’s Erasmus+ programme. The primary objective is to design and implement a highly innovative, effective, and sustainable Hydrogen Skills Strategy for Europe that will ensure the skills needs of the rapidly expanding and evolving Hydrogen Value Chain can be met in the short, medium, and long term. It will also generate a blueprint to address the skills need of workers in Declining Sectors and Transition Regions to provide them with upskilling and reskilling opportunities within the hydrogen sector.

Green Skills for Hydrogen will establish a long-term partnership between Industry and Education. It will design an innovative and sustainable Hydrogen Skills Strategy. It will develop, test and roll-out of VET curricula and training programmes in line with latest market needs and consistently linked with EU instruments and tools. It will foster continuous skills and career development that empower technical professionalism in both green and digital competencies. Finally, it will disseminate and rollout the VET training to maximise European impact.

The European Hydrogen Skills Alliance

Green Skills for Hydrogen is an Alliance of Hydrogen sector actors led by Karlsruher Institut für Technologie (KIT), Hydrogen Europe and Hydrogen Europe Research, bringing together key Industry and Education stakeholders from across the sector. Its composition is presented in the following table.

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\(^1\) Source: Hydrogen Roadmap Europe, FCH-JU, 2019
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Deliverable D2.2: “European Hydrogen Skills Strategy”

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1. Definitions

The definitions are based on the content provided by the CEDEFOP terminology\(^2\), by the European Commission\(^3\), as well as by commonly found information.

**FCH**

Fuel Cells & Hydrogen, encompassing all technologies of hydrogen, from generation to usage.

**ESCO**

ESCO is the multilingual classification of European Skills, Competencies, and Occupations. The ESCO classification identifies and categorises skills, competencies, and occupations relevant for the EU labour market, education and training. This standard unified system allows different actors to use ESCO for services like matching jobseekers to jobs on the basis of their skills, suggesting trainings to people who want to reskill or upskill etc.

**Occupational profiles**

An occupation is a grouping of jobs involving similar tasks and which require similar skills set. Occupations should not be confused with jobs or job titles. While a job is bound to a specific work context and executed by one person, occupations group jobs by common characteristics\(^4\).

**Skills**

Skills means the ability to apply knowledge and use know-how to complete tasks and solve problems.

**Competence**

Competence means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.

**Qualifications**

Qualifications are the formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards.

**Initial education**

General or vocational learning carried out in the initial education and training system, usually before entering working life.

**RTO**

Research and technology organisation.

**KPI**

Key performance indicator.

**SRIA**

Strategic and Research Innovation Agenda.

**Continuous education**

Any formal or non-formal learning (general, specialised or vocational) undertaken after initial education and training – or after entry into working life – which aims to: improve or update knowledge, know-how, skills or competencies (upskilling); acquire new skills for a career move (retraining / reskilling); ensure personal or professional development.

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\(^3\) The European Skills, Competencies, Qualifications and Occupations ESCO part of the Europe 2020 strategy.[ Esco (europa.eu)](https://esco.europa.eu) and The Framework for Qualifications of the European Higher Education EQF, Description of the eight EQF levels | Europass

European Qualification Framework (EQF)

European reference tool for the description and comparison of qualifications developed at national, international or sectoral level. It consists of eight levels of qualifications, expressed as learning outcomes (knowledge, skills and responsibility and autonomy) with increasing levels of proficiency. They serve as a translation device between different qualifications systems and their levels. The age of learners and the length of an EQF may vary from one country to another. For initial education the ranking in Figure 1 is proposed. In continuous education, EQF are not consistently applied.

Vocational Education and Training (VET)

Learning which aims to acquire knowledge, know-how, information, values, skills and competencies – either job-specific or transversal – required in specific occupations or more broadly on the labour market (CEDEFOP, Terminology of European education and training policy). VET education can be part of continuous education as well as initial education. In initial education, higher VET and lower VET can be distinguished as per the Figure 2.

**FIGURE 1 – EQF EQUIVALENCE IN DEGREES**

<table>
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<td>EQF 7</td>
<td>Masters degree or eq.</td>
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<tr>
<td>EQF 6</td>
<td>Bachelors degree or eq.</td>
</tr>
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<td>EQF 5</td>
<td>Short-cycle tertiary education</td>
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<td>EQF 4</td>
<td>Post-secondary non-tertiary education</td>
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<tr>
<td>EQF 3</td>
<td>Upper secondary education</td>
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<td>EQF 1</td>
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FIGURE 2 – EDUCATIONAL LEVEL TERMINOLOGY

**Academic studies**
- **EQF 8**: Doctorate
- **EQF 7**: Master
- **EQF 6**: Bachelor

**Higher VET**
- **EQF 7**: Vocational Master
- **EQF 4, 5, 6**: Vocational Bachelor and Advanced Vocational Programmes

**Lower VET**
- **EQF 3, 4**: Upper secondary programme
2. Executive Summary

A trained and skilled workforce is a prerequisite for achieving the EU’s objectives of scaling up local clean hydrogen production and establishing resilient hydrogen ecosystems. It is estimated that 1 million jobs will be created by the hydrogen value chain by 2030. In years ahead there will be a lot of pressure to train and skill people to take on jobs in this growing sector. The first step in this undertaking is to understand what the needs of the industry are and what training programmes are already being offered across Europe.

The Green Skills for Hydrogen project has collaborated closely with hydrogen stakeholders across the EU to comprehensively understand, document, and outline the existing and future demand for hydrogen-related occupational profiles. The aim is to identify the occupational profiles in high demand, assess the characteristics and intensity of this demand, and analyse the required level of “hydrogen knowledge” of these profiles.

The occupational profiles facing significant demand and encountering difficulties in recruitment predominantly lie within technical domains. Demand for engineers and technicians specialising in chemical processes, industrial engineering, health and safety, and high-voltage electricity is particularly high, coupled with an acute shortage of qualified individuals within these professions. Additionally, the development of other clean energy sectors, such as solar and wind power, has increased competition for professionals with experience in electricity systems. Many countries are already experiencing shortages of technicians across various sectors. Project managers capable of overseeing projects from inception to construction also prove challenging to find, largely due to the extensive experience and expertise required to handle hydrogen-related risks in such positions. Furthermore, within the public sector, a notable absence of knowledge and experience in approving and authorising hydrogen projects hinders the timely deployment of hydrogen technologies and infrastructure.

The skills and knowledge required for occupational profiles in the hydrogen sector can be categorised along three dimensions:

1. **Level of hydrogen knowledge**: The highest level of hydrogen knowledge is usually attained through the acquisition of a specialised degree in hydrogen or a related discipline such as gas systems; or through substantial track record of practical experience. These profiles typically encompass technical engineering roles, top management positions, as well as executives and legal personnel who require in-depth knowledge of hydrogen.

2. **Transversal skills and knowledge**: These are cross-cutting themes that are essential across a wide range of occupational profiles. They encompass understanding hydrogen risks and safety; knowledge of regulations and authorisations related to hydrogen projects; comprehension of hydrogen systems and integration with renewable systems; and expertise in the maintenance of hydrogen equipment and facilities.

3. **Specialised skills and knowledge**: This category includes specialised expertise in hydrogen production, transport, storage, operation of equipment and facilities, electrolyser, fuel cells, and hydrogen refuelling stations. The complexity of the hydrogen industry lies in the intertwining of various disciplines and energy systems such as chemical, industrial and electrical engineering, along with gas, electricity and renewable energies. Specialised technical knowledge comes as an additional requirement for workers with another primary expertise.
In addition to analysing industry’s demand for occupational profiles, availability and format of training programmes related to hydrogen was also assessed. As it stands, on-the-job learning and short training courses delivered by external providers are common practices for companies to train their staff on hydrogen. Over the past decade, the number of specialised programmes in hydrogen and fuel cells in initial education has increased, primarily at the Master’s level. This growth is not yet reflected in the current composition of the hydrogen workforce where most workers were trained in another discipline than hydrogen. Modules on fuel cells and hydrogen are increasingly being introduced across degrees, highlighting the interdisciplinarity of the hydrogen sector. Short programmes for specialists are identified as missing from training offers in initial education. Looking at continuing education, higher-level non-technical training targeted at decision makers are easy to find. Tailor-made trainings are a common practice in the hydrogen sector, however, the capacity of training providers to offer such training on a large scale is limited.

In terms of content taught, safety and practical education are considered as fundamental in the education delivered to technical profiles. Access to infrastructures to operate in conditions close to real life is highly valued. It is important to note that the availability of both initial and continuing education programmes and training on hydrogen vary significantly from one country to another.

Common challenges to the establishment of training and education on fuel cells and hydrogen can be identified across Europe. Among them, the lack of qualified trainers and teachers and the costs associated with equipment and infrastructures needed to provide practical education have been highlighted by a majority of training providers interviewed. Additionally, uncertainty regarding the expected demand from both industry and students, as well as the length of the process to adapt certain educational pathways, can deter or delay the update of training and/or the development of new offers.

On the other hand, company commitments or large-scale projects, such as hydrogen valleys, are a clear driving force to the development of training, as they create demand and career opportunities. The best practices identified are supported by policy incentives and/or funding from public authorities and industries. Collaboration between stakeholders fosters economies of scale, building on the expertise of various partners and limiting the financial and human costs often seen as barriers. Not surprisingly, internal expertise, access to equipment, labs, and infrastructures contribute to convincing training providers and companies to develop training offers on hydrogen to capitalise on their knowledge.

To effectively educate, upskill and reskill individuals and address the needs of the hydrogen sector, a set of six strategic axes are proposed for consideration:

1. **Develop modular training:** providing a modular training corpus in a flexible, adaptable, and customisable form for different target audiences can help overcome the lack of resources identified by teachers and trainers seeking to develop specialised training. By breaking down complex topics into smaller modules, the training becomes more manageable and easier to comprehend. Key areas of training and delivery methods are identified and discussed as well as a long-term strategy to propose the integration of such a corpus into existing programmes and the development of specialist training.

2. **Define training standards:** setting common European or international training standards to qualify as able to safely work with hydrogen across various work environment will enhance the recognition of qualifications in the sector as well as enable workers mobility.
3. **Improve access to continuing professional development**: continuing education for workers should be facilitated both by public authorities and employers. Whilst this strategic axis is not specific to the hydrogen sector, it is an essential element to allow the scaling up of the sector. Hydrogen industries cannot solely rely on new graduates from initial education to reply to their needs. Up- and re-skilling must take place in parallel to the update of curricula, ensuring that workers have access to continuous learning opportunities to meet the evolving demands of the sector.

4. **Establish an online community**: establishing a central hub and a digital community would serve as a reference for both hydrogen learners and education providers. This hub would provide resources, databases and visibility to existing initiatives and programmes shared by the online community. Embracing a crowd-sourcing model, all stakeholders are encouraged to actively contribute to this online community, enriching the available resources and fostering collaboration among actors in the hydrogen education domain.

5. **Encourage the uptake of European mobility for hydrogen education**: initiating, supporting, and facilitating the mobility of learners and trainers to learn and gain practical experience of hydrogen is key to advance hydrogen education quality and attractivity. Mobility can help overcome the lack of training opportunities available locally and foster the dissemination of skills on a European level.

6. **Promote the attractiveness of the sector**: raising public awareness about the potential of hydrogen technologies and developing a narrative will help build the attractiveness of the sector. Audiences most likely to become tomorrow's hydrogen workforce are particularly targeted in the set of priority actions defined.

The actions foreseen are to be facilitated by various stakeholders, including companies, industries, public authorities, training providers, EU projects, professional organisations, but also by individuals such as teachers, trainers, workers, employers or career counsellors.

The [Green Skills for Hydrogen](#) project, an Erasmus + supported blueprint, will aim to contribute to some of the recommendations outlined above. It will also seek alliances and synergies with other initiatives, such as the future [European Hydrogen Academy](#), in order to implement the actions outlined in the Hydrogen Skills Strategy. These efforts are essential to address the urgent need of preparing the European workforce for the growth of the hydrogen sector.
3. Introduction

With the global transition towards sustainable energy systems driving the European policy agenda, fuel cells and hydrogen (FCH) have emerged as a key solution for decarbonising various sectors, including transportation, industry, and power generation. The adoption of REPowerEU, placing a 10Mt target for domestic production of renewable hydrogen by 2030, and the implementation of targets for the penetration of hydrogen into industry and transports set within the Alternative Fuels Infrastructures Directive and the Renewable Energy Directive, are clear signals of this increased ambition. As the demand for these technologies grows, it is crucial to assess the skills requirements and develop effective education and training programmes to equip individuals with the expertise needed to support the widespread adoption and integration of FCH technologies in the economy.

The European Hydrogen Skills Strategy aims to investigate the skills needs in the FCH industry and provide insights into the current landscape of education and training programmes available to develop these skills in Europe. By identifying the specific skills required for a career in this domain, we seek to bridge the gap between industry demands and educational offerings. Furthermore, the study aims to feed into the European Net Zero Industry Act proposed by the European Commission on 16 March 2023. The Act set the target to enhance skills and manufacturing capacity of net zero technologies, among which are electrolysers and fuel cells. Providing a set of actions to implement a European Hydrogen Skills Strategy will also help to deliver the Hydrogen Academy mentioned in the Net Zero Industry Act, with the goal to skill, upskill and reskill individuals.

As FCH emerge as key components of sustainable energy systems, it is imperative to nurture a skilled workforce capable of designing, developing, and implementing these technologies effectively. Skills development plays a pivotal role in meeting the evolving needs of industries and ensuring a smooth transition to a hydrogen-based economy. By focusing on the acquisition of specialised knowledge and skills as well as technical proficiencies, education and training programmes can prepare individuals for the challenges and opportunities presented by hydrogen and fuel cells.

This study offers a comprehensive analysis of the skills requirements in the hydrogen and fuel cells sector, across the hydrogen value chain. The value chain encompasses actors involved in technical and support activities. They range from equipment manufacturing to authorisation and public bodies. Through engagement of industry’s experts and stakeholders, the project identifies occupational profiles currently employed in hydrogen related activities, occupational profiles currently in high demand, and future demand expectations for hydrogen occupational profiles. The analysis outlines and describes the knowledge and competencies required for each occupational profile in the hydrogen industry. The requirements are based on the feedback from various interviewed actors that cover the whole hydrogen value chain.

Classifying the status of demand for occupational profiles helps identify the priorities and focus that future training offers need to have to alleviate supply shortages. Additionally, it draws a projection of the evolution of the demand with the development of the hydrogen industry and commissioning of projects currently at the study phase. A quantitative measure of the demand of hydrogen occupational profiles is presented in the analysis based on interview results, providing insights on the proportion of training provision. For example, the need for specialised engineers and technicians is far greater than sales and marketing specialists.
This analysis provides a foundation for designing targeted educational programmes that align with industry needs. By examining the current landscape of education and training programmes in Europe on hydrogen and fuel cells, this study will aim to assess where the gaps are and how a more complete training offer could be developed.

Based on the findings of the study, this report presents recommendations and strategies for enhancing education and training programmes on FCH. This includes curriculum development, hands-on training opportunities, industry partnerships, apprenticeships, and lifelong learning initiatives. By aligning educational offerings with industry demands, we can ensure that learners acquire the knowledge, skills, and practical experience necessary to contribute effectively to the hydrogen and fuel cells sector. By fostering collaboration between academia, industry, and policymakers, we can create a skilled workforce equipped to drive innovation and address the challenges of a hydrogen-powered future.
4. Industry needs analysis

4.1 Introduction of findings

Industry’s demand for hydrogen occupational profiles has been identified through an interview campaign covering the whole hydrogen value chain in 19 European countries along with the desk research of the existing publications. Analysis and demand identification incorporated the European Qualification Framework (EQF) and the European Skills, Competencies and Occupational (ESCO) coding, along with the level of hydrogen knowledge requirement for each occupational profile. For further information on the methodology, EQF and ESCO, please refer to Annex 1 – Industry Need Analysis Methodology.

The interview campaign included 93 interviews covering 19 countries and has identified 913 occupational profiles across the whole value chain. The distribution of interviews by countries (see Figure 3 – Distribution of interviews by country below) considers the level of development of the hydrogen ecosystem, giving more focus to countries that have a higher level of sector development. Countries at the forefront such as Germany, France, Italy, Belgium, Spain, Denmark, Sweden and the Netherlands have been extensively covered.

Other countries at early stages of hydrogen ecosystem development or having a limited number of different types of actors have been proportionally covered at a lower level. There are a few exceptions such as Finland, which recently conducted a similar survey. Diversity of occupational profiles demand and differences between countries is explained in the following sections.

The hydrogen value chain representation has been broken down into three groups: Manufacturing, Projects and Support. These three groups include 10 verticals of the hydrogen industry as described in Figure 4 - Distribution of interviewees over the hydrogen value chain. Diverse actors across the hydrogen value chain were present in the interview campaign. Each of these three categories has several types of players that are active in a certain vertical or verticals of the value chain. For example, an equipment manufacturer can be active in electrolyser manufacturing or in hydrogen storage tanks manufacturing. Please note that some players are active in several verticals of the value chain, which explains why the total numbers are superior to the numbers of interviews.
We consolidated over 912 different occupational profiles from the interviews and summarised them into an Excel file, where the ESCO, EQF, status of the profile, skills and competencies associated, H2 knowledge required and qualifications have been attributed according to the feedback of interviewees as illustrated in the example in Figure 5 – Classification of occupational profiles, skills and competencies required.

![Figure 4 - Distribution of interviewees over the hydrogen value chain](image)

**FIGURE 4 - DISTRIBUTION OF INTERVIEWEES OVER THE HYDROGEN VALUE CHAIN**

**FIGURE 5 – CLASSIFICATION OF OCCUPATIONAL PROFILES, SKILLS AND COMPETENCIES REQUIRED**

<table>
<thead>
<tr>
<th>Company activity</th>
<th>Occupational Profile</th>
<th>ESCO</th>
<th>EQF</th>
<th>Status</th>
<th>Skills &amp; Competencies</th>
<th>H2 Knowledge</th>
<th>Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment manufacturer</td>
<td>CEO</td>
<td>112</td>
<td>7</td>
<td>1</td>
<td>Experience automotive, energy sector</td>
<td>1</td>
<td>PhD in chemical engineering</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Chemical engineer</td>
<td>214</td>
<td>7</td>
<td>1</td>
<td>Catalysts, electrolysers</td>
<td>3</td>
<td>Engineering degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Chemical, and innovation</td>
<td>214</td>
<td>7</td>
<td>1</td>
<td>Catalysts, practical experience, innovation to improve efficiencies</td>
<td>3</td>
<td>Engineering degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Electrical engineer</td>
<td>215</td>
<td>7</td>
<td>1</td>
<td>Electrolysers, power electronics</td>
<td>3</td>
<td>Engineering degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Industrial engineer</td>
<td>214</td>
<td>7</td>
<td>1</td>
<td>Manufacturing, assembly hydraulics</td>
<td>1</td>
<td>Engineering degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Supply chain specialist</td>
<td>243</td>
<td>6</td>
<td>1</td>
<td>Supply chain of the H2 industry</td>
<td>3</td>
<td>University degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Welding worker</td>
<td>721</td>
<td>5</td>
<td>1</td>
<td>Welding, fitting, tubing, orbital welding of stainless steel</td>
<td>1</td>
<td>Vocational degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>electrical and electronics</td>
<td>311</td>
<td>6</td>
<td>1</td>
<td>Electrolysers, power electronics</td>
<td>2</td>
<td>Vocational degree</td>
</tr>
<tr>
<td>Equipment manufacturer</td>
<td>Assembly technician</td>
<td>313</td>
<td>5</td>
<td>1</td>
<td>Experience in catalysts, electrolysis</td>
<td>2</td>
<td>Vocational degree</td>
</tr>
</tbody>
</table>
4.2 Occupational profiles in demand

The main hydrogen occupational profiles identified during the interview campaign are classified according to the ESCO framework, see Annex 4 – Limitation of the ESCO Framework. However, the ESCO framework codes do not completely cover the variety of occupational profiles found in the hydrogen sector. This is why an additional description of the occupational profile is provided along the ESCO code.

Hydrogen occupational profiles are grouped into three sets according to the level of their occurrence during the interview campaign. The occurrence reflects demand trends according to interviewees, but the sample is not necessarily representative of the whole market demand.

- **Set 1** represents occupational profiles with the highest occurrence - for example engineering professionals.
- **Set 2** represents occupational profiles with medium occurrence - for example legal professionals and machine operators.
- **Set 3** represents occupational profiles with low occurrence - for example information technology specialists.

**FIGURE 6 – OCCUPATIONAL PROFILES DEMAND LEVEL (OCURRENCE) ACCORDING TO INTERVIEWEES**

<table>
<thead>
<tr>
<th>Occupational Profile</th>
<th>ESCO Code</th>
<th>Occurrence</th>
<th>Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering professionals (excluding electrotechnology)</td>
<td>214</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td>Physical and engineering science technicians, draftsmen, Computer-aided design (CAD) drafter technicians</td>
<td>311</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Electrotechnology engineers</td>
<td>215</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Sales, marketing and public relations professionals</td>
<td>243</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Project managers</td>
<td>210</td>
<td>56</td>
<td>1</td>
</tr>
<tr>
<td>Process control technicians</td>
<td>313</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Physical and earth science professionals</td>
<td>211</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Chief executives, senior officials and legislators</td>
<td>112</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Sales, marketing and development managers</td>
<td>122</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Finance professionals</td>
<td>241</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Administration professionals including public servants</td>
<td>242</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Sheet and structural metal workers, moulders and welders, and related workers</td>
<td>721</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Software and applications developers and analysts</td>
<td>251</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Legal professionals</td>
<td>261</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Finance Managers, Human Resource Managers, Policy and Planning Managers</td>
<td>121</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Chemical and Photographic Products Plant and Machine Operators</td>
<td>813</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Electrical and electronic equipment assemblers</td>
<td>821</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>
### Other Stationary Plant and Machine Operators
- Other Stationary Plant and Machine Operators: 818
- Architects, planners, surveyors and designers: 216

### Electrical and Electronic Trades Workers
- Electrical and electronic trades workers: 741
- Database and network professionals: 252
- Ship and aircraft controllers and technicians: 315
- Ships’ deck crews and related workers: 835
- Information and communications technology operations technicians: 351
- Civil worker: 712
- Heavy truck and bus drivers: 833

Engineering, technical and process related occupational profiles are by far the most mentioned by hydrogen industry stakeholders, followed by project managers, sales and marketing, and senior officials and professionals. Examples of occupational profiles often mentioned are chemical, industrial, electrical, electrolysers, fuel cells, automation, system and process engineers. Technicians in similar disciplines are also frequently mentioned, in addition to operations and maintenance positions. Managers, communication specialists, planners, developers and permitting specialists are also part of Set 1. A snapshot of the occurrence for each occupational profile is detailed in Figure 6 – Occupational profiles demand level (occurrence) according to interviewees based on their corresponding ESCO profile code.

**Furthermore, hydrogen occupational profiles are categorized into the following categories based on their status:**

- **Current**: profiles currently employed in hydrogen related functions
- **Missing**: profiles that are currently hard to find due to the demand exceeding the available supply
- **Future**: profiles that will be in demand in the future to support the hydrogen industry

**Annex 6 – Lists of Current, Missing and Future Hydrogen Occupational Profiles** Profiles list the occupational profiles identified according to their status – current, missing and future. Some profiles are found across all three categories such as “chemical process engineer”. This profile is currently in high demand for diverse roles across the hydrogen industry and will still be relevant in the future. Profiles with prior experience in the hydrogen industry are particularly hard to find. Some profiles like “maintenance technicians” and “hydrogen refuelling stations operators” will be in high demand in the future with the roll-out of refuelling stations and hydrogen production plants. Although currently there are not many technician-level positions in the hydrogen sector, these profiles are hard to find due to the competition with other industries.
The term ‘missing occupational profiles’ refers to profiles that are difficult to find in the market. These profiles could also be occupations that are in high demand. As for the missing occupational profiles, various engineering functions are facing market shortages, especially electrical and chemical engineers that are required throughout the hydrogen value chain, along with supporting technical functions performed by technicians. Other missing profiles include sales and marketing,
economists and project management roles. The hydrogen industry is competing to attract similar occupational profiles as in other energy and industrial sectors, for example in renewable energies. Moreover, in some countries, traditional industries absorb high numbers of technicians. This is the case for example with the automotive industry in Czechia. This phenomenon is not unique to this country and applies across Europe. Furthermore, according to the feedbacks received, this trend has been exacerbated by the growing tendency of younger generations to join higher academic education levels or pursue a social science track resulting in further lower supply of qualified technicians. Figure 7 – List of occupational profiles in high demand provides a detailed list of missing hydrogen occupational profiles.

FIGURE 8 – LIST OF MISSING - HARD TO FIND – OCCUPATIONAL PROFILES

<table>
<thead>
<tr>
<th>Missing ESCO Profiles</th>
<th>ESCO Code</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering professionals (excluding electrotechnology)</td>
<td>214</td>
<td>103</td>
</tr>
<tr>
<td>Physical and engineering science technicians, draftsmen, technician</td>
<td>311</td>
<td>37</td>
</tr>
<tr>
<td>Electrotechnology engineers</td>
<td>215</td>
<td>35</td>
</tr>
<tr>
<td>Sales, marketing and public relations professionals</td>
<td>243</td>
<td>14</td>
</tr>
<tr>
<td>Project Managers</td>
<td>210</td>
<td>10</td>
</tr>
<tr>
<td>Physical and earth science professionals</td>
<td>211</td>
<td>9</td>
</tr>
<tr>
<td>Process control technicians</td>
<td>313</td>
<td>9</td>
</tr>
<tr>
<td>Finance professionals</td>
<td>241</td>
<td>5</td>
</tr>
<tr>
<td>Legal professionals</td>
<td>261</td>
<td>2</td>
</tr>
<tr>
<td>Sales, marketing and development managers</td>
<td>122</td>
<td>2</td>
</tr>
<tr>
<td>Software and applications developers and analysts</td>
<td>251</td>
<td>1</td>
</tr>
<tr>
<td>Managing directors and chief executives</td>
<td>112</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>228</strong></td>
</tr>
</tbody>
</table>

In conclusion:

According to the interviews, the high in demand and also hard to find occupational profiles in the hydrogen sector are:

a. Engineering professionals (excluding electrotechnology)
b. Physical and engineering science technicians, draftsmen, technician
c. Electrotechnology engineers
d. Sales, marketing and public relations professionals
e. Project managers
f. Physical and earth science professionals
g. Process control technicians
4.3 Skills needs

The interviews provided several dimensions of skills, competencies and knowledge needs for hydrogen professionals. In our analysis we identified the skills, competencies, and knowledge requirements on a scale from 0 to 3, 3 being the highest level of knowledge required. The level of skills required can then be analysed through different lenses, for example by ESCO profile.

Hydrogen Knowledge

The level of hydrogen knowledge required of each occupational profile differs based on the role and responsibilities of the position. Occupational profiles are categorised into three groups-based hydrogen knowledge requirements from very high (group 1) to low (group 3).

The first group is composed of occupational profiles that require a high level of hydrogen knowledge (“level 3”). This is illustrated in Figure 9 – Level of hydrogen knowledge. This group includes workers with an academic degree in hydrogen or in a related discipline, or workers that have a substantial record of experience in the sector or in a similar domain. The majority of these profiles are managerial or technical engineering profiles; however, the first group also includes executives and legal personnel who must have deep knowledge of hydrogen to be able to fulfil their roles and job requirements. In other words, it is not only engineers who need to be experts in hydrogen, other profiles also require a high level of hydrogen knowledge.

<table>
<thead>
<tr>
<th>Occupational Profile</th>
<th>ESCO Code</th>
<th>H2 Knowledge</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical and earth science professionals</td>
<td>211</td>
<td>2,4</td>
<td>1</td>
</tr>
<tr>
<td>Project Managers</td>
<td>210</td>
<td>2,4</td>
<td>1</td>
</tr>
<tr>
<td>Engineering professionals (excluding electrotechnology)</td>
<td>214</td>
<td>2,2</td>
<td>1</td>
</tr>
<tr>
<td>Chief executives, senior officials and legislators</td>
<td>112</td>
<td>2,1</td>
<td>1</td>
</tr>
<tr>
<td>Architects, planners, surveyors and designers</td>
<td>216</td>
<td>2,0</td>
<td>1</td>
</tr>
<tr>
<td>Electrotechnology engineers</td>
<td>215</td>
<td>1,9</td>
<td>1</td>
</tr>
<tr>
<td>Sales, marketing and development managers</td>
<td>122</td>
<td>1,9</td>
<td>1</td>
</tr>
<tr>
<td>Legal professionals</td>
<td>261</td>
<td>1,8</td>
<td>1</td>
</tr>
<tr>
<td>Sales, marketing and public relations professionals</td>
<td>243</td>
<td>1,5</td>
<td>2</td>
</tr>
<tr>
<td>Finance professionals</td>
<td>241</td>
<td>1,4</td>
<td>2</td>
</tr>
<tr>
<td>Process control technicians</td>
<td>313</td>
<td>1,4</td>
<td>2</td>
</tr>
<tr>
<td>Physical and engineering science technicians, drafts man, CAD drafter technician</td>
<td>311</td>
<td>1,3</td>
<td>2</td>
</tr>
<tr>
<td>Administration professionals including public servants</td>
<td>242</td>
<td>1,3</td>
<td>2</td>
</tr>
<tr>
<td>Other Stationary Plant and Machine Operators</td>
<td>818</td>
<td>1,3</td>
<td>2</td>
</tr>
<tr>
<td>Finance Managers, Human Resource Managers, Policy and Planning Managers</td>
<td>121</td>
<td>1,3</td>
<td>2</td>
</tr>
<tr>
<td>Sheet and structural metal workers, moulders and welders, and related workers</td>
<td>721</td>
<td>1,1</td>
<td>3</td>
</tr>
<tr>
<td>Ship and aircraft controllers and technicians</td>
<td>315</td>
<td>1,0</td>
<td>3</td>
</tr>
<tr>
<td>Ships’ deck crews and related workers</td>
<td>835</td>
<td>1,0</td>
<td>3</td>
</tr>
</tbody>
</table>
Information and communications technology operations technicians 351 1,0
Heavy truck and bus drivers 833 1,0
Software and applications developers and analysts 251 0,5
Chemical and Photographic Products Plant and Machine Operators 813 0,4
Electrical and electronic equipment assemblers 821 0,3
Database and network professionals 252 0,3
Electrical and electronic trades workers 741 0,0
Civil worker 712 0,0

The second group of profiles require a medium level of hydrogen knowledge. This group includes technical and non-technical profiles. Non-technical profiles require a good understanding of hydrogen technology, production and business, whereas technical profiles would require a good understanding of the technologies' specificities as well as a strong understanding linked to the object they are operating on, i.e., storage, operation, equipment manufacturing, maintenance etc. A driver of a hydrogen-powered bus is required to have a general knowledge of hydrogen properties and technology, coupled with good knowledge of hydrogen power train, storage tanks, pressure, risks and refuelling. These skills and knowledge are specific and directly tied to the function of each occupational profile. It is also worth noting that some of these profiles, like process control technicians, are in very high demand according to the interview analysis.

The third group of profiles requires no or a low level of hydrogen knowledge, corresponding to a couple of hours to a couple of days training to learn the basics of hydrogen. Examples of profiles within this group include information technology specialists, software engineers, some assemblers and machine operators, as well as certain administrative jobs. Hydrogen doesn’t change the nature or the activities of these jobs.

Key Thematic Skills and Knowledge Domains

The skills and knowledge required are identified across various roles in the value chain.

Figure 10 – Main thematic skills and knowledge requirements below provides an overview of the thematic areas of skills and knowledge frequently in demand. These skills and knowledge can be classified into two groups:

- **Cross-cutting themes**: required by a wide-range of occupational profiles
- **Technology or function focused themes**: specific to a certain activity or function
FIGURE 10 – MAIN THEMATIC SKILLS AND KNOWLEDGE REQUIREMENTS

<table>
<thead>
<tr>
<th>KEY THEMATIC SKILLS &amp; KNOWLEDGE</th>
<th>CROSS-CUTTING</th>
<th>OCCURRENCE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td></td>
<td>103</td>
<td>11%</td>
</tr>
<tr>
<td>Hazards</td>
<td>Yes</td>
<td>87</td>
<td>10%</td>
</tr>
<tr>
<td>Systems</td>
<td>Yes</td>
<td>61</td>
<td>7%</td>
</tr>
<tr>
<td>Operation</td>
<td></td>
<td>57</td>
<td>6%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Yes</td>
<td>57</td>
<td>6%</td>
</tr>
<tr>
<td>Electrolysis</td>
<td></td>
<td>57</td>
<td>6%</td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td>55</td>
<td>6%</td>
</tr>
<tr>
<td>Fuel cell</td>
<td></td>
<td>55</td>
<td>6%</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td>44</td>
<td>5%</td>
</tr>
<tr>
<td>Refuelling</td>
<td></td>
<td>29</td>
<td>3%</td>
</tr>
<tr>
<td>Legal &amp; permitting</td>
<td>Yes</td>
<td>23</td>
<td>3%</td>
</tr>
</tbody>
</table>

Priority Cross Cutting Knowledge Domains:

The analysis has revealed that several areas of hydrogen knowledge are critical requirements of many occupational profiles regardless of their function. These areas are cross-cutting and impact the responsibilities of technical and sometimes non-technical professionals. These main cross-cutting themes are:

1. Health, Safety and Hazards related to hydrogen
2. Legal aspects, regulation and permitting of hydrogen projects and
3. Hydrogen system components and integration with renewable energy

A detailed list of the occupational profiles requiring the *cross-cutting* and *technology focused* themes identified is outlined in Annex 7 – Target Audience of the Main Hydrogen Skills and Knowledge. Additionally, content elements needed for these thematic skills are also identified based on the qualification requirements highlighted by interviewees.

For example, in Figure 11 – Hydrogen safety and hazards target audience, you can find a list of target occupational profiles and proposed content for hydrogen safety, risks, and certification. Additionally, proposed content is identified in Figure 12 – Hydrogen safety and hazards module proposed content below.
FIGURE 11 – HYDROGEN SAFETY AND HAZARDS TARGET AUDIENCE

Hydrogen Safety and Hazards Target Audience

ESCO 112
• Senior executive manager

ESCO 132
• Senior operational manager
• Senior technical manager

ESCO 214
• Health, and safety design engineer
• Design engineer
• Safety and occupational hazards engineer
• Marine engines expert
• Production, supply engineer
• Risk and safety professional
• Environmental, health and safety specialist
• Design engineer
• Marine engineer
• Project engineer
• Risk and safety professional
• Gas facilities construction Project manager
• Specialist in compression and safety
• Chemical engineer
• Safety construction, operation engineer
• Gas facilities construction Project manager
• Expert in H2 hazards and safety in industrial facilities

ESCO 215
• Electrical engineer
• Automation engineer

ESCO 216
• Naval architects

ESCO 241
• Financiers and modelers
• Local public servants responsible for projects validation

ESCO 243
• Communication specialist

ESCO 261
• Legal and regulations specialist
• Lawyer

ESCO 311
• Health, and safety technician
• Maintenance technician
• Safety technician
• Health and safety technician
• Commissioning technician
• Certifications specialist
• Risk and safety technician

ESCO 313
• Operations technician
• Maintenance operator
• Operation and maintenance of electrolysers technician
• Refuelling stations technician

ESCO 721
• Mechanical fitter
• Metal carpenter
• Pipefitter
• Welder

ESCO 741
• Electrical fitter
• Instrumentation fitter
• Mechatronic worker

ESCO 811
• Plant and machine operator
• Plant operator

ESCO 818
• Refuelling stations operator

ESCO 821
• Assembly line operator

ESCO 835
• Lock operator

FIGURE 12 – HYDROGEN SAFETY AND HAZARDS MODULE PROPOSED CONTENT

Hydrogen Safety and Hazards Module Proposed Content

• Basic understanding of hydrogen gas, mechanical precision, risk assessment and safety aspects
• Hazards and safety of hydrogen production, distribution, storage and refuelling
• Risk, hazards and safety procedures of hydrogen production, storage and transport
• Project safety planning and analysis, process safety, failure simulation
• Legal framework and approval of hydrogen projects and safety standards
• Hazards and safety of high voltage equipment, monitoring and control
• Risk, safety, regulation, certification, and approval of industrial hydrogen projects
• High pressure equipment, power electronics, norms and standards of gas facilities
• Explosion, jet fire modelling, testing, test facility management, deep knowledge of
• Safety using ammonia in refuelling vessel, ammonia and methanol-powered engine
• Refuelling stations, safety, hydrogen production technologies
4.4 Diverse situations across Europe

Countries do not have the same demand for occupational profiles, the type and volume of demand differs from one country to another based on several factors. The main driver of demand is the level of maturity and diversity of the hydrogen ecosystem in the country. For example, France and Germany have well-established hydrogen ecosystems that cover the whole value chain from equipment manufacturing to project development and construction. This is reflected in a high and diverse demand for all hydrogen related functions. At the other end of the spectrum, there are countries that do not have a well-established hydrogen ecosystem. They are just starting to mobilise their resources and to identify how to advance the industry. In this case current demand is either non-existent or concentrated around very highly qualified positions of experts who work on research and development or on initiating new projects on hydrogen. The demand in these countries will eventually evolve once projects progress into the construction and operation phases, however, it is not foreseen to be similar in the type and number of occupational profiles required in countries with a diverse ecosystem that has a lot of equipment manufacturing and product development. Countries like Romania, Czechia, Slovakia and Bulgaria currently have opportunities and are looking for hydrogen experts who can lead research and development projects in this nascent industry.

### In conclusion:

Profiles that require the highest level of hydrogen knowledge and competencies according to the ESCO classification are:

1. Physical and earth science professionals
2. Project Managers
3. Engineering professionals (excluding electrotechnology)
4. Chief executives, senior officials and legislators
5. Architects, planners, surveyors and designers
6. Electrotechnology engineers
7. Legal professionals

Key thematic skills and knowledge identified by the industry as the most relevant can be classified into two areas:

**Cross-cutting competencies that include:**

I. Health, Safety and Hazards related to H2
II. Legal aspects, regulation and permitting of H2 projects and
III. Hydrogen system components and integration with renewable energy
IV. Maintenance of hydrogen equipment and production facilities

**Technology and activity specific competencies and knowledge that include:**

I. Hydrogen Production, storage and transport
II. Fuel cells, electrolyser technology
III. Hydrogen in mobility application and refuelling stations
IV. Operation and maintenance of hydrogen equipment and facilities
development in academic institutions or lead the planning and development of projects. In this case, there is not yet a demand for technicians or operators.

The nature of how the country strategically positions its industry also plays a decisive role in the type of occupational profiles required. For example, Denmark has developed its Power2X – hydrogen strategy – based on its strategic advantage of having a surplus of wind energy capacity that can be leveraged to produce green hydrogen. However, due to the low local demand, Denmark's strategy is targeted towards export. Occupational profiles demanded are linked to hydrogen storage, bunkering, marine infrastructure, ship refuelling as well as international project developer and regulations experts. Other examples are Ireland and Portugal where the ecosystems are nascent with no large industrial demand for hydrogen – according to interviewees – influencing the type of occupational profiles required. Demand is characterised by PhD and researchers who work on academic and research institutions and project developers. Interviewees mentioned that the hydrogen industry will evolve around final utilisation mainly in mobility applications. This would mean demand for refuelling stations operators, design, construction and maintenance of these facilities and other supportive activities.

The demand for qualified technicians is cited as either an existing or future concern in many countries. Large countries, or those with developed ecosystems, highlight the difficulty to find and recruit qualified technicians and foresee future shortages with scaling-up the hydrogen industry. Although this is the case in Germany, Netherlands and Sweden for example, it is not the same in Spain. Despite being a large economy with a large and diverse hydrogen ecosystem, interviewees didn’t find difficulty hiring technicians and don’t believe that technicians’ profiles will be missing in the future.

**FIGURE 13 – COUNTRIES’ STATUS OF HYDROGEN OCCUPATIONAL PROFILES DEMAND**

<table>
<thead>
<tr>
<th>Status</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly qualified profiles, PhD holders and experts</td>
<td>Ireland, Portugal, Czech, Greece, Estonia</td>
</tr>
<tr>
<td>Current and/or future supply shortage of technicians</td>
<td>Austria, Belgium, Germany, Italy, Netherlands</td>
</tr>
<tr>
<td>Project development, operation and utilisation</td>
<td>Ireland, Portugal</td>
</tr>
<tr>
<td>Diverse demand of all professions</td>
<td>German, France, Belgium, Sweden, Netherlands, Spain, Italy</td>
</tr>
<tr>
<td>Not enough information</td>
<td>Other countries</td>
</tr>
</tbody>
</table>

*Please note that this analysis is only based on the conducted interviews, and it is not perfectly representative to the country status and ecosystem demand.

4.5 Solutions from market players to address skills gaps

The interview campaign has revealed several strategies that hydrogen market players employ to tackle the absence or limited supply of qualified hydrogen workers. On a national level, countries like Finland have developed a collective and collaborative hydrogen training programme following the work undertaken by FITECH. This project integrates diverse market players and service providers in developing a hydrogen training programme and making it widely accessible. Some market players like the port of Antwerp, SIEMENS, SYMBIO Academy, PKN ORLEN and EUROMEKAŃIK have launched their own hydrogen academy to train their employees, with the possibility to make trainings accessible to externals. Other companies hire external training providers to train their employees, however many expressed limited availability of external
hydrogen trainings. In other cases, partnerships with universities were developed to address specific demand. Another strategy is collaborative partnership between companies and providers to co-create specialised programmes. One example is MASSYHLIA\(^5\), a project that groups three large companies ENGIE, TOTAL Energies and RTE who, in collaboration with Bureau VERITAS, developed a specialised academy on Safety and Risks of hydrogen to train their employees.

**Conversion of workers** from the oil and gas sector, petrochemicals or other similar domains to work with hydrogen is widely considered as a viable alternative to the shortage of experienced hydrogen occupational profiles. These sectors involve similar job requirements and functions, as well as academic or technical specialisation. Engineers, technicians and project managers in these sectors can easily be converted to work on hydrogen. Additionally, many oil, gas and petrochemical companies already use hydrogen produced from coal or natural gas and have considerable experience in the domain. Upskilling these profiles to work with green hydrogen produced by electrolysis is currently a viable solution. Additionally, there are profiles engaged in hydrogen usage application that need to understand hydrogen regardless of its origin – grey, blue or green. The difficulty faced by these market players is linked to the nature of their core business, chemical processes. They do not have problems finding managers, engineers and technicians in industrial processes, compression, safety and operation, but they lack new functions like high voltage or electrolysis engineers and technicians that are critical to their transition to green hydrogen. Each industry has its own specificities when it comes to demand of hydrogen profiles. Existing base of hydrogen profiles for oil and gas company is different from an electricity company. As such, the potential to upskill certain profile and challenge finding certain profile are case specific.

**External hiring** is adopted by companies that can’t find the required profiles internally in the company. This can go even beyond the borders of the country when the supply is either not sufficient or doesn’t meet the required skills and competencies to work with hydrogen. Market players in the Netherlands, Sweden, Austria and Belgium mentioned hiring profiles from other countries to fill the gap and meet their demand for profiles that they have difficulty finding locally.

\(^5\) [https://www.concertation-masshylia.fr/]
5. Status of education on hydrogen in Europe

The literature reveals that despite some commonalities, there is a wide diversity of Vocational Education and Training (VET) systems across Europe, with "30 (or more) genuinely national approaches to VET." Therefore, for European projects aimed at addressing various European VET systems, it is crucial to incorporate flexibility into the development of training content. This flexibility would enable VET providers to adapt the training to meet their specific local requirements. One way to achieve this flexibility is by developing modular training, which would provide the option to use modules independently or in combination.

The concept of VET in Europe is evolving. VET was initially perceived as predominantly geared towards providing occupation-specific education to young individuals, typically at EQF levels 3 and 4. However, recent analyses have highlighted the evolving nature and emerging trends in VET. A growing diversification in terms of the targeted audiences and the EQF levels covered can be seen. VET programmes are no longer limited to students in initial education at EQF levels 3 and 4; adults and individuals from different educational backgrounds are now becoming students.

"It can be expected that by 2030 national qualification frameworks in most EU Member states will be firmly established thereby organising a diversity of vocational qualification ranging from EQF level 1 to 8 (...) the heartland of VET will have certainly shifted from EQF level 3 to level 4 and 5 and the increase of adult learners in VET will somewhat weaken the prevalent idea of VET mainly signifying IVET."

The concepts of "hybridization of VET and general education" and of "vocational drift in education" have been introduced to capture the blurring boundaries between VET and general education, which were traditionally perceived as separate educational systems. Hybridisation entails a shift in VET towards a less specialised education, incorporating broader knowledge similar to that provided in general education. Simultaneously, vocational drift translates the growing inclusion of work-based learning within general education. Dual programmes, internships, apprenticeships, and project-based learning are increasingly integrated into general education curricula. The distinctions are not as clear in practice, and this plays a role in designing new programmes and training that will deliver the needed skills for a hydrogen workforce.

Focusing on hydrogen in education and training, the Strategic Energy Technology (SET) Plan Study on Energy Education and Training in Europe published in 2014 can be used as a reference to assess the evolution of educational offers and training activities. The study emphasises the significance of research-based education in 2014: both Marie Skłodowska-Curie actions, and the COST actions (European Cooperation in Science and Technology) are

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specifically designed to promote the training and mobility of researchers. Furthermore, **European projects are driving the development of educational offers:** 21 occasional training modules catering to workers are listed, and approximately one-third of them are provided as part of European projects.

**Regarding initial education, the focus solely revolves around academic pathways, as no VET programme is mentioned.** The study draws a distinction between modules and full programmes. It identifies 20 universities or schools offering 37 postgraduate-level modules on fuel cells and hydrogen. Only two universities provide modules for undergraduate studies. Additionally, only eight educational programmes on FCH are listed, and they are available in only two countries (Denmark and the UK), exclusively at the postgraduate level.

**The development of a comprehensive education and training offering on fuel cells and hydrogen faces several barriers** which have been identified in the report as follows: (a) a lack of local expertise, (b) inadequate connections between educational curricula, industry, and policy requirements, (c) a lack of a comprehensive understanding of industrial needs, and (d) the absence of a coordinated European strategy. Additionally, the absence of a systematic and coordinated follow-up to European projects was also identified as a significant gap.

The study conducted as part of the SET Plan was the most comprehensive study found at European level on FCH education. Given the increased ambitions for the hydrogen sector at both European and national levels, it is sensible to undertake a new analysis in order to align with these new aspirations. **Comparing the insights of 2014 to the ones of 2023 allow us to monitor trends and evolutions in the past nine years.** To complement information gathered through desk research, 53 interviews were carried out with stakeholders from 20 European countries (Figure 14 – Country coverage of interviews, Figure 15 – Distribution of interviews by country), as well as organisations with a European or an international scope. Further insights were shared by 10 organisations in informal discussion outside the scope of the interview guide.
Interviews were conducted with representatives from various organisations, as indicated in Figure 16 – Distribution of interviews by categories. Each interviewee was categorised based on their primary affiliation, even if they were involved in multiple settings (e.g., national association). The category of “Initial VET provider” encompasses colleges, universities of applied sciences, and other national VET institutions. The category of “Public authority” includes regional or national agencies and authorities.

The limitations of the interview campaign stem from the inability to cover all European countries. Nevertheless, the insights collected have proven valuable to assess the overall situation on a European level. It is worth noting that while the representativeness of the organisations contacted could be enhanced, it does reflect the current landscape of those involved in providing training on fuel cells and hydrogen in Europe. The main findings of the research are detailed in the following sections.
5.1. Education of current employees in the hydrogen sector

To understand how workers in the hydrogen sector are being trained in Europe we first examined where current employees received their training. This analysis incorporates data from the interview campaigns to industry stakeholders and training providers.

As shown on Figure 17 – Training of current workers in the field of hydrogen, on-the-job training emerges as one of the most common methods to train workers. Some companies have taken action to address the need for training by developing their own training academies. These academies offer modular training content for staff at all levels and for both technical and non-technical profiles. The programmes are sometimes offered to external beneficiaries as part of expansion efforts. Examples of companies engaging in this path are Symbio, Siemens and PKN Orlen. The lack of external training offers tailored to their needs was often quoted as a reason for developing internal academies, as detailed in the section 4.10.

Furthermore, companies also make use of short practical training courses offered by external providers. Several companies mentioned that they commissioned the services of external providers to train their employees and address specific technical areas related to hydrogen. On-the-job training adapted to a company’s needs and lasting from a couple of hours to several days is a popular choice in the sector. These training courses can be tailored to the specific needs of the company or provided as standardised catalogue courses, indicating they are listed and described in the institution course catalogue. Various types of providers, including research and technology organisations (RTOs), universities, private training providers, and companies themselves, offer these programmes. Among external offers provided “in catalogue”, as part of a regular and listed offer from a provider, Kiwa’s offers can be quoted as an example. A one-day
training is proposed in the UK on hydrogen and the Natural Gas Network. The training takes place in a classroom and is targeted at professionals working in the gas and appliance industries.

Short knowledge-based trainings delivered by external providers are similar to the ones described above but are less specialised. These programmes do not aim to target specialists; instead, they focus on decision-makers or managers seeking a general understanding of the opportunities, risks, and challenges associated with the hydrogen sector. For example, the French school for energy and health technology (INSTN) provides a regular two-day training on the hydrogen industry, targeted at any professional taking part, or likely to take part, in an industrial development project, an R&D programme, or promotion or dissemination linked to the hydrogen sector.

Doctorates currently play a significant role within the hydrogen workforce. The strong research and innovation characteristics of the hydrogen market leads to a high demand for doctorate profiles to fulfil tasks that are not yet standardised and integrated in industrial processes. At Master level, the limited availability of specialised Master’s programmes on fuel cells and hydrogen contributes to the scarcity of graduates with such specific expertise. As a result, graduates with a Master of Science degree are more prevalent in the workforce than graduates with specialised degrees on hydrogen.

Although they currently do not offer a high level of specialisation in fuel cells and hydrogen, higher VETs programmes serve as a source of workers. This holds true for bachelor’s degree programmes as well, where specialised knowledge in FCH is not extensively provided.

The investigation conducted by SNAM supports this point. By examining the background of the 40 workers in their decarbonisation unit, which focuses on hydrogen and carbon capture and storage, SNAM found that the majority of employees (75%) hold a Master of Science, while 15% hold PhDs. The employees primarily have engineering backgrounds, encompassing a diverse range of specialties, but none of them specialised in hydrogen and fuel cells through their degree.

**FIGURE 18 – STATISTICS ON THE QUALIFICATIONS OF EMPLOYEES IN A COMPANY UNIT WORKING WITH HYDROGEN**

*Energy, Nuclear, Management, Mechanical, Chemical, Civil, Environmental
Source: SNAM, Decarbonisation Unit
In contrast, internships and apprenticeships serve as valuable resources for companies to train young workers in the specifics of hydrogen while allowing them to pursue studying a broader field in parallel. These opportunities enable companies to develop the necessary skills and knowledge among young professionals, aligning their training with the specific requirements of the hydrogen sector.

**In conclusion:**

- On-the-job training and short practical training offered by external providers are prevalent methods to train workers in the hydrogen sector.
- Graduates or postgraduates specialised in hydrogen are not common in the workforce. Instead, workers typically hold a Master of Science degree in one of the disciplines related to Hydrogen and its applications.
- Internships and apprenticeships provide young workers and students with the chance to gain specialisation on FCH by learning on the job while pursuing their degrees simultaneously.

**5.2. Assessment of fuel cells and hydrogen topics in educational offerings**

To facilitate the assessment of educational offerings, initial and continuing education will be considered separately as the actors and mechanisms to introduce training are sometimes different. A comparative analysis of offerings in the European countries covered is then proposed. A valuable reference tool for assessing the development of educational programmes will be the key performance indicators (KPIs) established by the collaborative efforts of the European research and industry community within the Clean Hydrogen Partnership. With the inception of this partnership in 2020, a Strategic and Research Innovation Agenda (SRIA) was formulated, outlining a roadmap with defined objectives and KPIs to be accomplished within the next decade (Figure 19 – KPIs for education and public awareness set out in the Clean Hydrogen Partnership SRIA). These objectives provide a reference framework to compare the development of educational offers with the targets.
5.2.1. Hydrogen in initial education

This section covers all levels of education with an emphasis on higher levels of education, as they present programmes in which FCH could be integrated as part of the curriculum.

When looking at higher education, two distinctions can be made:

- **VET vs. Academic education:** academic degrees typically have a research-oriented focus, while VET programmes tend to have a more practical approach. It is true that the distinction may not be as clear-cut nowadays, however, educational institutions involved in providing training often remain different. It is worth noting that universities of applied sciences are categorised under VET.

- **Modules vs. Full programmes:** the differentiation between modules and full programmes aligns with the 2014 SET Plan study presented in the methodology. Modules are provided over a semester for a certain number of credits, whereas full programmes encompass several modules and grant a degree.

The Figure 20 – Occurrence of hydrogen and fuel cells in initial education presents an assessment on the status of fuel cells and hydrogen education in initial education today, looking at the frequency and the type of activities proposed. EQF levels can be covered in different categories as their attribution to a certain educational level varies from one country to another.
The main trends on how the topic of FCH is being integrated into initial education are captured below. These trends provide a more dynamic perspective that complements the information presented in Figure 20 – Occurrence of hydrogen and fuel cells in initial education.

**Increase of the offer of specialised FCH modules and programmes in higher education**

When looking at higher education, there is a noticeable increase in the availability of courses related to FCH. According to the SRIA report in 2020, there were 12 universities or institutes
offering FCH courses, both as modules and complete programmes. However, based on the information gathered and presented in Figure 22, the coverage has expanded significantly, with at least modules on FCH being offered in 18 out of the 20 countries studied. To better understand this evolution, the European Hydrogen Observatory’s tracking could provide valuable insights.

The demand for technical education on FCH is expected to increase due to the rise of projects, infrastructures, and technologies requiring operation and maintenance expertise. In recent years, several academic degrees with a focus on fuel cells and hydrogen have been introduced, and there are indications that additional educational programmes in this field are being planned or considered. The growing interest in FCH technologies is driving the expansion of educational offerings to meet the rising demand.

Tracking the involvement of pupils is more challenging. The SRIA sets targets to increase general awareness by gradually reaching out to more pupils. Initiatives like HySchools or FCH Go aim to facilitate this process by providing resources for teachers who are not yet familiar with the topic.

The majority of specialised education is available at Master level across a wide range of disciplines

Most of the modules identified on fuel cells and hydrogen are found at Master’s level, however, a few courses at the Bachelor’s level can also be found. The content of these modules is varied. It can be broad, covering the hydrogen value chain and technologies, as well as delving into more specialised topics. Here are a few illustrative examples from the data in the European Hydrogen Observatory:

- Fuel Cell technologies
- Materials for Hydrogen and Fuel Cells Technologies
- Smart energy and Hydrogen management
- Introduction to Electrochemistry and Fuel Cells technology
- Principles of hydrogen safety
- Hydrogen as an energy carrier
- Hydrogen energy systems
- Hydrogen storage in metal hydrides

Depending on the organisation, the modules can be offered as elective courses or integrated into the regular curriculum. A twostep approach first tests interest and checks the new module via elective modules, before integrating it into the programme. A wide range of disciplines found it relevant to integrate hydrogen into their curricula. These disciplines include Energy systems, Electrical engineering, Energy engineering, Mechanical engineering, Construction engineering, Process metallurgy, Marine engineering, Process engineering, Chemical engineering, among others. Additionally, non-technical degrees such as economics, politics, law, or social sciences are proposing case studies and activities on hydrogen, or even consider offering elective modules, as foreseen for the Master of Energy and Climate Law in the University of Groningen.

FCH: a multidisciplinary field of study with cross cutting elements

This highlights the multidisciplinary nature of hydrogen education, a point that consistently emerged during discussions with stakeholders. Indeed, hydrogen can qualify as a multi-physics field intersecting with electricity, gas, liquids, materials, polymers and metals. Ideally, individuals trained to work in the hydrogen sector should possess knowledge across these diverse areas, rather than specialising in one. Currently, companies and research organisations assemble teams consisting of experts from different disciplines. However, an educational approach conceived
for specialists could address the interdisciplinary needs of the sector. This approach would complement the inclusion of fuel cells and hydrogen modules as a module of other specialisation degrees.

Safety was unanimously identified as a fundamental element applicable to all specialisations, requiring, as a priority, its integration into existing curricula. Following the integration of safety considerations, other hydrogen-related topics would then be approached through the specific lens of each specialisation within the degree programme.

The difficulty of grading the level of specialisation of a degree partially including FCH elements was highlighted by some interviewees. A grading system with numbers could be proposed to allow for a quick assessment of the degree of specialisation. This approach was implemented by the French National Research Network on Hydrogen Energy when assessing existing educational offers in France, in 2021, by offering a ranking from 0 to 4 to translate the degree of specialisation.

Several programmes fully dedicated to FCH were also identified. To have a good overview of how hydrogen training offers are conceived, see Annex 9 which compiles all degrees and training dedicated to FCH only that were encountered throughout the research.

*Practical education is a cornerstone of FCH training*

Practical education conducted in laboratories and/or specialised hydrogen infrastructure was identified as a crucial component of a specialist's training. However, challenges related to the limited access to such infrastructures and a shortage of trained personnel to provide adequate training were considered to limit the capabilities. These limitations often restrict the number of students who can be accommodated and enrolled in these programmes.

European consortia such as the HySkills project found it challenging to consistently incorporate practical experience in laboratories or visits in a training implemented across different locations and institutions. They addressed this issue by providing recommendations on how to proceed in the trainers’ implementation handbook, by suggesting experiences, pedagogical materials and visits that could benefit the trainees.

In addition, various approaches are being explored to enhance practical education. One avenue involves integrating information technology (IT) tools to facilitate pre-lab preparation. This allows students to familiarise themselves with the lab procedures in advance, speeding up the actual hands-on experience during in-person sessions. Students can virtually observe researchers working in the lab through video streams and later analyse the experimental data provided. Another solution discussed involves the implementation of mobile labs. This approach aims to minimise costs and enable broader access to educational materials across larger territories, however not always with the same capabilities than other infrastructures.

*Modules or specialised programmes: a complementary approach?*

A gap on the availability of short-duration programmes lasting up to three years and specifically designed to train hydrogen specialists was identified. One Bachelor's degree on FCH was found, whereas the majority of degrees are offered at Master's level. In response to this gap, the development of short non-academic training programmes at higher levels of VET could be proposed, as foreseen in Green Skills for Hydrogen. The primary objective of these programmes would be to equip technicians with the necessary skills to directly enter the job market upon completing their studies. To complement their education, apprenticeships or internships in
companies operating within the sector could be incorporated. **The implementation of such programmes would be particularly valuable in regions where established companies can provide training and job opportunities, such as in hydrogen valleys.** By offering these targeted programmes, individuals would be equipped with the essential knowledge and skills for immediate employment, while the combination of practical training and classroom learning would enhance their overall competency.

In contrast, some stakeholders emphasised the importance of maintaining a broad coverage in the content taught in Bachelor's degrees to avoid premature specialisation and provide students with flexibility to work across different sectors. A majority of stakeholders (14) questioned on whether degrees should focus exclusively on hydrogen or if the introduction of specific modules within existing curricula would suffice considered that both approaches were complementary. A few suggested that modules would be adequate (9). The latter group emphasised the need to avoid an excessive proliferation of specialised programmes and argued that it would be more effective to train workers capable of operating across various renewables or industries, for example. The underlying idea is that different renewable sectors should be interconnected and stand together for education, hence, benefitting from the development of a wide pool of workers with transferable skills.

A balance between both these approaches should be found in order for each country and region to move at their own pace in line with the level of market development and the needs of the sector.

### 5.2.2. Hydrogen in continuous education

The organisation and financing of Continuing Professional Development (CPD) vary from country to country. Depending on the circumstances, funding for training can be provided by the company, the government, or the individual worker through initiatives like individual learning accounts. While accreditation of training providers is often required to access specific funding, it is not always mandatory. The accreditation can be both organised by private and public organisations. Stakeholders generally observed that CPD is more responsive in delivering new content and adapting to market demands than initial education.

The SRIA expects an important increase of trained professionals on FCH by 2030, from 1,000 in 2020 to 62,500 in 2024 and 180,000 in 2030. In order to reach these targets, the training capacity must be scaled up and supported by sustainable funding programmes specifically designed for workers. One may note that the availability of professional training programmes on FCH has been developing and many offers can be retrieved via a simple internet search.

These training programmes are offered by diverse providers, such as RTOs, universities, institutes for professional education or companies with industrial activities. **Figure 21 – Hydrogen training in continuous education** proposes a categorisation of learning objectives and the format of the training depending on the target group being trained. It includes an indicative popularity index of each of the categories identified.
**FIGURE 21 – HYDROGEN TRAINING IN CONTINUOUS EDUCATION**

<table>
<thead>
<tr>
<th>TARGET AUDIENCE</th>
<th>LEARNING OBJECTIVES</th>
<th>FORMAT</th>
<th>POPULARITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decision makers</strong></td>
<td>Understanding and assessing</td>
<td>High level / General short training in person or online provided by RTOs, universities and other training providers.</td>
<td>Popular</td>
</tr>
<tr>
<td></td>
<td>Learn about hydrogen technologies and the value chain to assess business opportunities and projects in the sector.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Professionals working or entering the FCH sector</strong></td>
<td>Specialising</td>
<td>On the job training provided internally with variable duration.</td>
<td>Popular</td>
</tr>
<tr>
<td></td>
<td>Gain specialised knowledge to perform core missions in a hydrogen environment or with hydrogen technologies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Refresh existing knowledge/skills to work in safe conditions and with up-to-date information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Professionals whose occupation is affected by FCH development</strong></td>
<td>Adapting</td>
<td>Short training covering safety aspects and possible technical elements related to the field of activity of the professional. Diverse training providers, in line with sectoral professional organisations.</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Upskill to adapt to changes induced by FCH developments in the sector of work.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Workers from declining sectors with highly convertible skills</strong></td>
<td>Reskilling and upskilling</td>
<td>Short training supported by local / national authorities.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Upskill to work in the field of FCH building on existing knowledge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Workers with no prior knowledge on FCH</strong></td>
<td></td>
<td>Long training supported by local / national authorities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reskill to work in the hydrogen sector on specific in demand position.</td>
<td>Apprenticeship with companies.</td>
<td></td>
</tr>
</tbody>
</table>

*Training offers for CPD are gradually structuring from higher level training to more practical and hands-on approach.*

While there are many providers offering training programmes for decision makers on a general level, other programmes such as those aimed at training workers from declining sectors, are still in the early stages of development. Short training programmes, which do not involve practical components, focus their content on the hydrogen value chain, business opportunities or the development status of technologies. Skills linked to the assessment and management of projects in the hydrogen sector can also be conveyed in the training. These programmes cater to a broad audience, including non-technical profiles, and can be delivered online. On the other hand, when training technical profiles, other content elements are proposed, more often requiring face to face teaching, at least for the part of the training requiring hands on experience.
There is a need for more comprehensive and organised offerings at national levels to provide transition paths and upskilling/reskilling programmes for workers. Some one-off training offers and initiatives for the unemployed or for specific sectors impacted by hydrogen development have been found, for example in Norway, or in France, but established programmes are not yet well developed. At European level, the Just Transition Fund and the Recovery and Resilience Fund were mentioned as relevant source of funding to develop such structural programmes.

Tailor made training: a common practice with limited absorption capacity.

Customised on-demand training programmes that cater to the specific needs of companies are common in the FCH sector. The content of these programmes can be co-created to incorporate the company’s specific technologies. Some training providers outlined being close to their maximum capacity to deliver such training. With the increasing demand, accommodating customised programmes may become challenging due to the limited absorption capacity. This raises questions about the future of more standardised training programmes, who will be responsible for providing them, and what common certificate could be granted to ensure consistency in the skills acquired by workers.

Classifying hydrogen skills in professional titles and competencies

Several national or regional initiatives have developed their own classification of jobs and competencies similar to the one provided by ESCO. For instance, the Piemonte Region has developed a Repertoire of Standard Qualification, which encompasses descriptions of approximately 700 technical profiles across various fields. It is used as a reference for the design of training courses. Last year the region initiated a review of the repertoire with the support of companies. It is an opportunity to introduce new courses focused on hydrogen if companies identify a shortage of skilled professionals in this domain. Based on the companies’ insights, VET can be updated accordingly. Such approaches should be fostered to ensure that trainings are still up to date and relevant.

Similarly, in France a National Directory of Professional Certifications (RNCP) exists. Qualifications registered with the RNCP ensure that learners acquire the necessary skills and knowledge required for specific professions, while also clearly identifying available job opportunities and sectors. A recent initiative led by the Region Auvergne Rhone Alpes in collaboration with Symbio has prompted discussions on how to integrate and qualify new elements related to hydrogen within the repertoire. As a result, they decided to register a new certification as a "stacking agent" for individuals without prior industry experience who require comprehensive training. Additionally, they developed a module or "stack" for individuals in transition or who are job seekers and already possess assembly skills. These considerations and approaches can be further explored and potentially replicated in other regions.

Promoting hydrogen-specific education in continuous training requirements for workers

In various professions, workers are obligated to regularly update their skills to stay abreast of evolving technologies, standards, and regulations that impact their work. A certificate confirming their competency is awarded based on their participation in training sessions. Employers are required to collect and ensure the validity of these certificates. These training opportunities can serve to introduce FCH knowledge and skills in relevant sectors. For instance, this could benefit sectors such as gas, electricity, intensive industries, and transportation.
Safety is a key aspect to be addressed via this regular professional skills update. It is particularly relevant for gas and related appliances workers who may start to work with hydrogen. Currently the ATEX certification is required from workers of the hydrogen sector as it covers working in hazardous atmosphere installations. Although a lack of standardised minimum requirements for safety was highlighted, some organisations have proposed their own system of progression to address different levels of expertise on safety. An example of this can be found with the HyResponder project, which provides lecture materials with four different learning levels tailored to specific target audiences: firefighters, crew commanders, incident commanders, and specialists.

Professional organisations and sectoral training centres can play a crucial role in providing such training programmes, as demonstrated by the offer developed by Educam in Belgium, for the automotive sector. Aimed at mechanics, they developed a three-level certification on hydrogen safety on vehicles.

Open initial education modules to adult learners as part of continuing education

Certain educational offerings within initial education are extended to continuous education for adult-learners, thereby maximising the potential for synergies. These courses are often scheduled in the evenings or on weekends, allowing individuals to accommodate their work schedules and attend the classes. Alternatively, some workers may request their employers to make arrangements for them to participate in these educational programmes. This flexible approach to scheduling enables individuals to pursue further education and training while balancing their professional commitments, hence, fostering a conducive environment for continuous professional development.

5.2.3. Hydrogen education: varied situations across European countries

Conducting a European analysis allows us to identify common challenges experienced across the continent. However, it is essential to recognise that the situation can vary significantly from one country to another. The level of development of the hydrogen market in a particular country, as well as its industry's experience with hydrogen (e.g., in petrochemical industries), impact the availability of knowledge and the extent to which skills on hydrogen are widespread among professionals. Countries with existing practices in working with hydrogen have an advantage, as they may already possess a reservoir of skilled workers.

The map below proposes three categories of countries and their advancement in terms of educational and training offers in the field of FCH. The map is elaborated on the data presented in the Figure 23 – Development of hydrogen training and education in Europe.
Quantifying the extent of educational offerings in each country can be a challenging task. Drawing on the information presented in the previous sections regarding initial and continuous education, we propose a classification system to evaluate the training offers across the countries studied, with the countries in grey not covered. This classification considers the type of training available for initial education and the target audience addressed in training programmes for continuous education. Each occurrence of a specific type of training is assigned a point value of one, symbolised by a cross. Awareness of a programme or training in development grants a point value of 0.5, while the absence of training does not grant point.

It is important to bear in mind that the table developed reflects the best available knowledge at the time of drafting, but it does not provide a comprehensive overview on a European level. However, it serves to emphasise the diverse range of situations and the opportunities for development at national levels across Europe. It is interesting to note that, in comparison with the data presented in the SET Plan study in 2014, the geographic coverage of modules and programmes on FCH is expanding across Europe. In 2014, only four educative centres or universities located in two countries were mentioned as offering higher education fully dedicated programmes on hydrogen and/or fuel cells. Based on our research seven out of twenty countries covered are now offering fully dedicated programmes in academic tracks, as well as in higher VET. Five organisations in other countries also shared their intention to develop complete educational programmes on FCH in initial education.
In conclusion:

- The offer of FCH modules and programmes in higher education is increasing. Specialised modules are available mainly at Master level, across a wide range of disciplines.
- Education for FCH specialists requires interdisciplinarity. Safety and practical education are considered as cornerstones of FCH training. Access to the necessary infrastructures must be facilitated by local authorities to fully enable the development of training.
- Modules on FCH as well as specialised programmes are both needed to spread knowledge across disciplines as well as to build a reservoir of specialists on FCH. Short programmes for specialists were identified as missing from the offer of training.
- The training offers for CPD is gradually structuring, starting from higher-level training to more practical and hands-on approach. While tailor-made training programmes are a common practice, their capacity for accommodating participants is limited.
- Discussions are currently underway in certain countries on how to effectively integrate new qualifications and certifications related to hydrogen technologies and applications. Sharing best practices and aligning on a European level would benefit to the swift implementation of changes and facilitate the professional mobility of workers on a European scale.
- To facilitate the upskilling of workers, several paths could be explored such as the opening of initial education modules to continuous education or the integration of FCH into the regular skills update of professionals.
- Hydrogen training offers are more common across Europe than ten years ago; however, the situation varies greatly from one country to another.
5.3. Challenges and drivers to the development of hydrogen education and training

When asked about the challenges and driving factors influencing the development of training programmes related to hydrogen, stakeholders outlined common elements. Their responses were based on their personal experiences as well as their observations of the education and training landscape within their respective countries or regions.

**Challenges**

The shortage of qualified teachers and trainers in the field of hydrogen can be attributed to a limited pool of instructors available to meet the growing demand for training and/or to a lack of expertise within the fuel cell and hydrogen sector in certain areas.

The interviews also shed light on the challenge of financial viability in developing training and education programmes dedicated to fuel cells and hydrogen. The profitability of educational programmes is an important consideration when developing training. This applies to both continuous and initial education. The expansion of educational offerings comes with a cost. Educational institutions evaluate the cost-effectiveness of a new degree before introducing it, taking into account available resources (teachers and trainers), as well as the interest from potential students and industries in the programme. Some training providers found that there is not yet enough interest from students and companies to develop dedicated training. The funding allocated to training organisation by the country or a region can also have a great influence in the decision to propose elective courses or develop new training. All this can potentially hinder the responsiveness of the education system to address in a timely manner new demands such as FCH.

Another aspect linked to financial considerations is the access to infrastructures and equipment. Practical training has been described as a cornerstone of technical staff education. Having appropriate facilities and demonstration setups is necessary to provide hands-on experience with the technology, especially for installers and technicians. However, acquiring pedagogical fuel cells or electrolyzers can entail significant investments for training organisations and educational institutions. Conducting experiments and manipulations under real-life conditions requires access to specialised infrastructure. It is important to note that these infrastructures are not uniformly distributed across a given territory, and their accessibility for training purposes may vary. Suggestions and innovations are being tested to solve this issue. For example, projects of mobile labs are considered by industrial actors, or virtual labs by universities.

The rigidity of educational pathways was also identified as a constraint that hampers the development and implementation of training programmes. It was generally observed that continuous education provides greater flexibility and responsiveness in introducing new topics related to Hydrogen. In contrast, universities and VET institutions often face lengthy processes to introduce and accredit new educational offers. Certification procedures for a new training can extend over several years. The review of existing curricula can present an opportunity to incorporate new elements into current degrees. It should be noted that not all interviewees regarded this aspect as problematic, and some found that changes to existing programmes would occur organically, over time.

Training providers also raised concerns about the time constraints faced by workers to attend training as part of CPD. This issue is not specific to hydrogen training but is a common challenge in continuing education. Employees are given limited time to upskill alongside their regular work, making it difficult for training providers to accommodate their needs. Additionally, the
development of continuous education is sometimes driven by project-based initiatives, indicating a lack of sustained funding to establish a comprehensive training offering to up and reskill workers. The question of funding responsibility is central. Striking a balance between public and private funding is essential to create incentives for training and ensure the sustainable development of CPD.

Another significant challenge mentioned by interviewees is the delivery of training in the absence of established standards for education to the use of hydrogen and related technologies. This is particularly crucial in terms of safety standards, which form a fundamental component of hydrogen training. Without harmonised standards, there is a risk that trainers adopt different approaches to risk management, leading to inconsistency in workers' training. Furthermore, this lack of standardisation hampers worker mobility within the sector.

Drivers

A main driver for the development of FCH training programmes is the growth of the hydrogen industry. As the industry expands, there is and will be a demand for new profiles and specific skills in the workforce, offering clear career opportunities for trainees. The establishment of hydrogen valleys and ecosystems plays a crucial role in driving the development of degree programmes and training focused on fuel cells and hydrogen. This was especially mentioned by interviewees from countries where new projects are starting, and those questions are considered for the first time. In some cases, industries jointly expressed their interest in seeing training and study paths being developed to address their expanding needs in the coming years. This was the case reported by the University of Applied Sciences in Western Norway, where companies from the maritime industry sent a letter to express their needs for hydrogen competencies to regional public authorities. Courses were then developed to answer their request.

Public policy incentives also serve as a driving force for the establishment of new training programmes. This is particularly evident in transitioning regions that are moving away from fossil fuel-driven economies toward other activities. These regions undergo significant job distribution changes, and political impetus defines new paths for their local economies. In this context, upskilling and reskilling opportunities are facilitated to ensure a smooth transition without leaving anyone behind. The local level plays a vital role in implementing these actions, as seen in the Northern Netherlands (Netherlands) or in Stara Zagora (Bulgaria) for example. In both these regions, hydrogen valleys are being established as a transition path to exit respectively natural gas and lignite activities.

National coordination also plays a pivotal role in the development of training programmes. For example, in Finland, a consortium of universities gathered to provide a lifelong learning programme. They built on the resources of each partner to provide a complete expertise and share the costs linked to running a full programme. Rather than competing, training organisations collaborate to meet the public demand and promote synergies.

Availability of funds, aligned with public policy incentives, is another key factor in establishing new training opportunities and upskilling initiatives for workers. Interviewees from Romania and Portugal mentioned the EU Just Transition Fund and the Recovery and Resilience Fund as relevant sources of funding at European level. Various national schemes complement the European funding, and public agencies at national or local levels mandate organisations to develop projects and training offerings. These projects not only finance the development of training and training materials but also aim to introduce new content into existing curricula, often with the involvement and approval of relevant ministries. As an example, the Spanish government
has mandated a consortium of organisations to identify the VET titles and related professions that are going to be impacted by hydrogen to improve and/or introduce skills that are relevant for hydrogen. About 30 professions were identified.

Non-state funding can also be a driving force to establish training close to market needs. This was demonstrated in other sectors, with for example, the case of the Hefaïs school in France that aims at training welders and should open in September 2023. Hefaïs is a joint initiative of the nuclear and the naval sector to answer the needs of these sectors.

Existing expertise within organisations serves as a starting point for the development of training programmes. This expertise may be based on internal knowledge derived from research or industrial activities. It can also be developed through past projects, particularly European projects that have focused on developing training materials. Additionally, providing access to equipment, labs, and infrastructures is an added value to build on.

For training providers that do not yet possess this expertise, hydrogen represents an opportunity to expand their offerings and to stand out in a new market. Given the commitments made by the industry and policymakers, along with the current lack of training programmes, developing high-quality training can be a business opportunity.

In conclusion:

- The development of training offers for FCH is limited by the lack of qualified trainers and teachers, the costs associated with equipment and limited access to infrastructures.
- Uncertainty regarding the demand and the financing of a training can create reluctance to establish new offers. The length of the process to adapt educational pathways in some educational settings can deter or delay the update of training or the development of new ones.
- Continuing education funding and organisation are a key challenge to develop training adapted to the needs of workers.
- The absence of established standards for education on fuel cells and hydrogen, especially on safety, is a barrier to the development of recognised training programmes.
- Industry growth and hydrogen valleys project drive the development of FCH training programmes, creating demand for new profiles and specific skills in the workforce, offering clear career opportunities.
- Public policy incentives and funding facilitate the establishment of new training programmes, particularly to foster the transition in regions moving away from fossil fuel-driven economies, as well as to promote synergies among training organisations by encouraging them to coordinate and collaborate.
- Internal expertise and access to equipment, labs, and infrastructures contribute to the development of high-quality training programmes, presenting a business opportunity.
6. Strategic axes and recommendations

The strategic recommendations proposed here address the supply and demand of occupational profiles required for various positions in the hydrogen sector. While education and training providers play a leading role in addressing market demands, other institutions, associations or initiatives are equally important. Close collaboration between all stakeholders is required to facilitate and encourage hydrogen trainings and address the rapidly evolving market needs.

The analysis outlined in the previous sections clearly shows the urgent and critical demand for certain occupational profiles in the hydrogen sector. Particularly, qualified engineers and technicians specialised in hydrogen, and support functions such as sales, management and public servants are in high demand. While the development of educational offers both in initial and continuing education is underway, there are still discrepancies in their accessibility across audiences and countries. To address both the skills demands and the gaps in training and education offers, a Skills Strategy for the hydrogen sector is presented in the following chapter, outlining strategic recommendations and actions which need to be implemented.

The strategic recommendations presented below are not exhaustive. Instead, they build on existing resources and initiatives as well as on insights from the interview campaign and desk research conducted as part of the Green Skills for Hydrogen project. The project aspires to contribute with its deliverables to several of the recommendations and serve as an umbrella platform to facilitate and nurture collaborative contributions of stakeholders, which could build on the resources developed and complement them.

The action-oriented recommendations are grouped into six strategic areas referred to as axes, as illustrated in Figure 24 - Six strategic axes for the development of a skilled Hydrogen workforce. These axes encompass various actions such as the development of training content, communication activities, policy measures, facilitations, and sectoral structuring.

FIGURE 24 - SIX STRATEGIC AXES FOR THE DEVELOPMENT OF A SKILLED HYDROGEN WORKFORCE

1 - Develop Modular Trainings
2 - Define Trainings Standards for Hydrogen
3 - Improve Access to Continuing Professional Development
4 - Establish an Online Hydrogen Community
5 - Encourage the Uptake of Mobility for Education to Hydrogen
6 - Promote the Attractiveness of the Hydrogen Sector
6.1 Develop modular trainings

Given the high demand for specialised professionals, particularly engineers and technicians, it is crucial to develop additional training programmes to educate, upskill, and reskill individuals to work with hydrogen. Depending on the target audience the knowledge and skills demanded as well as the training requirements may vary. For instance, a salesperson dealing with fuel cell-powered vehicles requires a basic understanding of fuel cell technology, its benefits, and associated risks. Conversely, a fuel cell maintenance technician necessitates in-depth expertise and specific skills for working with fuel cells. To cater to the specific needs of the intended audience, modular trainings should be developed.

Modular training would allow for customisation and offer flexibility of learning. Learning units could be selected and combined to create personalised learning paths tailored to individual needs and aspirations. Such a design would simplify the replication of training programmes and modules across different national educational systems. Training providers could pick the most relevant items and integrate them in their training rather than having to adopt a full programme proposed as a block. Additionally, a modular approach would leave room to introduce modules addressing local requirements and specificities. For example, in regions where access to pure water resources for electrolysis is limited, extra modules could be introduced to cover topics like water desalination.

A low-hanging fruit to prioritise the implementation of these modules would be to integrate them into existing programmes in which hydrogen knowledge and skills should be widespread. At the same time, it is essential to develop new specialised academic and vocational programmes aligned with the local demand for skilled professionals. By pursuing these two paths, the integration of hydrogen-related education can be accelerated.

Actors involved and actions:

The implementation of these recommendations involves a diverse range of stakeholders. While training providers play a crucial role in developing and adapting training content, institutional players also have a significant responsibility in updating curricula, particularly in VET. Additionally, the contribution of European projects in developing modules and translating them into multiple languages is relevant. It is important to guarantee coordination among the content developed by different projects.

6.1.1 Build a modular training corpus

A first step is to develop educational content in a modular form and make it available to training providers and teachers.

6.1.1.1 Assess existing resources prior to developing educational content

Prior to developing training materials from scratch, content that is already available should be considered. In other words, an analysis should be conducted on what is available, how up to date the materials are, and what are the gaps in the topics covered.

The Fuel Cells and Hydrogen Observatory (FCH Observatory) is a relevant resource as it provides a list of educational materials publicly accessible online. To prevent unnecessary duplication of content, awarded EU and other publicly funded projects should share their forthcoming activities related to material development with the FCH Observatory. Additionally, Annex 10 of
the Strategy contains a list of forthcoming modules that are not yet publicly available. Furthermore, activities planned as part of the upcoming projects such as the Hydrogen Academy, funded by the Clean Hydrogen Partnership, should also be considered when designing training modules. The future Hydrogen Academy will gather and review materials from closed or ongoing EU-supported projects.

To provide clarity on the available resources, a comprehensive mapping similar to the one conducted by EIT InnoEnergy for the topic of “Storage” as part of the former European Battery Academy (EBA), could be beneficial. This mapping categorises the modules developed (in-house) placing them according to the EQF level and the area of the value chain addressed (from raw materials to recycling). Such mapping can inspire and inform the development of curricula by training providers. Furthermore, having an EU-level reference point for training modules on hydrogen could facilitate the mutual recognition of qualifications and promote workers’ mobility if common content is utilised across Europe.

6.1.1.2 Address the needs identified by industry stakeholders

Drawing from the information presented in section 4, it becomes feasible to discern the essential skills and knowledge that industry players require. The Key Hydrogen Thematic Competencies and Knowledge Needs per Target Audience outlined in Annex 7 highlight the most critical skills required by industry stakeholders and lists the occupational profiles for whom these skills would be required.

On the one hand, cross-cutting competencies needed across sectors and for various type of occupational profiles can be identified. The top three cross-cutting competencies are:

I. Health, Safety and Hazards related to hydrogen
II. Legal aspects, regulations and permitting of hydrogen projects
III. Hydrogen system components and integration with renewable energy

In complementarity, the top three technology and activity specific competencies and knowledge, linked to a specific professional area, are:

I. Hydrogen Production, storage and transport
II. Fuel cells, electrolysers technology
III. Hydrogen in mobility application and refuelling stations

These modules are highly demanded by industry stakeholders and should be addressed in priority.

6.1.1.3 Choose the optimal training delivery method(s)

Modular training can be adapted to different formats based on the target audience, content, and requirements of the training programme. In terms of length, it can be consolidated into a Masterclass conducted over a few days for workers or incorporated as a module within a VET school curriculum.

Various options are available for delivering trainings, such as traditional classroom sessions led by an instructor, whether in-person or through virtual platforms. E-learning utilising pre-recorded materials is also a relevant avenue, allowing learners to access content at their own pace. Integrating simulations, online tools, and games provide innovative ways to deliver knowledge.
Additionally, practical learning should be integrated into some hydrogen training programmes. Access to infrastructures that complement theoretical learning is essential, although it often involves significant costs. As such, local actors and authorities in charge of providing VET trainings need to cooperate and coordinate their efforts to efficiently provide these infrastructures for their training and knowledge providers. Initiatives coordinated at local level should facilitate access to such facilities for training purposes.

Local partnerships between training providers and industry are encouraged to bring added value and relevant content to these programmes. Such partnership should look at proposing 'learning by doing' approaches, where learners engage in challenges or projects alongside companies, and could take part in apprenticeships and internships if compatible with the training.

6.1.2 Adapt existing training programmes

An initial step in disseminating hydrogen skills and knowledge to a wide range of learners is to integrate hydrogen modules into existing programmes and curricula. For example, this could translate into an integration of hydrogen modules in gas process engineering training. Interviews have revealed that this integration process can be time-consuming, particularly in initial education. However, it is generally quicker than developing an entirely new training programme. Gradually integrating modules over time can also assist in progressively building a repository of content, which can later be utilised to create a comprehensive programme focused on FCH, encompassing several modules.

To ensure the uptake of the training corpus developed and aggregated through the activities funded at EU level and if relevant, at national level, it is crucial to work on incorporating these modules into national programmes and curricula. This can be accomplished by establishing connections and advertising this content to training organisations, VET providers, universities, and technical schools interested in implementing hydrogen training. Ministries and local authorities, which have a critical role in the formulation of education strategies and in the deployment of hydrogen projects could take the lead in incentivising local actors to translate training materials into their local languages and diffuse them to directorates and technical schools. Additionally, continuing European projects that aim to translate common materials into different languages would be beneficial, particularly when multiple educational institutions commit to adopting the content developed in collaboration with their European partners.

6.1.3 Develop new specialised training programmes

In addition to integrating modules on hydrogen as part of existing training, specialised programmes are needed to develop a workforce of experts on hydrogen and fuel cells. These programmes are needed both in initial and continuing education. Examples of existing specialised training can be found in Annex 9, particularly at Master level or as short training for workers. Hydrogen valleys are well-positioned to spearhead the implementation of such programmes, aligning them with existing job opportunities and leveraging local resources for practical learning experiences (access to infrastructures and equipment, apprenticeships, or internships).
Encouraging the coordination of specialised programmes at regional and/or national levels is recommended as it can help ensuring a comprehensive coverage of needs across geographic areas and educational levels. Moreover, public authorities can incentivise training providers to collaborate and jointly develop specialised training programmes, capitalising on each other's expertise. Collaboration can help to overcome challenges such as scarcity of trainers and teachers on FCH or the high costs associated with developing and running new training programmes.

Best Practice – TeacHy project

The TeacHy project aims to develop accessible Master courses on fuel cells and hydrogen technologies, allowing universities to participate with a minimal local investment. Any university being able to offer 20% of the course content locally, can draw on the other 80% to be supplied by the project. By developing a centralised hub for European training providers, it seeks to bridge the expertise gap in countries with limited knowledge on FCH. The TeacHy project provides a relevant example of specialised training and collaboration on a European scale.

6.2 Define training standards for hydrogen

Training standards typically serve as a reference point or framework to develop training programmes, assessments, and certifications. They outline the specific learning outcomes, core competencies, and performance indicators that individuals should acquire and demonstrate to meet the requirements of a particular profession or industry. Training standards may cover various aspects, including theoretical knowledge, practical skills, ethical considerations, safety protocols, industry-specific regulations, and professional conduct. They reflect the best practices of each industry. Adherence to training standards helps establish a common baseline of knowledge and skills within a sector, fostering professional development, standardisation, and the overall competencies of the workforce.

The lack of guidance on training standards in the field of hydrogen poses a challenge for training providers who lack common recognised guidelines or criteria to define the expected proficiency level to safely work with hydrogen. Safety standards have been identified as essential across the hydrogen value chain and in various professional hydrogen applications. They would apply in continuing education, where workers are required to acquire specific certifications or undergo refresher training, as well as in initial education, particularly in VET.

Having these standards in place enables employers to quickly assess the qualifications and competencies of individuals seeking employment within the hydrogen sector. Additionally, recognised standards facilitate workers mobility, which is particularly important in the European market where it should be avoided to have different legislations and requirements applying from one country to another. By recognising common standards, employers can avoid redundant in-house training efforts. Finally, from an employee's perspective, having standards provides clarity on the knowledge and skills they should acquire to advance their careers or gain professional recognition.
Actors involved and actions to implement:

The process must be driven by interested parties such as professional associations, industry bodies, regulatory agencies, and educational institutions. On a European level, sector organisations such as Hydrogen Europe and Hydrogen Europe Research could gather interested parties to work on these problems. Further discussions to determine the specific roles and responsibilities of these entities in implementing and updating these standards should be organised. This will take place beyond the scope of Green Skills for Hydrogen.

6.2.1 Establish training standards for safe hydrogen handling

A first step to establish training standards will be to identify hazards faced by workers in the hydrogen sector. The hazards must be identified together with industry stakeholders based on their work practice and experiences. An initial look at incidents occurring in the sector will help to define a list of hazards depending on the work environment and the activity performed. Researching existing standards that may have been developed at local level or through specific projects would feed into the data collection.

From these hazards and the best practices in industry, it should be possible to draft training standards describing rules to learn how to safely handle hydrogen and related technologies. The standards would be implemented into training and certification programmes for workers. They encompass information on the learning outcomes and the minimum standards to be enforced in the training. The frequency at which workers in the hydrogen sector should undergo refresher training for each of the standards identified should also be set.

The need to establish further standards in areas in which emerging hydrogen technologies are deployed should regularly be assessed.

6.2.2 Establish a governing body responsible for enforcing and regularly updating the training standards related to hydrogen

In close cooperation with the industry, a dedicated organisation should oversee the implementation and update of standards. The objectives and scope of the governing body must be clearly set along with its responsibilities, authority, and limitations. Several legal forms and funding mechanisms could be considered, inspired from other sectors organisational structures to enforce training standards. This organisation would benefit from being run as non-profit. In-line with the funding and resources needed to perform the tasks attributed to the entity, several sources of funding could act in complementarity to sustain the work of the organisation, for example public grants, industry contributions or user fees.
6.3 Improve access to continuing professional development.

Enabling access to continuing professional development (CPD) is crucial to foster the penetration of hydrogen-related skills into the existing workforce. Given Europe’s ambitious hydrogen plans, the demand for specialised skills and a trained workforce is already here and cannot solely rely on the entry of youth into the job market, via the update of initial education curricula. The challenge of accessing CPD is not unique to the hydrogen sector but is shared by industries impacted by rapid technological advancements or experiencing significant growth, such as the wind and solar sectors.

The availability of CPD opportunities varies across different countries. While various initiatives have been implemented to encourage harmonisation of CPD practices at the European level, the authority to regulate continuous education ultimately lies with the Member States.

Enhancing access to CPD is crucial for promoting the upskilling and reskilling of the existing workforce, addressing the increasing demand for skilled workers in the hydrogen sector. Establishing a robust CPD system is particularly valuable for employers as it lightens their responsibility of providing extensive on-the-job training, which is still prevalent in the hydrogen sector.

**Actors involved and actions to implement:**

These measures would need to be implemented by national and regional governments responsible for employment and education policies, trade unions and training providers. Additionally, employers would be in charge of freeing time for workers to access the opportunity they are provided with in continuing education.

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**Best Practice – Wind sector training standards**

The wind sector and the Global Wind Organisation (GWO) set a good example for the hydrogen sector. The GWO establishes standards based on inputs from industry stakeholders, including turbine manufacturers, owners, and operators, incorporating information on incidents, hazards, and best practices. The standards define many items that certified training must respect, such as general requirements, prerequisites from participants, the contact time foreseen, the ratio instructor to participant, the learning outcomes, among other things.

Training providers seeking to deliver training for workers of the wind sector training must obtain certification in accordance with these criteria. In line with certain ISO norms and other requirements, certification bodies are approved by the GWO to perform audit and grant certifications to training providers, applying the GWO standards. They ensure that training providers are compliant with the established standards. A database is maintained by the GWO, containing information on certified training providers, which can be accessed by interested parties. Certification for training providers is valid for a period of two years and must be renewed thereafter.

Examples of training standards within the wind sector include Advanced Rescue, Working at Heights, or Blade Repair. Some standards require refresher training, such as the Advanced Rescue Training, which must be updated before its expiration, typically every 48 months.
6.3.1 Prepare skilling plans in anticipation of hydrogen development

Organisations affected by the development of hydrogen should be encouraged to establish skilling plans that outline the transition paths for workers, as their roles and responsibilities evolve. Skilling plans should be developed by organisations in the public sector, for example for first responders, and in the private sector for auto mechanics, as an example. The latter will see a growing number of hydrogen vehicles on the road that may need repair; the former might deal with accident management and recovery. In other words, professional organisations, companies and public authorities would benefit from establishing skilling plans to identify workers that will need to be upskilled or reskilled and introduce a training schedule over the coming years to offer possibilities to acquire these new skills. Such plans should entice companies to foresee granting time to their workers to be able to attend relevant training instead of asking them to train in addition to their regular job responsibilities.

6.3.2 Support continuing professional development with policies and funding

Developing a supportive policy framework and implementing funding mechanisms are crucial in providing reskilling and upskilling opportunities for job seekers and workers. While this approach is not exclusive to the hydrogen sector, public authorities can provide guidance and incentives to promote the establishment of training programmes on specific topics and offer funding opportunities for specific groups of workers. This step is the logical follow up to answer the needs of companies and organisations, and the ambitions they defined in their skilling plans. In certain countries, training on hydrogen have been funded by local or national governments to address specific industries, for example in the maritime sector or in the oil and gas industry. Generalising such practice and building on the interest of local industries would greatly benefit the sector.

6.3.3 Open initial education modules to workers in continuous education

Establishing synergies between initial and continuing education would benefit the fast development of hydrogen skills. This shortage of experienced trainers and teachers identified in the field of hydrogen is an incentive to develop synergies between educational actions. Opening modules taught as part of initial education to workers would maximise the impact of training by broadening its reach. We observed that modules on FCH were increasingly being introduced at Master level, and this could be an opportunity to open them to workers. Additionally, the (work) experience of people attending the class as part of CPD could provide interesting insights to students. Finally, workers could collect micro-credentials that could lead to a university degree equivalence once they accumulated enough, therefore enhancing the recognition of their training and skills.
6.4 Establish an online hydrogen community

Considering the multiple projects and initiatives aimed at addressing skills needs in the hydrogen sector, there is a noticeable fragmentation of available resources. The absence of a shared platform accessible to all stakeholders hinders the potential for collaboration and synergy. To address this issue, the establishment of an open-access online hydrogen community could be proposed as a foundation and central reference point for all current and forthcoming initiatives. In collaboration with the future European Hydrogen Academy, Green Skills for Hydrogen can serve as a foundation for developing this community, leveraging connections and synergies with past, ongoing, and future EU initiatives and projects in the sector.

The creation of an online community focused on skills, education, training, and jobs in the hydrogen sector would offer the following benefits:

1) Enhancing the visibility of existing programmes and initiatives.
2) Acting as a centralised hub for accessing and participating in online training hosted on the platform.
3) Building a network connecting training providers and learners.
4) Promoting collaboration and synergies among projects and initiatives.

Taking stock of existing resources, notably the FCH Observatory, the platform should focus on aspects that are not yet offered elsewhere.

Actors involved and actions to implement:

The online community, centred on the crowd-sourcing concept, can benefit from the participation of diverse stakeholders. These stakeholders may include training providers, EU projects, or other national or local initiatives, and companies.

6.4.1 Deliver online training content building on existing e-infrastructures

A centralised online platform that serves as a hub for a wide range of hydrogen-related training and resources can enhance access and visibility for these resources developed by multiple stakeholders. Online training courses could be made available in an open-access format, similar to Massive Online Open Courses (MOOCs), thereby expanding the reach and accessibility of

Best practice – Transition and retraining finance in Sweden

In Sweden, measures have been implemented to support workers in transitioning and retraining by offering student finance options. This financing scheme covers up to 80% of a worker's salary while they engage in upskilling or reskilling activities. Although there is a maximum limit to the amount of financial support provided, individuals have the option to supplement their income through facilitated loans. The duration of financial assistance is capped at 44 weeks for full-time training programmes, but it can be extended for part-time study arrangements. This mechanism is particularly valuable to enable the workforce to pursue upskilling or reskilling opportunities. Among other stipulations, participants are required to have a minimum of 8 years of work experience, to be eligible for financing.
these programmes to a large number of learners, unrestricted by geographical limitations that in-person training may impose. This virtual community should build upon the accomplishments of projects like Green Skills for Hydrogen.

Additionally, the incorporation of e-infrastructures, such as the ones provided by NET Tools, would provide added value by offering a comprehensive package and creating opportunities for further expansion. NET Tools, which received support from EU funding, offers open-source software and e-infrastructures specifically designed to support education and training related to hydrogen and fuel cell technology. They are available to users free of charge.

The FCH Observatory has already compiled an extensive database of hydrogen-related training courses and resources. By taking the next step of hosting the content and providing tools to develop training programmes on the platform, the accessibility would be enhanced, and the platform's impact would be multiplied.

6.4.2 Map out physical labs and infrastructures

Accessing laboratories and infrastructures has been recognised as crucial and challenging for training, upskilling, and reskilling the workforce. Such infrastructures may not be equally accessible across Europe. To address this issue, an initial measure could involve creating an online database that compiles information about these facilities, labs, and test centres, including details about the equipment available at each location. The database should also provide information about the facilities' locations, accessibility, and contact persons to facilitate communication. It would be sensible to start this endeavour by focusing on the local level, for example in regions where there is already a demand for hydrogen-related training. The database would then aggregate all this on a European level.

Making this information readily available would help capitalise on existing infrastructures and increase the utilisation rate of these facilities. Furthermore, if any gaps are identified, it would be possible to consider further investments at the local, national, or European levels. Lastly, establishing collaborative training programmes that utilise resources from different locations would be made easier. Partnerships between complementary training providers could be established more seamlessly. In this regard, the European Hydrogen Academy’s plan to develop a network of at least five jointly operated training laboratories that can be accessed by teachers, pupils, academic staff, and students for educational purposes represents an initial step towards achieving this objective.

Best practice – Mapping of training and educational materials

The Fuel Cells Hydrogen Observatory has compiled a rich database of hydrogen trainings and education resources. Details on language, type of programme, location and other useful information can be easily found through an integrated research and filtration option. The FCHO offers also direct access to and download of the listed teaching materials. Such platform is a resource for trainees and trainers alike.
6.5 Encourage the uptake of mobility for education to hydrogen

Mobility is characterised by two dimensions: geographical mobility across countries and regions, and sector mobility that allows individuals to explore and transition across various disciplines. It presents an avenue for both learners and professionals to venture beyond their current institutions and companies to acquire knowledge and skills that may not be available within their own organisation or local area. By promoting mobility of learners and trainers, it is possible to collectively enhance access to training and facilitate sharing of experiences on a European scale. Given the various availability of skills, trainers and teachers on hydrogen across Europe, promoting mobility becomes crucial in addressing these disparities and collectively elevating the knowledge and skills within the European workforce.

Actors involved and actions to implement:

The key stakeholders involved in enabling hydrogen mobility are academic institutions, training providers, ministries of education and higher education, multilateral European education agencies, as well as existing projects and initiatives focusing on hydrogen education. These stakeholders should be encouraged to initiate and facilitate bilateral and multilateral hydrogen mobility programmes.

6.5.1 Enable learners’ mobility

Promoting learners’ mobility is essential as it provides them with access to a wide range of educational opportunities that may not be available in their local areas. Furthermore, in the context of initial education programmes, facilitating the mobility of learners across different training institutions makes it possible to share resources between training providers. Instead of relying on a single institution responsible for delivering a comprehensive specialised programme that requires many expert trainers, it is possible to draw on the expertise of various institutions by organising student mobility between them. Calls for proposal aimed at fostering collaboration and partnerships between European educational institutions will facilitate the development of such programmes. This could be implemented on a European level, as already done with the Erasmus+ programme, as well as on a national scale to cater to audiences that require training in their local language. The upcoming European Hydrogen Academy will facilitate learners’ mobility by creating a network of at least 500 schools regularly offering hydrogen-related education and of minimum of 100 universities and educational institutions offering hydrogen-related courses. These networks will help identifying institutions with hydrogen expertise that would be beneficial for learners seeking mobility, or at organisation level, identifying partners to organise mobility or to learn from. The recently awarded Center for Vocational Excellence project, H2EXCELLENCE is also a relevant initiative in this regard.

Additionally, the mobility of learners can facilitate access to infrastructures and equipment necessary for technical training on hydrogen. In line with the recommendation (6.4), information regarding these infrastructures should be available to inform learners about their location and accessibility. Ensuring the presence of expert trainers knowledgeable about the operation of these platforms is needed to scale up the roll out of practical skills in the hydrogen sector.

6.5.2 Enable trainers’ mobility

The shortage of trained trainers poses a significant challenge in rolling out training programmes across different disciplines, regions, and countries. Facilitating the mobility of trainers can contribute to addressing this issue effectively. Trainers would be mobilised to deliver a training
in a partner organisation when no expert was found locally. This would foster the deployment of cutting-edge skills on hydrogen and contribute to the dissemination of knowledge across Europe. To facilitate this process, it would be beneficial to establish a network of trainers capable and willing to provide hydrogen training across Europe. Creating a database of such trainers would greatly assist learners and organisations in their search for expertise, allowing them to easily identify and reach out to the trainers who can offer the necessary support. Various mechanisms detailed in section 6.5.3 can help to fund this mobility.

To maximise the impact of mobility, **prioritising train-the-trainers programmes is essential. Trainers who are traveling to provide training would prioritise the training of local trainers** who would in turn be able to deliver trainings in their local languages and tailored to the local needs.

### 6.5.3 Secure funding for mobility

Securing funding is essential to support the mobility of learners and trainers. The EU’s Erasmus+ programme already plays a significant role by providing funding for the mobility of trainers, students, and, in certain cases, professionals. Furthermore, dedicated calls for proposals can facilitate the collaborative development of degrees and programmes among training organisations, often involving student mobility. Another opportunity to promote mobility among trainers and students across countries, sectors, and educational levels is through the establishment of university partnerships under the [European Universities initiative](#).

Several other EU funding programmes offer financial support for skills and training initiatives in strategic industrial and transitional areas. The [Just Transition Fund](#), for instance, provides assistance to regions most adversely affected by the climate transition, including funding for worker upskilling and reskilling. Transition training programmes could be financed to help workers update their qualifications for working in the hydrogen sector. The [Just Transition Platform](#) can serve as a resource, offering guidance to transitioning regions on upskilling and reskilling workers and showcasing good practices on effectively utilising the fund to support these efforts.

Furthermore, the [Recovery and Resilience Fund](#) can also be leveraged as a resource, particularly in countries where hydrogen is included in the National Recovery and Resilience Plan. In-line with national authorities administering the fund and with the foreseen actions, opportunities to educate, upskill and reskill workers through mobility or through the development of infrastructures could be envisaged.

Further funding at the national and regional levels can complement these initiatives as they are tailored to the specific needs of each European country.

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**Best practice – Joint European Master programme**

**HySET Master** – The Hydrogen Systems and Enabling Technologies Master set to start in September 2023 provides an interesting example of how different universities can team up to develop a common programme focused on Hydrogen. The core partners are Politecnico di Torino (Coordinator), Politecnico di Milano, Norwegian University of Science and Technology, Universitat Politecnica de Catalunya, and Eindhoven University of Technology.
6.6 Promote the attractiveness and raise awareness of the hydrogen sector

Increasing awareness and generating interest in hydrogen applications and technologies play a crucial role in attracting individuals to work in the sector. By raising awareness, pupils, students and workers, who may not have previously considered the hydrogen industry, can be inspired to explore and pursue careers in this field. The goal is to disseminate knowledge and create a narrative about the hydrogen value chain, its environmental benefits, and the industry’s growth potential.

To achieve this, providing comprehensive information about career prospects and educational pathways to work in the hydrogen industry is essential. Additionally, sharing best practices on the development of hydrogen training programmes could help training providers to identify ways to adapt existing offers to include hydrogen and/or to develop innovative content for trainees.

For companies, an increased interest in and awareness about the sector will facilitate talent acquisition. It will in turn broaden the pool of skilled workers available to address the industry’s skills shortages. Moreover, the development of a positive narrative could also help talent retention. Workers are more likely to remain in their position if they feel that they are contributing to the development of a sector that enables the clean energy transition and contribute to achieve the climate goals.

**Actors involved and actions to implement:**
Promoting the attractiveness of the sector could be done by a multitude of stakeholders, including employment agencies, local authorities, teachers, guidance counsellors, professionals from the sector, national associations, and European projects such as Green Skills for Hydrogen.

**6.6.1 Prepare and share information on hydrogen careers in secondary schools**

Information and career paths related to the hydrogen sector should be widely disseminated to secondary schools’ students as well as to guidance counsellors and teachers in relevant educational fields. Secondary students are at the age where they choose their orientation and therefore, they are a key audience to reach out to. Information would include job descriptions for various roles within the hydrogen sector linked with educational pathways for interested students. Due to the variations in educational systems, it is advisable to organise these efforts at national levels to point at specific degrees identified in local languages. National associations could be relevant hubs to collect information and prepare materials whilst dissemination would be facilitated by schools, teachers and guidance counsellors. At European level, information on the potential careers in the hydrogen sector could be disseminated by sectoral organisations as well as via different EU projects, including Green Skills for Hydrogen.

**6.6.2 Provide targeted information on transition paths for workers from declining sectors**

Workers from declining sectors, especially from the oil and gas sector, have been identified as a key target group due to their highly convertible skills to work in hydrogen. The transition to a green economy will likely lead to a change of their activities, so career options and job opportunities for an easy reconversion should be advertised to these workers. Information on good practices for the reconversion of workers should be identified and promoted at the European level, however, local authorities and employment agencies are well placed to deliver the message in local languages to individuals interested in these options as they are working with them more closely. Additionally, using existing platforms advertising jobs in the sector both at local, national, or European level would provide concrete examples of the career options open to those workers.
6.6.3 Organise discovery activities in lower levels of education

Conducting discovery activities for primary and secondary school students would help raise public awareness from a young age and potentially spark interest in pursuing careers in the hydrogen sector. This should be done by teachers in these education levels, building on available resources and possibly liaising with local stakeholders to organise activities (university students, industry stakeholders, etc.). To effectively reach the primary target audience of pupils and students, it is important to engage with teachers who serve as facilitators. Therefore, providing them with educational materials can both help them learn about hydrogen and fuel cells, and provide them with suggestions for activities and lessons to deliver to students. This would maximise the impact of such actions. This approach has already demonstrated its usefulness and success when carried out in European projects.

6.6.4 Disseminate best practices on hydrogen training.

Disseminating best practices on the establishment of dedicated training programmes for fuel cells and hydrogen or on effective methodologies for training development, for example through partnerships between organisations, is another way to build the capacity of teachers, educational institutions, training providers and local authorities to deliver on their own programmes. Sharing this type of information can inspire a best practice approach that can be replicated in other areas and avoid the duplication of efforts when certain resources are already available. Whilst some of these best practices would benefit from being disseminated across countries at European level, particularly via European projects, others would benefit from being drafted and translated into local languages and disseminated by local stakeholders such as national associations.

Best practices – European projects on lower educational levels

Several European projects have addressed the need to provide activities and educational content for primary and secondary education. The materials and information developed through these projects serve as valuable examples of best practices that can be replicated at the national level. By leveraging the experiences and materials from projects like FCH Go and HySchools, educational initiatives at national levels can benefit from established practices and gain access to multilingual resources, contributing to the wider adoption of Hydrogen education in primary and secondary schools across Europe.

1. **FCH Go**, funded by the Fuel Cells and Hydrogen Joint Undertaking 2, the FCH Go project proposes activities to pupils and their teachers to discover the energy of Hydrogen with innovative teaching materials and activities. **FCH Go**, funded by the Fuel Cells and hydrogen Joint Undertaking 2, the FCH Go project proposes activities to pupils and their teachers to discover the energy of Hydrogen with innovative teaching materials and activities. The materials are available in English, German, Italian, Polish, French, Portuguese, Romanian, Spanish and Turkish.

2. **HySchools** is a project funded by Erasmus + that aims to deliver educational and online resources created for use in secondary schools for teachers, to provide education on Hydrogen and fuel cell technologies. The project covers a wide range of topics connected with the Hydrogen value chain and the development of Hydrogen economy. The materials are available in English, French, Greek, Italian and Romanian.
7. Conclusion

The analysis of the demand of occupational profiles in the hydrogen sector has revealed the need for collaborative actions to train and educate engineers and technicians as well as other support functions across a range of activities. These occupational profiles need to be trained on cross-cutting hydrogen themes as well as other more technology-specific topics. The recommendations recognise the contributions of existing initiatives and call for leveraging their achievements to address market needs and scale up the offer of hydrogen training to accompany the development of the hydrogen market.

The immense tasks of training and up- and reskilling of people to work in the hydrogen sector will require the active involvement of various stakeholders including training and knowledge institutions, companies, professional organisations in the hydrogen sector, and other sectors affected by hydrogen advancements, as well as public authorities from local to European level. The scope and type of actions these actors can take will depend on their mandates and reflect the realities of the development of the hydrogen sector in their respective regions. That said, these efforts will result in individuals, students, workers, teachers, and trainers having access to the necessary tools to be educated about hydrogen, acquire new skills, and adapting the existing ones.

Efforts will be made to develop specialised modular training and adjust existing curricula to align with industry requirements (1), thereby increasing accessibility to hydrogen knowledge and training. An online platform will host modules and information (4), making data easily accessible. For workers, the establishment of training standards (2) and improved access to continuous professional development (3) will create new career opportunities and facilitate their up- and reskilling. Enabling the mobility of trainers and students will enhance the development of common European workforce skills and enable economies of scale (5). Finally, promoting the attractiveness of the sector will encourage students and workers to take an interest in and join the hydrogen workforce (6).

The proposed recommendations should not be seen as the responsibility of Green Skills for Hydrogen individually but rather a collaborative work of stakeholders. The project serves as an initiator that kick starts and stimulates strategic actions and tackles critical gaps, such as the development of modular training curricula. Additionally, Green Skills for Hydrogen enables other stakeholders to build on its activities, develop further actions and initiate partnerships and collaboration. The project also aims to group, host and promote all hydrogen initiatives and training programmes on its online platform to increase synergies and leverage common resources as well as accessibility of existing programmes. The creation of hydrogen education ecosystem and filling urgent gaps are just the beginning.

The Figure 25 - Strategic actions and facilitators summarises the strategic actions and facilitators to engage in the proposed activities.
## Strategic Actions and Facilitators

<table>
<thead>
<tr>
<th>Strategic Actions</th>
<th>Examples of Facilitators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Develop modular trainings</strong></td>
<td></td>
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<tr>
<td>1.1 <strong>Build a modular training corpus</strong></td>
<td></td>
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<tr>
<td>1.1.1 Assess existing resources prior to developing educational content</td>
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<tr>
<td>• Invite awarded EU and possibly national projects to share information on the</td>
<td></td>
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<tr>
<td>educational materials developed with the FCH Observatory.</td>
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<tr>
<td>• Develop a high-level mapping of modules available on FCH based on the data</td>
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<tr>
<td>from the Observatory and as a resource for future (EU) projects</td>
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<tr>
<td>1.1.2 Address the needs identified by industry stakeholders</td>
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<tr>
<td>1.1.3 Choose the optimal training delivery method(s)</td>
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<tr>
<td>• Encourage local framework initiatives to ensure access to infrastructures to</td>
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<tr>
<td>train hydrogen learners</td>
<td></td>
</tr>
<tr>
<td>• Develop and build on existing e-infrastructures and content</td>
<td></td>
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<tr>
<td>• Organise local partnerships between training providers and industry for</td>
<td></td>
</tr>
<tr>
<td>education and training</td>
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<tr>
<td>1.2 <strong>Adapt existing training programmes</strong></td>
<td></td>
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<tr>
<td>• Encourage education ministries and training providers to use the modular</td>
<td></td>
</tr>
<tr>
<td>training corpus developed at European level in their educational offer</td>
<td>Training providers, Education ministries, Public authorities</td>
</tr>
<tr>
<td>• Facilitate funding to translate training materials developed by European</td>
<td></td>
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<tr>
<td>projects</td>
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<tr>
<td>1.3 <strong>Develop new specialist training programmes</strong></td>
<td></td>
</tr>
<tr>
<td>• Coordinate the development of specialised training on a territory</td>
<td>Training providers, Education ministries, Public authorities</td>
</tr>
<tr>
<td>• Promote collaboration between training providers to develop specialist training</td>
<td></td>
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<tr>
<td>2. <strong>Define training standards for hydrogen</strong></td>
<td></td>
</tr>
<tr>
<td>2.1 Establish training standards for safe hydrogen handling</td>
<td>Companies and workers in the hydrogen sector, Professional organisations</td>
</tr>
<tr>
<td>2.2 Establish a governing body responsible for enforcing and regularly updating</td>
<td>Professional organisations, Companies</td>
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<tr>
<td>the training standards related to hydrogen</td>
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<tr>
<td>3. <strong>Improve access to continuous professional development</strong></td>
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<tr>
<td>3.1 Prepare skilling plans in anticipation of hydrogen development</td>
<td>Companies, Public authorities</td>
</tr>
<tr>
<td>3.2 Support continuing professional development with policies and funding</td>
<td>Public authorities, Companies</td>
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<tr>
<td>3.3 Open initial education modules to workers in continuous education</td>
<td>Training providers, Public authorities</td>
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<tr>
<td>4. <strong>Establish an online hydrogen community</strong></td>
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<tr>
<td>4.1 Deliver online training content building on existing e-infrastructures</td>
<td>EU projects, Training providers</td>
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<tr>
<td>4.2 Map out physical labs and infrastructures</td>
<td>Local authorities, Training Providers, EU projects</td>
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<tr>
<td>5. Encourage the uptake of mobility for education to hydrogen</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td><strong>5.1 Enable learners’ mobility</strong></td>
<td>Training providers, EU programmes</td>
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<tr>
<td><strong>5.2 Enable trainers’ mobility</strong></td>
<td>Training providers, EU programmes</td>
</tr>
<tr>
<td><strong>5.3 Secure funding for mobility</strong></td>
<td>Local, national and European public authorities, Hydrogen companies &amp; Associations</td>
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<tr>
<th>6. Promote the attractiveness of the hydrogen sector</th>
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<tr>
<td><strong>6.1 Prepare and share information on hydrogen careers in secondary schools</strong></td>
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<td><strong>6.2 Provide targeted information on transition paths for workers from declining sectors</strong></td>
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<tr>
<td><strong>6.3 Organise discovery activities in lower levels of education</strong></td>
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<tr>
<td><strong>6.4 Disseminate best practices on hydrogen training</strong></td>
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</tbody>
</table>
8. Areas for further consideration

While the European Hydrogen Skills Strategy primarily focuses on Europe, the demand for hydrogen skills is not specific to the continent and should be considered on a global scale. Europe has a strategic interest to support its international partners to further promote and develop hydrogen skills and knowledge, given that imports are a key element of its hydrogen strategy. As outlined in REPowerEU, it is envisaged to import 10Mt of renewable hydrogen to Europe by 2030. Ensuring that partner countries have the necessary capacity and expertise to produce hydrogen becomes crucial to make Europe’s plans reality.

In order to ensure a skilled workforce, skills mapping exercises are a relevant first step to assess of the skills missing in comparison with the requirements for hydrogen occupational profiles, as identified by Green Skills for Hydrogen. For instance, previous experience working with hydrogen (e.g., petrochemical industry), or the presence of sectors requiring similar skills as in the hydrogen sector (e.g., oil and gas industries) can significantly influence the skills reservoir available in a given area. Undertaking an analysis focused on a particular region or country provides a comprehensive understanding of the unique factors at play in this area, hence delivering a more detailed picture both of the industry skills needs and the supply, and the possible gaps in the trainings provided. The EU should build on its experience and that of Member States to help its partners undertaking this type of mapping. Based on this skills assessment, tailored training programmes, both in initial education and continuing education, could be delivered to bridge the skills needed. To facilitate this process, it would be beneficial to share the best practices identified in Europe and make modular training that are publicly available in the EU accessible to a broader audience. These resources should be disseminated to countries that need such support to meet their specific demands.

Some RTOs and universities have established training partnerships with organisations outside of the EU to provide them with expertise to carry out hydrogen projects. Expanding these practices and sharing the outcomes of European projects like Green Skills for Hydrogen can benefit countries beyond the EU and foster the implementation of local training programmes in countries embarking on hydrogen development. In this regard, the efforts of the United Nations for Industrial Development (UNIDO) and the Task Force on Skills initiated as part of the International Partnership for a Hydrogen Economy (IPHE) play a significant role in fostering these activities and facilitating global knowledge exchange and collaboration. They connect stakeholders to reflect on an international scale on the good practices and recommendations to be implemented in relation to skills and training. Collaboration with these organisations should be further explored to develop the hydrogen sector on a global scale.
9. Annexes

Annex 1 – Industry Need Analysis Methodology

Literature Review

Prior to the interview campaign, **Desk Research** has been conducted to identify, analyse and summarise existing publications on skills in the hydrogen sector. The desk research covered 10 European countries - Germany, Sweden, Austria, Belgium, Denmark, Finland, Netherlands, Italy, Spain, France – that have the most advanced hydrogen ecosystems. The analysis shows the relevance of each study to the hydrogen context and the coverage of occupational profiles, skills, competencies and qualifications related to hydrogen.

Interview Guide

Task 2.2 complements and extends the work previously delivered in Task 2.1 that aims at identifying the current and emerging occupational profiles required in the hydrogen sector. These profiles are identified according to the feedback of industry stakeholders that cover the whole hydrogen value chain across a significant part of the European Union. In total **93 interviews** have been conducted covering **19 countries** giving a comprehensive picture of current, missing and future occupational profiles found or needed across the hydrogen sector. Additionally, interviewees shared their perspectives about the skills, competencies and educational background needs of these occupational profiles. The interview guide used is available in Annex 3 – Interview Guide T2.2.

Status of Occupational Profiles’ demand

To outline the nature of the hydrogen occupational profiles demand, the level of urgency and/or difficulty to find occupational profiles is classified under three categories:

- “Current” lists currently employed and working profiles in the company,
- “Missing” lists the profiles that are hard to find and hence missing,
- and “Future” lists the profiles that participants anticipate will be in demanded in the future.

Along with the company’s background information and geographical scope, the interviewee is asked about the current, missing and future hydrogen-related jobs as well as skills and competencies required for each role. The interviewee is also asked to highlight areas of missing qualifications and difficulties to recruit certain profiles and how his/her company tackles this gap.

Hydrogen Knowledge and ESCO Classification

Interviews’ results are then analysed to define the trend in the demand of occupational profiles across the industry. Occupational profiles are grouped according to their **European Skills, Competencies, and Occupations ESCO** framework, e.g. **ESCO 215** which stands for: electrical engineers, electronics engineers, system control engineers, electrolysers engineers, etc.

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9 | Esco (europa.eu)
The level of hydrogen knowledge for each occupational profile is attributed on a scale of “0 – 3” based on the feedback of interviewees.

- “0” means no hydrogen knowledge is required at all,
- “1” generic or primary level of hydrogen knowledge is demanded which usually corresponds to couple of hours of training;
- “2” corresponds to a medium level of hydrogen knowledge is required corresponding to several weeks to few months of training;
- “3” is the highest level of hydrogen knowledge required which corresponds to academic specialisation or long experience in hydrogen or similar gases.

The level of hydrogen knowledge required should not be confused with the educational background and specialisation demanded for each occupational profile. An average value of the hydrogen knowledge is calculated for each ESCO based on the average of all values provided for the occupational profiles in this ESCO group.

EQF Classification

In addition to the ESCO, the analysis identifies and attributes the European Qualifications Framework EQF\(^\text{10}\) to each occupational profile. The EQF identifies and classifies the level of education in common framework to accommodate the different education systems across Europe. The EQF classifies education background into 8 different levels where EQF 1 is characterised by Basic general knowledge and skills required to carry out simple tasks and having a low level of education, while EQF 8 is characterised by knowledge at the most advanced frontier of a field of work or study and the most advanced and specialised skills and techniques, corresponding to the highest level of education i.e. PhD.

The hydrogen value chain

The hydrogen value chain is broken down into three groups: manufacturing, project and support. These three groups include 10 verticals of the hydrogen industry as illustrated in Figure 26. The interview campaign targeted and investigated market players across verticals of the hydrogen value chain. The goal was to build a representative sample, as much as possible, of all the key players and outline needs specific to their type of activities or their role in the value chain.

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\(^{10}\) [Description of the eight EQF levels | Europass](#)
FIGURE 26 - HYDROGEN VALUE CHAIN

<table>
<thead>
<tr>
<th>Manufacturing</th>
<th>Project</th>
<th>Support</th>
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<tr>
<td><strong>Components &amp; Material</strong></td>
<td><strong>Equipment</strong></td>
<td><strong>System Integrators</strong></td>
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<td>Catalysts</td>
<td>Fuel cells</td>
<td>Integrators of refuelling stations, power trains</td>
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<td>Membrane</td>
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<td>Valves</td>
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<td>Tubes</td>
<td>Compressors</td>
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<tr>
<td>Power electronics</td>
<td>Storage</td>
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<tr>
<td>Power electronics</td>
<td>Storage</td>
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Annex 2 – Desk Research T2.2

The Annex 2 covers the documentary research conducted as part of the Task 2.2 of the Green Skills for Hydrogen project. The content is available on the next page.
Scope of the study:

Identify current and emerging Occupational Profiles and Urgent Skills Needs:

• Focus will be on high demand roles and those requiring advanced technical and engineering skills

• Design an interview guide & coordinate execution of interview campaign (primary research) with ecosystem players, targeting 20 interviews (industry, national H2 associations, academics)

• First synthesis to consortium stakeholders on current and emerging Occupational Profiles for hydrogen sector including first draft with practical references to ESCO occupation profiles (to set the framework for the market needs analysis across the countries)
Definitions:

- **ESCO**: is the multilingual classification of European Skills, Competences, and Occupations. The ESCO classification identifies and categorises skills, competences, and occupations relevant for the EU labour market and education and training.

- **Occupational Profiles (OP)**: jobs within the EU labour market Europe. In this framework, 3008 different « occupations » are listed. Each occupation is mapped to exactly one ISCO-08 code. ISCO-08 can therefore be used as a hierarchical structure for the occupations pillar.

- **Skills**: means the ability to apply knowledge and use know-how to complete tasks and solve problems.

- **Competence**: means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development.

- **Qualifications**: are the formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards.

Notes:

We highlighted in Green the sections concerning green H2 jobs & skills

“p34” stands for page 34 of the document

FTE= Full Time Equivalent
Scope of the study

Conducted on the top 10 of Europe (in terms of H2 industry size)

- 45 documents were studied over these 10 countries:
  - Germany, Sweden, Austria, Belgium, Denmark, Finland, Netherlands, Italy, Spain, France
## Germany desk research: Summary

<table>
<thead>
<tr>
<th>Document Number</th>
<th>Document title</th>
<th>Authors</th>
<th>Date of publication</th>
<th>Language</th>
<th>Value chain covered</th>
<th>Time</th>
<th>Geographical perimeter</th>
<th>Activity sectors covered</th>
<th>Hydrogen focus</th>
<th>Occupational profiles</th>
<th>Skills needs</th>
<th>Competences</th>
<th>Qualifications</th>
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<tbody>
<tr>
<td>G1</td>
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G1 Synthesis: Fraunhofer study
Competence for the hydrogen age

Key data

• 2 millions tons of grey H2 used currently (per year?)
• Green-Hydro-Chem Central Germany -> Biggest electrolysers in the world of 100 MW by Siemens
• Description of the different R&D projects by Fraunhofer
• Electrolyzer: manufacturing production shifting to automated production (p 20) / same for Fuel Cells
• H2 council (Linde, Daimler, Audi, Bosch and BMW (p 24)
• 800 TWh of H2 needs in 2050 for electrolysis capacity of 80 GW. This will not allow to cover all the national H2 demand. So Germany will need to import H2.
G2 Synthesis: Work and social ministry study

Employment and skills needs for 2030

Scope of the study

Current picture and trends projection of employment needs by sector and type of activity with 2 scenarios:
1. Basic with the continuation of current developments and low development of digital technology
2. Accelerated digitization with strong political support for new technologies

What are the impacts of digital technology on employment needs?

Sector studied:
- Technical services (computer science and natural science)
- Buildings
- Industry (Part 2.2)

Professional groups studied:
- Workers without skills
- Professionals and senior professionals
- Academic occupations (p 34)

Skills & Competencies overview (p 30)

Applicable to all professional sectors:
- Physical activities will decrease for all levels
- Digital skills and man-machine interface management
- Ability to manage large amounts of information (p 35)
- Ability to transfer scientific research to industry in an interdisciplinary manner
- Ability to network in interdisciplinary teams
- Ability to learn quickly in new area

Applicable only to industry (p 38):
- Data Analysis, and programming
- R&D
- Communication

Focus on new Occupational Profiles and competencies related
- 150 new/changed business areas were studied.
- H2 does not appear
- In relation to energy, only domestic batteries and photovoltaic systems are mentioned (p 84)

Note: Red means that the needs are going to decrease and green that the need are going to increase
G3 Synthesis: Federal Ministry for Economic Affairs and Energy study
National Hydrogen Strategy

Key data
- Need 90 to 110 TWh of H2 by 2030 with 5 GW of generation + import (p 5)
- Insist a lot on the need to establish international markets and cooperation (p 7-8 and 11-12)
- 3 main final markets → Industry, Transport and Heat (p10)
- Focus on research, education and innovation (p 12). Insist on the need to accelerate and facilitate the bridge between education & research and between research & Industry.
- Explain national governance structure (see figure 2, here below on right side)
- Contain an action plan (roadmap to 2030) to develop H2 ecosystem with 38 measures

Focus on Education, Occupational Profiles and Skills needs
- **Measure 29 of the action plan is focused on education, skills, and knowledge.** They mention different interesting aspects like:
  - Strong governmental support for vocational and scientific training for H2 production, operation, and maintenance (including plant manufacturing and garage staff for transport).
  - OP needs: highly skilled professionals and outstanding/upcoming scientists
  - Creation of centres of excellence at non-university research institutions and institutes of higher education.
  - Cooperation in the creation of vocational trainings in export and partner country
  - Creation of special programs for example for PhD (started in 2021)
Scope of the study and key data (p 6-10)

Scope:
- Current picture and trend projection (2035–2040) of employment needs by sector and type of activity with the goal of a climate-neutral Germany in 2050. The study does not take into account employment needs for exported goods

Key data:
- High demand coming for 25 professional groups (p 9) including computer and building engineering professions
- Need for 750,000 new jobs in 2035 with 1/3 for industry and construction and 7% for manufacturing of electrical equipment
- Important need in mechanical and industrial engineering
- On these 750,000 new jobs, 40% of them are going to be in high demand including jobs in raw material extraction (Competition for high skilled workers), production and manufacturing, and construction-related parts.
- Impacts of digital technology on employment needs are going to be low.

Jobs in high demand by 2035
(p 59–61)

Employment difficulties by 2035 are qualified according to two criteria:
- The professional level
- The business sector

Results
- Jobs in raw material extraction (competition for high skilled workers), production and manufacturing, and construction-related parts and Professionals are the future bottleneck in the German labor market (see figure 3 and 4)

To avoid these tensions, various solutions are considered:
- Increase communication around training programs and increase their numbers
- Creation and enhancement of training to allow change of jobs during one’s career
- Increase the participation of women and seniors in the labor market
- Increase immigration (especially of qualified people) through simplified recognition of diplomas abroad, promotion of the acquisition of German language skills (p 10)
G5 Synthesis: CEDEFOP Study
Germany skills forecast

Key data and weaknesses of the study

Key Data:

- Jobs in high demand are classified according to the ESCO scheme
- Related to H2, the tensions are focused on plant and machine operators and assemblers
- There is going to be an important need for Professionals but without specific difficulties in hiring such kind of profile.

Weaknesses of the study:

- High level study that does not make possible to highlight needs related to specific sectors such as hydrogen

Figure 5: Indicators of future hiring difficulties
Scope of the study and key data (p 6-10)

Scope of the study:
- Status and overview of the H2 and fuel cell industry in Baden Württemberg (Market, players, and trends) including jobs creation potential

Key data:
- 90 companies (all along the value chain) and 18 research centres already are active on H2 subjects in the region (p 74)
- Historic region of the automotive industry
- 840 employees currently working on H2 mainly in the manufacturing and R&D departments of big companies. (p 87)
- Creation of 16 000 new jobs for 2030, 11 000 for components manufacturing, 5 000 for equipment manufacturing, and 350 for H2 production. It is representative of Germany where 70 000 new jobs are going to be created by 2030.

Figure 6: Leading H2 companies in Baden Württemberg
Key data and scope of the study

**Key Data:**
- 70,000 jobs will be required in the H2 sector by 2030
- No overview of the H2 labor market currently available in Germany
- Wide range of cross-cutting aspect in the H2 value chain
- Emphasizes the importance of not creating too many new education programs but building on top of existing ones & adding specific parts on H2

**Scope of the study:**
- Overview of the different fields of education and training in the H2 value chain and its cross-cutting topic. It also contains a view of the attractive jobs opportunities in the H2 sector.
- Use data from Enerdata’s study for France’s Hydrogen

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<th>Value chain and Occupational Profiles needed for H2 ecosystem</th>
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<td>CCUS and Blue H2</td>
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<td>Stationary applications</td>
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**Occupational groups involved**
- Electrical, mechanical, plant and network engineers, and project planners
- Gas employees, plant engineers, control room staff, gas plant engineers, master craftsmen, contract installation companies
- Electrical, Mechanical, plant and project engineers, administrative staff, master technician, distribution network specialist
- Network, welding engineers, pipelayers, welders, specialist in distribution network, plant and master network technicians
- Plant and civil engineers, planners, fitters and plant operators

**Key knowledge required**
- Electricity, Gas, Water and Economy
- Gas, Electricity, Geology and Economy
- Long-term regional functionality, electricity, gas, water, communication infrastructure, administration, geology, and geography
- Gas, communication, Geology and geography
- Electricity, Gas and Economy
## Sweden desk research: Summary

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S1 Synthesis: Fossil free Sweden study
Hydrogen strategy for fossil free competitiveness

Key data

• Several projects planned or in operation in the industry sector for the production and use of H2 (HYBRIT, Ovako). These projects required 55 TWh of electricity and electricity grid capacity will be a limiting factor in several places.

• Goal of 3 GW electrolysis power in 2030 and 8 GW in 2045

• Many projects are under development to support skills enhancement and research related to H2. These projects include public administration, universities, research centres and industries.

Focus on R&D, and skills

• The strategy insists on the need to train people on the safety aspects of H2.

• In 2020, the Swedish energy agency, opened a tender for new competence centres (networks between academia and industry). They will be inspired by those created for wind energy.

• The foundation for strategic research will support the creation of a research center for “Production, Use, and Storage of H2” led by RIT and KTH and with the participation of 3 other universities (Chalmers, Lund, and Umea university) and RISE research group.

• A coordinating agency for licensing issues related to hydrogen needs to be set up

• There is a need to train government agencies to H2.
S2 Synthesis: Industry economic council Study
Swedish industry and new European policies

Scope of the study
• This study is part of the definition of the new industrial policy defined by the European Commission in 2021.
• 3 main topics are addressed:
  • Impact of new technologies and industry skills needs
  • Green transition and competitiveness of the Swedish industry
  • Major issues in industrial policy

Skills & Competencies in the industry overview
• Current education level in the industry:
  • 60% of the employees have at least a secondary school diploma (2-3 years)
  • 30% have a post-secondary education
• Classification of most common current OP:
  • Process and machine operators
  • Machine setter and assembler for metals
  • Mechanical engineer and technician
  • Civil engineer
• Medium to long-term Op in high demand:
  • civil, industrial, energy, and electrical engineering

Key issues and current public policy
• Demand rises sharply for higher-skilled jobs and problem-solving, communication, creativity, and adaptability skills
• There are large differences in OP depending by region
Government policy:
• Strengthen lifelong learning because careers are longer (postponing the retirement age). A new law has been voted on this subject and public training organizations now offer evening programs to facilitate the acquisition of new skills during career
S3 Synthesis: Wsp Study for Kronoberg region
Analysis of skills needs in industry, transport and logistics

Scope of the study
• 3 sector are studied in this analysis:
  • Industry
  • Transport
  • Logistics
• This study looks at skills needs in 3 to 5 years

Skills & Competencies in the industry overview
• Current jobs in high demand in the industry:
  • Civil engineers
  • Machine operators
  • Electrician
  • Boilermaker
• Reasons for this high demand:
  • Often work in 3*8
  • Employees need to live close to the factory
• Skills needs:
  • Be fluent in Swedish for safety reasons
  • Ability to learn quickly
S4 Synthesis: Energi Företagen Study
Energy companies skills need and their attractiveness in the job market

Scope of the study
- Based on 95 interviews of energy sector companies (heating and electricity network, renewables installer, energy services, and nuclear).

Skills & Competencies in the industry overview
- Current job needs in the industry (top 5):
  - Electricity engineer
  - IT/data engineer
  - LV electrician
  - Operations engineer
  - Project manager
- Current jobs in high demand (top 5):
  - IT developer
  - Electricity network analyst
  - Energy quality analyst
  - Dam safety engineers
  - Senior project manager
- Education levels needs:
  - 7% of recruited people have ESCO level 7
  - 25% of recruited people have ESCO level 6
  - 27% of recruited people have ESCO level 5
  - 30% of recruited people have ESCO level 4

Figure 8: Regional recruitment difficulties
Key data and weaknesses of the study

Key Data:

- Jobs in high demand are classified by the ESCO classification.
- Related to H2, operators & assemblers of plant and machines are in high demand.
- There is going to be an important need for Professionals but with no specific difficulties in hiring for this kind of profile.
- 68% of job openings are for high-qualification workers. In 2030, they are going to represent the majority of the labor force.
- Number of workers over 60 years old will double by 2030.

Weaknesses of the study:

- Study is at a really high level and does not make possible to highlight needs related to specific sectors such as hydrogen.

Figure 9: Indicators of future hiring difficulties
## Austria desk research: Summary

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A1 Synthesis: Federal Ministry for climate action study
Austria hydrogen strategy

Key data

- Austria wants to position itself as a leader in hydrogen storage in Europe.
- To achieve climate neutrality in 2040, the industry will need 59 TWh of hydrogen.
- The development of 1 GW of electrolyzers by 2030 should create 5,000 full-time equivalent jobs.
- Creation of an interdepartmental working group and an advisory board to coordinate the implementation of the national hydrogen strategy.

A2 Synthesis: Ministry of transport, innovation, and technology study
Jobs and industry 4.0 in Austria

Key data and scope of the study

- The metal industry is the leading manufacturing industry in Austria. It is followed by mechanical engineering, food processing, electrical and chemical industry
A3 Synthesis: IBW study
Survey of companies on the need/shortage of skilled workers

Key data and scope of the study

• The survey was conducted in April/May 2022 among 3936 trade chambers member companies
• Austria is currently facing a record number of unfilled jobs for skilled trades (272 000 jobs).
• This shortage is particularly acute in the construction and technical craft sectors.
• In terms of OP, the manager or leader role are the most difficult to recruit.
• 3 main solutions are mentioned to solve this problem:
  • Encourage the unemployed to return to work
  • Financial support for the employment of women and older people
  • Simplifying the employment of workers from outside the EU
• This very generic study does not highlight specific shortages related to the hydrogen industries

Skills & Competencies in the industry overview

• Many companies indicate that it is difficult to find technical profiles (from managers to technicians) and plant and machine operators.
• For the OP related to hydrogen, 3 main ones are in high demand:
  • IT Professionals
  • Electrician and electrical engineer
  • Metal specialist
A4 Synthesis: Vienna institute for international economic studies Study
Employer’s Skills requirements in the Austrian labour market

Key data and scope of the study
• This study uses information extracted from over 1.5 million job advertisements over past 15 years from Austria’s largest online job portal.
• It uses a specific skills classification:
  • Information and communications technology skills
  • Cognitive skills
  • Non-cognitive (soft) skills
• It shows that the 3 most frequent requirements are:
  • Cognitively based skills (especially language skills)
  • Previous experience work
  • ICT
• In terms of noncognitive skills, the most in demand by employers are:
  • Ability to work as a team
  • Communication skills
  • Independence
  • Flexibility
  • Accuracy
A5 Synthesis: EY Study
Shortage of skilled workers in medium-sized companies

Key data and scope of the study
• The survey was conducted in December 2021 among 628 medium-sized companies.
• A majority of respondents in industry and the energy sector indicate that it is very difficult to find qualified workers.
• Some regions have more difficulties in finding skilled workers, such as Vorarlberg, Tyrol and Low-Austria.
• The main reason of these difficulties is the shortage of competencies.

A6 Synthesis: Economica Institute for Economic Research Study
Economical impacts of the national H2 strategy

Key data and scope of the study
• The survey shows the impact on the labor market of the national H2 Strategy.
• The construction of electrolyser factories is expected to create 4790 jobs.
Key data and weaknesses of the study

Key Data:

• Labour force is expected to growth for every age.
• **45% of job openings are for high-qualification workers.**
• There is going to be a high demand of technicians and associate professionals.

Weaknesses of the study:

• Study is at a really high level and does not make possible to highlight needs related to specific sectors such as hydrogen
# Belgium desk research: Summary

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<td>B4</td>
<td>Skills roadmap for the Flemish climate transition</td>
<td>Roland Berger</td>
<td>2021</td>
<td>Flemish</td>
<td>-</td>
<td>2020-2035</td>
<td>Belgium (Flanders)</td>
<td>Energy intensive industry</td>
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<td>B5</td>
<td>Belgium skills forecast</td>
<td>CEDEFOP</td>
<td>2020</td>
<td>English</td>
<td>All</td>
<td>2020-2030</td>
<td>Belgium</td>
<td>All</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
B1 Synthesis: Belgian government Study
Vision and strategy Hydrogen

Key data

**National hydrogen strategy:**

- Total demand for H2-molecules and H2-derivatives will raise 125 – 200 TWh/year in 2050 in Belgium.
- Electrolysis capacity will remain limited in Belgium because of the limited local renewable energy potential (150 MW in 2026).
- Belgium wants to be an important transit hub for H2 (20 TWh in 2030 and 350 TWh in 2050). To do that, they want to develop 3 main imports routes:
  - North Sea Route
  - Southern Route (Iberia and North Africa)
  - Shipping route

![Figure 11: H2 Value chain in Belgium](image)
Key data and scope of the study

- 4 major job categories will experience significant development, it will be jobs related to:
  - environment
  - customer relations
  - management
  - Technology

- 310,000 people (workers and jobseekers) will need to retrain by 2030 in order to retain or obtain sustainable employment.

Occupational profiles

- Occupational Profiles impacted by big changes:
  - Process design and management professions
  - Maintenance and machining professions
  - IT and network professions
  - Support professions

Figure 12: Specific competencies for Industry 4.0
Key data

- 80% of jobs in Flanders are in the services sectors.
- Manufacturing and Energy sectors represent only 13% of total jobs.
- Significant pressure for future recruitment, because 25% of the workforce will need to be replaced due to retirement in the 2022-2030 period.

Green transition impact on sectors

- **Manufacturing and extractive industries:**
  - Chemicals, metals, rubber, plastics, and petrochemicals will face labour shortage
  - For chemicals, jobs are going to shift from fossil fuel-based chemicals to bio-based chemicals + shortage of highly skilled profiles.
  - Major challenge to attract scientific employees
  - 111,000 employees need to be upskilled in 4 main green themes (durable design and engineering, renewable, efficient circular production, green business model)

- **Utilities:**
  - Most significantly affected by the green transition
  - Jobs growth in construction, installation, and manufacturing

- **Circular economy:**
  - 2020-2030 → a 22.4% job demand increase
Scope and goal of the study

- Evaluate the impact of the transition at work in the energy-intensive industry in Flanders (2020 – 2035)
- Mapping the key skills efforts to be delivered in the sectors
- Structural recruitment need of 30,000 workers between 2020 and 2035.

Focus on skills and Competencies

- 2 periods when there’s an expected labour shortage: **2025 and in 2030.**
- To meet the recruitment need, a **larger share of the available STEM** (Science Technology Engineering & Math) **profiles will have to be recruited.**
- Specific knowledge and skills regarding the 4 green themes will be crucial to make the climate transition reality (see graph)
- Significant upskilling is also required in terms of soft skills, with a focus on:
  - Flexible planning & organization
  - Agile project management

Figure 13: Impact of green transition per job and per sector
B5 Synthesis: CEDEFOP Study
Belgium skills forecast

Key data and weaknesses of the study

Key Data:
• Shortage in low and medium-qualified jobs.

Weaknesses of the study:
• Study is at high level and does not make possible to highlight needs related to specific sectors such as hydrogen

Figure 14: Indicators of future hiring difficulties
# Denmark desk research: Summary

<table>
<thead>
<tr>
<th>Document number</th>
<th>Document title</th>
<th>Authors</th>
<th>Date of publication</th>
<th>Language</th>
<th>Value chain covered</th>
<th>Time</th>
<th>Geographical perimeter</th>
<th>Activity sectors covered</th>
<th>Hydrogen focus</th>
<th>Occupational profiles</th>
<th>Skills needs</th>
<th>Competences</th>
<th>Qualifications</th>
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<td><strong>Government strategy for power to X</strong></td>
<td>Danish Ministry of Climate, Energy and Utilities</td>
<td>2021</td>
<td>English</td>
<td>-</td>
<td>2021-2050</td>
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<td>Brintbranchen</td>
<td>2021</td>
<td>Danish</td>
<td>-</td>
<td>2020-2030</td>
<td>Denmark</td>
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<tr>
<td>D3</td>
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<td>Denmark</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
D1 Synthesis: Danish Ministry for Climate, Energy and utilities study
The Governments strategy for Power-to-X

Key data
• 4-6 GW of electrolysis capacity by 2030 and a tender of 1,25 billion DKK to help this development
• Focus on innovative green technologies and R&D, especially on synthetic fuels.
• Creation of a Danish value chain project for hydrogen with regional growth teams (8 commercial beacons)
• 5 billion DKK of public investment for H2
• 250 million DKK for H2 tank network
• Target to export products and services on the entire value chain
• On the 6 GW target of electrolysis, 30% are going to be for export.
Key data and weaknesses of the study

Key Data:
- Manufacturing sector is highly dependent of German economy
- 66% of total new jobs opening are for high qualification employees.
- No shortage expected for Technician and Professionals

Weaknesses of the study:
- Study is at high level and does not make possible to highlight needs related to specific sectors such as hydrogen

Figure 15: Indicators of future hiring difficulties
## Finland desk research: Summary

<table>
<thead>
<tr>
<th>Document number</th>
<th>Document title</th>
<th>Authors</th>
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<th>Language</th>
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<th>Time</th>
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<tr>
<td>F1</td>
<td>A systemic view on the Finnish hydrogen economy today and in 2030</td>
<td>H2 cluster Finland</td>
<td>2021</td>
<td>English</td>
<td>-</td>
<td>2021-2030</td>
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<td>Hydrogen economy training and R&amp;D activities of universities and research institutes</td>
<td>H2 cluster Finland</td>
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<td>-</td>
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<td>Yes</td>
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</tbody>
</table>
Key data and scope of the study

- No clear shared vision by all the players (Governments, Industry, and R&D Centers)
- National target of carbon neutrality in 2035.
- Study made by interviewing members of H2 Cluster Finland.
- 21 GW (mainly wind power) of new electric capacity planned and a robust transmission grid.
- 46% of heating demand is supplied by district heating networks and produced by CHP.

Zoom on skills and competencies

National Hydrogen Study

Missing:
- Lack of competencies in low-temperature electrolysis (p 11)
- Lack of local technology expertise in hydrogen production.

Opportunities:
- Creation of 10 000 new jobs in the entire H2 value chain. (p 13)

Roadmap for skills and competencies (p19):
- Increased public funding for H2
- Increased collaboration between companies, research institutes, universities, and vocational training.
- Establishing study programs for training experts
- Create training for regulatory, environmental, legal, commercial, and safety aspects
F2 Synthesis: H2 Cluster Finland Study

Hydrogen economy training and R&D activities of universities and research institutes

Scope of the study

- The study has been made in 2021 with the collaboration of 7 universities (Aalto, Oulu, LUT, Tampere, Turku, Vaasa and Abo Akademi).

Key Data

**Hydrogen training in Finland**

- Current H2 courses are distributed within more traditional training programs as individuals or parts of them.
- Current focus of universities is on master degree students.
- Main challenges are the learning of different energy markets and their integration – Electricity market will affect H2 market and its derivatives and vice versa. How these factors should be taken into account in training and curricula is still unclear.

![Figure 17: Education offering, universities summary](image)

The number of plus signs indicates the number of courses available and the color indicates the need to create new courses (Yellow -> Clear need of training, Red -> Need of R&D program)

![Figure 18: Examples of possible university cooperation of training modules to be implemented](image)

An Hydrogen Courses has been created after this study: - Introduction to hydrogen economy

### Table: Energy, Hydrogen Production and Logistics, Products and Use

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>HYDROGEN PRODUCTION LOGISTICS</th>
<th>PRODUCTS AND USE</th>
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<td><strong>Gas</strong></td>
<td>Electrolysis</td>
<td>Electricity, hydrogen networks</td>
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<td>Wind</td>
<td>Thermocatalysis</td>
<td>Liquidification</td>
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<td>Nuclear power</td>
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<td>Hydroelectric</td>
<td><strong>Energy storage</strong></td>
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<td><strong>Hydrogen</strong></td>
<td>Power electronics</td>
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<tr>
<td><strong>Energy</strong></td>
<td><strong>Power electronics</strong></td>
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</tr>
<tr>
<td><strong>Integration</strong></td>
<td><strong>Integration network</strong></td>
<td><strong>Power machines</strong></td>
</tr>
</tbody>
</table>


Mechanical engineering, engines, hydrogen network搜狐. Materials Safety.


Business model, national economy, politics, the environment and the green transition as a whole. Socio-economic issues, social sciences.
Key data and weaknesses of the study

Key Data:

- High-skilled occupations (professionals and technicians and associate professionals) are expected to see lots of job openings. It will be the same for elementary occupations like plant operators.
- In 2030, there will be more medium-qualified people than highly-qualified people.
- There is going to be a big shortage of professionals and technicians and associate professionals in 2030.

Weaknesses of the study:

- Study is at a really high level and does not make it possible to highlight needs related to specific sectors such as hydrogen.

Figure 19: Indicators of future hiring difficulties
# Netherlands desk research: Summary

<table>
<thead>
<tr>
<th>Document number</th>
<th>Document title</th>
<th>Authors</th>
<th>Date of publication</th>
<th>Language</th>
<th>Value chain covered</th>
<th>Time</th>
<th>Geographical perimeter</th>
<th>Activity sectors covered</th>
<th>Hydrogen focus</th>
<th>Occupational profiles</th>
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<tr>
<td>N1</td>
<td>Netherlands Hydrogen Strategy</td>
<td>Ministry of economic affairs and climate policy</td>
<td>2020</td>
<td>English</td>
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<td>N2</td>
<td>THE NORTHERN NETHERLANDS HYDROGEN INVESTMENT PLAN 2020</td>
<td>New energy coalition</td>
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<td>CE Delft</td>
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<td>N7</td>
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<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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</tbody>
</table>
Key data and scope of the study

- 250 companies already active in the field of H2.
- H2 will be a top priority for the industry.
- By 2050, gaseous energy carriers will provide at least 30% of final energy consumption. Depending on the scenario, this would correspond to the consumption of green gas ranging from 337 to 775 PJ (peta joules).

Zoom on research and innovation

- Government strategy on H2:
- Dutch universities and research institutes are developing some specific H2 programs, like the Electrochemical Conversion & Materials program.
- Netherland organization for Applied Scientific Research is also pushing applied research programs as part of the multi-year mission-driven innovation programs.
- Main focus for research are:
  - Industrial production and application
  - Development of offshore wind energy through sustainable gases.
N2 Synthesis: New Energy Coalition Study
The Northern Netherlands hydrogen investment plan 2020

Key data and scope of the study (p 5)

- Northern Netherlands is the leading European Hydrogen valley and is supported by the national investment plan (9 billion €).
- It would provide the Netherlands with the opportunity of securing 66,000 existing recurring FTEs (e.g., gas infrastructure, mobility), attracting 41,000 new recurring FTEs (e.g., maintenance, operations), and up to 104,000 new one-off FTEs by 2050.
- Goal of 4-6 GW of offshore wind capacity dedicated to H2 production in 2030 in the northern Netherlands, for an expected H2 production capacity of 100 PJ/year (65 for the northern Netherlands) and a storage capacity of 150 PJ.
- Available and dense gas infrastructure for transport and storage.
- Historical gas and H2 knowledge.
- More than 50 projects on the existing project pipeline.

Zoom on Knowledge and innovation

- Northern Netherlands H2 Strategy.
- Investments are needed in professional training programs and for job certificates.
- Numerous initiatives are being developed to train people:
  - Regional governments support vocational training to develop blue-collar technical capabilities (installation, engineering).
  - Knowledge institutes have incorporated programs focused on technical and business-related H2 topics.
  - HydroHub provides a testing bed to scale up H2 cases.
  - New Energy Coalition and DNV GL offer H2 courses for energy professionals.

Figure 20: Northern Netherlands roadmap
N3 Synthesis: Netherlands Enterprise Agency study
Excelling in Hydrogen: Dutch technology for a climate neutral world

Key data and scope of the study
• Goal of 21 GW of offshore wind by 2030 and 3-4 GW of electrolyzer by 2030.
• Actual production of 9 million m3 of grey H2.
• 136 000 km of high-quality gas pipeline and parts of its pipes are going to be retrofitted (« National hydrogen backbone » project in 2027).
• Key policies on the Dutch climate agenda is that over 2 million homes must have switched to natural gas alternatives by 2030.
• A detailed list of the bigger H2 projects and companies in the Netherlands is available on this study.

N4 Synthesis: CE Delft Stud
50% green hydrogen for Dutch industry: Analysis of consequences draft RED3

Key data and scope of the study
• The study examines 3 possible variants to achieve the national climate goal (80 PetaJoules, 110 PJ, and 130 PJ). In all these variants 30 PJ are included for transport, and the rest is for the industry.
• Netherlands is the second largest consumer of Hydrogen in Europe.
N5 Synthesis: UWV Study
Industry factsheet 2020

Key data scope of the study
• The study divides the industry into 4 sub-sectors (metallurgy and technology, food, chemical, and other) and looks at trends, highly demanded jobs, skills needs, and opportunities in these sectors.
• Industry represent 9% of all jobs in the Netherlands with 757,000 employees in 2018.

Occupational profiles
• Lots of jobs are in high demand in the industry.
• Low/medium qualified jobs in high demand:
  • Measurement and control technician
  • Mechanic technician
  • Finishing smelter
  • Production planner
  • Pipefitter and welder
  • Machine installer
  • Electrician
• High-qualified jobs:
  • Mechanical project manager
  • Industrial and R&D Manager
  • Automation technician
  • Regulatory advisor
  • Industrial designer

Skills need
• Future skills need in the industry:
  • Know how to use digital tools and simulation technology.
  • Electronics, sensors, and mechatronics
  • Data analyzing
  • Process monitoring
  • Continuous improvement
  • Communication and collaboration
N6 Synthesis: CEDEFOP Study
Netherlands skills forecast

Key data and weaknesses of the study

Key Data:

- Number of **workers over 60 years old will be six times higher in 2030 than in 2000.**
- Primary sector and utilities are going to experience a significant fall in employment.
- Professionals and highly qualified jobs are going to see a lot of job openings.

Weaknesses of the study:

- **Study is at a high level** and does not make it possible to highlight needs related to specific sectors such as hydrogen.

Figure 21: Indicators of future hiring difficulties
Key data and scope of the study

Green H2 study

- The study shows different scenarios of job employment in the H2 sector.
- These scenarios depend on several factors, like H2 production capacity, H2 prices, or end-use sectors’ evolution.
- It shows that mobility and building in high scenario account for an exceptionally large share of labour demand.
- Industry doesn’t represent an important part of the labour demand.
- * Hydrogen in buildings is for hydrogen central heating boilers, hybrid heat pump, and heating networks.
- Detailed per sector are available p 18-34.

<table>
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<tr>
<th>Year</th>
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<th>Recurring demand for labor (in FTE/year)</th>
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<td>2040</td>
<td>2.000–13.300</td>
<td>9.200–43.000</td>
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<tr>
<td>2050</td>
<td>2.200–20.000</td>
<td>14.200–72.600</td>
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</table>

Table 1 – Overview of labour demand (rounded to hundreds)

Figure 22: Overview of labour demand in Netherlands

Figure 23: One-off demand for labour, by sectors

Figure 24: Returning labour demand, by sectors
<table>
<thead>
<tr>
<th>Document number</th>
<th>Document title</th>
<th>Authors</th>
<th>Date of publication</th>
<th>Language</th>
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<td>I1</td>
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<td>Asso Lombarda, EY, Mangroup and Pearson</td>
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<td>Forecast on professionals employments needs Italy at medium term (2022-2026)</td>
<td>Unioncamere and ANPAL</td>
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</tbody>
</table>
**I1 Synthesis: EY, Man Power Group and Pearson Study**

The future of skills in Italy

**Key data and scope of the study**

- Different results are available on the website of the study: [https://www.job2030.it/website/](https://www.job2030.it/website/)
- This study looks at the impact of megatrends on the labor market.
- They are: Social inequalities, Changing working patterns, Climate change and environmental degradation, Urbanization continues and Scarcity of natural resources, Diversification of learning and education processes, Expansion of the economic influence of the East and the South, Growing influence of new governance systems, Growing consumerism, Increase in migration, Changing health challenges, Technological innovation, Change in security, Increase in demographic imbalances.

**Results of the study (p 64–65)**

Skills need (p 24):
- Ability to propose ideas
- High adaptability
- Autonomy
Key data and scope of the study (p 22-26)

- In this study, different national H2 strategies were studied, and recommendations were made on the content of the future Italy’s H2 strategy.

- 2 sectors that are going to benefit the most from H2 in Italy are transport and building with respectively 39 and 32% of the total H2 demand by 2050.

- Italy wants to be a hydrogen hub between north Africa and Europe.

- Italy is the biggest manufacturer of thermal technologies in Europe and second for mechanical and systems and components.

- H2 can create between 70 000 and 115 000 new jobs by 2030 and between 320 000 and 540 000 by 2050.

Zoom on skills and competencies

Recommendations on H2:

- Introduction of new educational programs and running of specifically designed training programs for workers. (p 26)

- Used existing skills in the production of evaporators, condensers, burners, boilers and plant components to help the development of H2 supply chain (p 44).

- Used Italian skills in biomethane production to help with the production of renewable H2 (p 51).
I3 Synthesis: Unioncamere and ANPAL Study
Forecast of professionals employment needs in Italy at medium term (2022-2026)

Key data and scope of the study

- The scenario takes into account 3 major transitions already underway, the digital transition, the environmental transition, and the demographic transition.
- Italian governments have planned to invest 25 billion in the digitization of the production system and, 24 billion in renewable energy and sustainable mobility.
- Italy wants to increase the number of young people in the labor market by increasing the number of vocational education training and developing tertiary vocational training systems

Zoom on skills and competencies (p 25-43)

Occupations needs
- Industry sector will have an important growth of employed people thanks to national public investment plan → important need of Technical professionals (especially market relations technicians, training and research specialist, engineering technician).
- There will also be a strong need of mechanics, fitters, repairers, and maintenance workers for mobile and stationary machines.

Skills need:
- Transport sector need new skills in green technology.
- Strong needs of environmental IT specialist and marketing expert.
- For all the employees, needs to develop digital skills.
- Need of highly specialized and technical professions like software analysts, control specialist or electronic, energy, industry, marketing, designers, and mechanical engineers.
Key data and weaknesses of the study

**Key Data:**
- Number of workers over 60 years old will increase
- In terms of sub-sector computer programming, and research and development will grow.
- Primary sector and utilities are going to experience a significant fall in employment.
- Professionals, technicians, associate professionals, and highly qualified jobs will see many job openings.

**Weaknesses of the study:**
- Study is at a high level and does not make it possible to highlight needs related to specific sectors such as hydrogen

*Figure 26: Indicators of future hiring difficulties*
<table>
<thead>
<tr>
<th>Document number</th>
<th>Document title</th>
<th>Authors</th>
<th>Date of publication</th>
<th>Language</th>
<th>Value chain covered</th>
<th>Time</th>
<th>Geographical perimeter</th>
<th>Activity sectors covered</th>
<th>Hydrogen focus</th>
<th>Occupational profiles</th>
<th>Skills needs</th>
<th>Competences</th>
<th>Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES1</td>
<td>Employment in Spain by 2025</td>
<td>Ramon Alos</td>
<td>2019</td>
<td>Spanish</td>
<td>All</td>
<td>2019-2025</td>
<td>Spain</td>
<td>Industry, Public Administration and Tertiary</td>
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<tr>
<td>ES2</td>
<td>Young people and the labor market in Spain</td>
<td>Spain social council</td>
<td>2020</td>
<td>Spanish</td>
<td>-</td>
<td>2020</td>
<td>Spain</td>
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<td>No</td>
<td>No</td>
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<td>ES4</td>
<td>Case study on green jobs and skills development for people with low qualifications</td>
<td>RAND Europe</td>
<td>2022</td>
<td>English</td>
<td>-</td>
<td>2020-2030</td>
<td>Spain</td>
<td>Green Industry</td>
<td>Yes</td>
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<tr>
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<td>National Hydrogen Roadmap</td>
<td>Ministry of Ecological transition</td>
<td>2020</td>
<td>Spanish</td>
<td>-</td>
<td>2020-2050</td>
<td>Spain</td>
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<td>ES6</td>
<td>Spain skills forecast</td>
<td>CEDEFOP</td>
<td>2020</td>
<td>English</td>
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<td>2020-2030</td>
<td>Spain</td>
<td>All</td>
<td>No</td>
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<td>Yes</td>
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</tr>
</tbody>
</table>
**Key data**

- Study the impact of different factors like climate change, or digitization on jobs and skills by 2025.
- The number of jobs will increase in the following sectors (p28): *Technology and Transport*.
- Occupation where demand will increase the most (p29):
  - Physicist
  - Engineers
  - Mathematician
  - Finance specialist
  - ICT Professionals
- Cross-cutting skills most in demand in the years to come:
  - Creativity
  - Ability to solve complex issues
  - Ability to work on teams
  - Cognitive flexibility
  - Ability to take decision
ES2 Synthesis: Spain Social Council Study
Young people and the labor market in Spain

Key data

Introduction:
• High unemployment rate for young people in Spain because of several factors like the lengthening of the training period, the increase in temporary jobs, and the growing difficulty of accessing housing.
• Moreover, there is a general mismatch between the training offered to young people and the demands of employers.

Recommendations:
• To solve its problems the economic council recommends to take certain measures:
• Promote alternative vocational training
• Increase the number of higher education graduates
• Improve the scholarship and student aid system
Key data and scope of the study

- The study looks at the impact of the ecological transition on jobs in Spain with a focus on Madrid and low qualifications jobs.
- This transition should create between 250,000 and 350,000 new jobs in Spain by 2030.

Occupational Profiles

- Renewable energies is the first sector of growth in Spain in 2020 (especially in electric vehicles and energy products (e.g. biofuels))
- 9,145 new jobs are going to be created in Hydrogen sector by 2030.
- Biggest future green occupations are going to be:
  - Analyst of sustainable technology solutions and projects
  - Renewable energy expert
  - Environmental engineer
  - Technician for quality and environment
- In terms of occupations for low qualified people, the most in-demand are:
  - Electro-engineering workers
  - Science and engineering technicians
  - Sales workers

Skills needs

- Soft skills are the most sought after by employers, including namely communication, collaboration and creativity, attitudes, assisting and caring.
- Employers also often look for:
  - Ability to work with computers
  - ICT Skills
  - Business knowledge
  - Administration and law
  - Management and information
  - Language skills
  - Skills in engineering, manufacturing and construction
  - Knowledge of natural sciences, mathematics and statistics.
Key data and scope of the study (p 22-26)

H2 potential in Spain (classify by order of feasibility and importance):

- 1. Industry
- 2. Heavy duty Transport
- 3. Energy storage
- H2 can also be used in islands and isolated energy systems.
- Goal of 4 GW of electrolyzers installed in 2030.
- 500 000 tonnes per year of grey H2 already produced for industry

Zoom on skills and competencies (p 36)

Recommendations for H2 skills:

- Adapt the profiles and technical inspections to deal with tasks related to H2 (e.g. train firefighters, road attendants, and workshop technicians).
- Promote H2 in existing education plans, especially at university and intermediate and higher degree cycles.
- Strengthen the role of the National Hydrogen Centre as a reference public R&D centre.
Key data and weaknesses of the study

Key Data:
• Employment in Manufacturing and Primary and Utilities is forecast to decline by 2030.
• Nevertheless, some sub-sectors, such as electricity, gas, steam & air conditioning, and water supply are forecast to see increases in employment over the same period.
• Science and engineering professionals and highly qualified jobs will see many job openings. These OP will face tension in recruitment in the years to come.

Weaknesses of the study:
• Study is at a high level and does not make it possible to highlight needs related to specific sectors such as hydrogen
## France desk research: Summary

<table>
<thead>
<tr>
<th>Document number</th>
<th>Document title</th>
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<th>Occupational profiles</th>
<th>Skills needs</th>
<th>Competences</th>
<th>Qualifications</th>
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</thead>
<tbody>
<tr>
<td>Fr1</td>
<td>Hydrogen: Analysis of industrial and economic potential in France</td>
<td>ADEME</td>
<td>2019</td>
<td>French</td>
<td>Production, Transport, Storage and Applications</td>
<td>2020-2035</td>
<td>France</td>
<td>H2 industry</td>
<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>Fr2</td>
<td>Hydrogen: Skills and training needs &amp; Overview of the training offer</td>
<td>Caux Seine</td>
<td>2019</td>
<td>French</td>
<td>Production, Transport, Storage and Applications</td>
<td>2020-2030</td>
<td>France (Normandie region)</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Fr3</td>
<td>Value Chain and Skills &amp; Professions of the Hydrogen Industry</td>
<td>France hydrogène</td>
<td>2020</td>
<td>French</td>
<td>Equipment manufacturing, Production and Applications</td>
<td>2020</td>
<td>France</td>
<td>H2 industry</td>
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<td>Yes</td>
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<td>No</td>
<td>Yes</td>
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<tr>
<td>Fr4</td>
<td>Jobs and skills in the H2 sector in AURA</td>
<td>Tennerdis</td>
<td>2020</td>
<td>French</td>
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<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Fr1 Synthesis: Ademe study
Hydrogen: analysis of industrial and economical potential

- Partial existence of the H2 trades
- Upgrading of skills rather than a complete reorientation:
- Need for rapid upgrading to meet future industry acceleration
- 58,000 to 107,000 new jobs generated by 2030
- 10 parts of the Value chain analyzed: none of them has a need in skills & training priorities are elsewhere

### Key Data

<table>
<thead>
<tr>
<th>Production</th>
<th>Logistics</th>
<th>H2 Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2 Production Equipment</td>
<td>Transport, Distribution &amp; Storage</td>
<td>Vehicles</td>
</tr>
<tr>
<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Activities evolution in the future

- **2025**
  - Electrolysers
  - Specialized equipment: Compressors, H2 transport trucks, tubes, and liquefaction stations
  - Distribution pump/Charging station

- **2030**
  - Carbon capture equipment for methane reforming plants
  - Trucks
  - Airplanes

#### Competencies

- ★ Membranes manufacturing
- ★ Manufacture of large capacity electrolyser
- ★ Membranes manufacturing
- ★ Manufacture of large capacity electrolyser
- ★ Manufacture and maintenance of additional electrical components
- ★ Stacks & PAC integration
- ★ Control of the safety related to H2

#### FTE Generated in 2030

- Electrolysers: ~6 000 à 12 000 FTE
- ~11 000 à 12 000 FTE including a significant share of metal products manufacturing (~80%)
- ~40 000 à 76 000 FTE
- ~1 000 à 6 000 FTE

#### Note:
- We speak of "Technical Skills" and "Activities" rather than "Competencies".

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## Fr2 Synthesis: Caux Seine Study (1/3)
Hydrogen: Skills and training needs & Overview of the training offer

### Production

<table>
<thead>
<tr>
<th>Competences</th>
<th>Transversal competencies</th>
<th>OP</th>
<th>Futur context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td>Fluent in English</td>
<td>Site manager</td>
<td>Few needs of engineers Experience in factory management</td>
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<tr>
<td>Electricity</td>
<td>Computer tools</td>
<td>Process engineers</td>
<td>Refinery/chemical plant experience</td>
</tr>
<tr>
<td>Automation</td>
<td>Operation technician</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piping</td>
<td>★ Maintenance technician</td>
<td>H2 basic knowledge</td>
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</tr>
</tbody>
</table>

### Fuel cell

<table>
<thead>
<tr>
<th>Competences</th>
<th>OP</th>
<th>Futur knowledge</th>
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<tbody>
<tr>
<td>Electronic</td>
<td>Mechanical engineers</td>
<td></td>
</tr>
<tr>
<td>Electromechanical</td>
<td>Electronics engineers</td>
<td></td>
</tr>
<tr>
<td>Montage / assemblage</td>
<td>Technician</td>
<td></td>
</tr>
<tr>
<td>PhD (FC efficiency)</td>
<td>Production technician</td>
<td>Will be from the automotive sector H2 and FC knowledge</td>
</tr>
<tr>
<td>Maintenance technician</td>
<td>Electromechanics</td>
<td></td>
</tr>
<tr>
<td>Maintenance engineers</td>
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</tbody>
</table>

### Logistics

<table>
<thead>
<tr>
<th>Competences</th>
<th>OP</th>
<th>Futur context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mecanisme</td>
<td>Ingeieurs</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>PhD (electrolysis H2 purification)</td>
<td>Automation</td>
</tr>
<tr>
<td>Automation</td>
<td>Technician</td>
<td>Electricity</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Production/ Quality/ Methods engineers</td>
<td>HVAC systems</td>
</tr>
<tr>
<td>Command control</td>
<td>Production technician</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Piping</td>
<td>Laboratory technician / Chemist Bac+2/3</td>
<td>Skills on H2 technologies</td>
</tr>
<tr>
<td>Boilermaking</td>
<td>Maintenance technician</td>
<td>★ Technical sales representative</td>
</tr>
</tbody>
</table>

### Fuelling station manufacturer

<table>
<thead>
<tr>
<th>Competences</th>
<th>OP</th>
<th>Futur context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics</td>
<td>Ingénieurs</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>PhD ( électrolyse H2 purification )</td>
<td>Automation</td>
</tr>
<tr>
<td>Automation</td>
<td>Technicians</td>
<td>Electricity</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Production/ Quality/ Methods engineers</td>
<td>HVAC systems</td>
</tr>
<tr>
<td>Command control</td>
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</tr>
<tr>
<td>Piping</td>
<td>Laboratory technician / Chemist Bac+2/3</td>
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<tr>
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<td>Maintenance technician</td>
<td>★ Technical sales representative</td>
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### Fuelling station operator

<table>
<thead>
<tr>
<th>Competences</th>
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<th>Futur context</th>
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<tr>
<td>Electronic</td>
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<tr>
<td>Electromechanical</td>
<td>Electronics engineers</td>
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<tr>
<td>Montage / assemblage</td>
<td>Technician</td>
<td></td>
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<tr>
<td>PhD (FC efficiency)</td>
<td>Production technician</td>
<td>Will be from the automotive sector H2 and FC knowledge</td>
</tr>
<tr>
<td>Maintenance technician</td>
<td>Electromechanics</td>
<td></td>
</tr>
<tr>
<td>Maintenance engineers</td>
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</table>

### H2 transport

<table>
<thead>
<tr>
<th>Competencies</th>
<th>OP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy truck license with experience</td>
<td>★ Drivers « Heavy truck »</td>
</tr>
</tbody>
</table>

Attention, on the whole sheet:
- The skills are described as technical skills
- We talk about training levels and not profiles
- The term “Mechanism” is not clear

Activities
- Conception
- Fabrication
- Operation
- Maintenance
- ★ Expected jobs
- Missing kbs

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## Fr2 Synthesis: Caux Seine Study (2/3)

**Hydrogen: Skills and training needs & Overview of the training offer**

### Light mobility

**Competencies**
- Mechanical Engineers
- Installation/assembly
- Maintenance technician
- Automotive maintenance

**Futur context**
- Mechanics and automotive maintenance
- Basic knowledge of intervention procedures on vehicles H2 operation FC

**Opportunities**
- Production technician

**Expected jobs**
- Knowledge on EVs is essential to work on VH2

### Heavy mobility

**Competencies**
- Mechanical Engineers: Electronics
- Electricity Technicians
- Maintenance technician: électromécaniciens, électriciens, électrotechniciens
- Maintenance technician: électriciens
- Industrial maintenance technician

**Futur context**
- Knowledge of the basics & procedures

**Expected jobs**
- Transfer of skills from the supplier to the vehicle manufacturer

### Industry

**Competencies**
- Automation Operators
- Mechanical Team Leader
- IT safety Risk management
- Maintenance technician

**Futur competencies**
- Non-specific H2 profiles
- Basic knowledge & H2 safety
- Link to IT safety

### Gas network

**Competencies**
- Electromechanical Construction operators
- Automation Pipeline installers
- Maintenance Technician

**Futur context**
- HVAC engineering
- Maintenance technician
- Non-specific H2 profiles
- Basic knowledge & H2 safety
- Link to IT safety

**Specialized maintenance**
- By supplier

### Railway

**Competencies**
- Electromechanical Engineers and R&D
- Automation Production technician

**Futur context**
- Non-specific H2 profiles
- Specialized maintenance

**Activities**
- Conception
- Fabrication
- Operation
- Maintenance

**Missing links**

### Buildings

**Competencies**
- Mechanical Engineers: Renewables generalists, electro technicans
- Electricity Engineers
- Electronic Technicians

**Futur context**
- Experience of Technicians on FC & boilers basic knowledge H2

**Specialized maintenance**
- By supplier

**Expected jobs**
- Engineers or PhD level

---

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### Occupations

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Skills &amp; Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitter</td>
<td>Maintenance, Assembly, Mechanics</td>
</tr>
<tr>
<td>Boilermaker</td>
<td>Boilermaking &amp; Piping</td>
</tr>
<tr>
<td>Automated Line Operator</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Maintenance Electrician</td>
<td>Assembly, Mechanics</td>
</tr>
<tr>
<td>Electromechanic</td>
<td>Maintenance, Mechanics, Electrical Engineering, Control and Quality, Assembly</td>
</tr>
<tr>
<td>Electronics Technician</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Electrotechnician</td>
<td>Maintenance, Electrical Engineering, Control and Quality, Mechanics</td>
</tr>
<tr>
<td>Maintenance Mechanic</td>
<td>Maintenance, Mechanics, Electrical Engineering, Assembly</td>
</tr>
<tr>
<td>Refinery Operator</td>
<td>Electrical Engineering, HVAC engineering</td>
</tr>
<tr>
<td>Computer Numerical Control Machine Operator</td>
<td>Electrical Engineering, Assembly, Mechanics</td>
</tr>
<tr>
<td>Chemical Technician</td>
<td>Mechanics, Control and Quality, Electrical Engineering</td>
</tr>
<tr>
<td>Design Technician</td>
<td>Assembly</td>
</tr>
<tr>
<td>Inspection Technician</td>
<td>Assembly, Maintenance, Mechanics, Electrical Engineering</td>
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<td>Testing Technician</td>
<td>Maintenance, Electrical Engineering, Control and Quality, Mechanics, Montage Assemblage</td>
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<td>Gas Network Operation Technician</td>
<td>Maintenance, Electrical Engineering, Control and Quality, HVAC engineering</td>
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<td>Laboratory Technician</td>
<td>Electrical Engineering, Control and Quality</td>
</tr>
<tr>
<td>Industrial HVAC Maintenance Technician</td>
<td>HVAC engineering</td>
</tr>
<tr>
<td>Industrial Maintenance Technician</td>
<td>Assembly, Maintenance, Génie électrique, Mechanics, Control and Quality, HVAC engineering, Assembly</td>
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<td>Automation Technician</td>
<td>Electrical Engineering, Maintenance, Control and Quality, Mechanics, HVAC engineering, Assembly</td>
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<td>Method Technician</td>
<td>Mechanics, Montage Assemblage</td>
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<td>Oil Technician</td>
<td>Electrical Engineering, Control and Quality, HVAC engineering</td>
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<td>Process Technician</td>
<td>Maintenance, Control and Quality</td>
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<td>Quality Technician</td>
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<td>Robotics Technician</td>
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</tr>
<tr>
<td>Pipelighter</td>
<td>Boilermaking &amp; Piping</td>
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</tbody>
</table>
Fr3 Synthesis: France Hydrogene Study
Value Chain and Skills & Professions of the Hydrogen Industry

### National Strengths
- Local production of electrolysers & PAC
- The components of the BoP are located in France
- French expertise on tanks, piping & HT reactors to process biomass

### National Weaknesses
- Lack of experience in the manufacture of electrolysers & PACs in the international market
- Lack of French skills in the field of:
  - Electrochemical cells PEMs
  - Stationary H2 compressors
  - Stationary power conversion equipment
  - Control systems for stationary installations

### Equipment manufacturing
<table>
<thead>
<tr>
<th>Level of training</th>
<th>60% Engineers</th>
<th>40% Technicians</th>
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</thead>
<tbody>
<tr>
<td>Jobs</td>
<td>Careers in industrial mass production</td>
<td>★ R&amp;D engineer H2</td>
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<tr>
<td>Impacts</td>
<td>Strong growth expected</td>
<td>Creation of jobs upstream at the component supplier level</td>
</tr>
</tbody>
</table>

### Vehicle Integration
<table>
<thead>
<tr>
<th>20% Engineers</th>
<th>30% Technicians</th>
<th>50% Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jobs</td>
<td>★ EV jobs</td>
<td>★ H2 System Engineer</td>
</tr>
<tr>
<td>Impacts</td>
<td>Retraining of personnel on VH2</td>
<td></td>
</tr>
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</table>

### O&M
<table>
<thead>
<tr>
<th>Technician(s)</th>
<th>Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities requiring non-specific profiles with H2 knowledge</td>
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</tr>
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</table>

### Stationary systems installation
<table>
<thead>
<tr>
<th>70% Engineers</th>
<th>30% Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jobs</td>
<td>★ Experienced site manager</td>
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<tr>
<td>Impacts</td>
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### O&M
<table>
<thead>
<tr>
<th>30% Engineers</th>
<th>40% Technicians</th>
<th>30% Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Gas technician</td>
<td>★ Electrical technician</td>
<td></td>
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<tr>
<td>Activities requiring non-specific profiles with H2 knowledge</td>
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### Transport
<table>
<thead>
<tr>
<th>Engineers</th>
<th>Technician(s)</th>
<th>Workers</th>
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<tr>
<td>Jobs</td>
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<tr>
<td>★ Trucks driver</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Level of training**
- Engineers: 60%
- Technicians: 40%

**Impacts**
- 60% Engineers
- 40% Technicians

**Expected jobs**
- ★ R&D engineer H2
- ★ H2 System Engineer
- ★ Mechanical technician / H2 piping

**Attention, in this study:**
Operators are not represented
What is the definition of the training level Worker?
Develop existing training courses in line with the needs of companies
• Ratio of 2 between the need for Engineers and Technicians and 4 between the need for Engineers and Operators by 2023
• Need for specific training for Technicians, who are less versatile than Engineers
• Operator profiles must be made aware of security
• Attractiveness of the sector to be developed because the jobs are already in tension

Key data

Jobs need in 2023:

- 295 Engineers
  - R&D Engineers
  - Commercial Engineers
  - H2 project Manager
- 160 Technician
  - Operation technician
  - Maintenance technician
  - Development Technicians
- 95 Operators
  - Production operators
  - Maintenance operators
  - Fitters Installers

Not representative of the national situation: only one region and only 9 actors interviewed. In AURA, a lot of design

Note: This should be referred to as Technical and Non-Technical Skills rather than Knowledge

Note: The areas of knowledge and skills differ depending on the positioning on the CoP. The expected levels of knowledge differ according to the profile.

Basic knowledge
- Process Engineering
- Fluid Mechanics
- Mechanics
- Electricity
- Chemistry
- Automatism
- Modeling
- Instrumentation

Specific knowledge
- H2 processes: production & transport
- Risk analysis – Safety
- Gas
- Industrial processes using carbonated H2
- Technological bricks including innovations
- Legislative framework
- Monitoring of financing mechanisms
- Renewables

Fr4 Synthesis: Tenerrdis Study
Jobs and skills in the H2 sector in AURA

Funded by the European Union
Annex 3 – Interview Guide T2.2

### National Studies, Strategies & Publications

1. Is there a national study or analysis about the urgent skill needs and occupational profiles? If yes, what is the name and link?
2. What are the available publications or reports about H2 Skills needs? In what language are they?

### Organisation structure

1. What is the total Number of employee (total vs. active in H2) employed in your organisation?
2. What are your organisation activities?
   - Ex. (R&D Design Manufacturing Installation Operations Maintenance Services to the industry (e.g. certification), Training & Education Administration, regulation, etc.)
3. Could you specify how many different jobs in the organisation on H2?

### Company

1. **Company’s main activity? Details by each job (occupational profile)**
   - Trainings levels you look for in your work force?
2. Are employees specialised on H2 when they arrive, or do they learn on the job?
3. Do you require any particular qualifications?
   - (Certifications, Specific Trainings, Specific experiences)
4. What technical / non-technical skills qualification you company look for?
5. What is the H2 knowledge you look currently and in the future?
   - (Basic knowledge, expert knowledge)
6. Do you offer any upskill/reskill training for your employees? Is it made internally or externally?
7. To which of the company’s activities or department are these functions associated?
8. What are the jobs and specialization missing? (i.e. difficult to find/hire) Particular skills missing
9. External activities? Do you get services from Suppliers and subcontractors to cover lack of internal capacities of H2?
10. If yes, what type of H2 skills/jobs subcontracted % in country, % outside country?
11. Transferability of skills?
12. How Often you hire from another industrial sector? Which ones and for what profiles?
13. What profiles will be in high demand in the coming 5 to 10 years? What qualifications, skills and competencies would they be required to have?
Annex 4 – Limitation of the ESCO Framework

The European Skills, Competencies, and Occupations ESCO classification identifies and categorises skills, competencies and occupations relevant to the EU labour market, education and training. Regarding occupations, it uses the International Standard Classification of Occupations (ISCO) in order to gather them into a tree structure. In ESCO, each occupation is associated to one ISCO-08 code, it divides occupational profiles into ten major groups:

0 – Armed forces occupations
1 – Managers
2 – Professionals
3 – Technicians and associate professionals
4 – Clerical support workers
5 – Service and sales workers
6 – Skilled agricultural, forestry and fishery workers
7 – Craft and related trades workers
8 – Plant and machine operators and assemblers
9 – Elementary occupations

Major groups highlighted in a green font are the ones corresponding to occupational profiles relevant to the hydrogen sector. They have been identified according to inputs from industrials interviewed and ESCO descriptions.

The ESCO provides a generic framework for occupational profiles classification and description. It is not meant to address a specific industry but rather to outline specific functions that could be applicable to any industrial context with good level of description of skills and competencies required. In the case of Hydrogen, which is an evolving industry, we couldn't find the level of specification that covers all the occupational profiles in the Hydrogen industry. For example, there is no specific ESCO code for electrolysers or electrolysis engineer. Eventually, this forced us to use the ESCO as a reference tool that groups similar disciplines.

For example, ESCO 215 stands for “Electrotechnology engineers” and is described as “Electrotechnology engineers conduct research on and design, advise, plan and direct the construction and operation of electronic, electrical and telecommunications systems, components, motors and equipment. They organize and establish control systems to monitor the performance and safety of electrical and electronic assemblies and systems”. In our analysis we used this ESCO 215 description to group the following occupational profiles:

\[ \text{ESCO (europa.eu)} \]
\[ \text{Science and engineering professionals | Esco (europa.eu)} \]
- Power electronics engineer
- Electrical design engineer
- Electrochemical engineer
- Electrolysers engineer
- Fuel cell engineer
- Renewable energy engineer
- High voltage electrical engineer
- Grid management, operation engineer
- Conversion, instrumentation engineer
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<thead>
<tr>
<th>Country</th>
<th>Company activity</th>
<th>Occupational Profile</th>
<th>Skills &amp; Competences</th>
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<th>Qualifications</th>
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<td>Public servants specifically on the local level to handle administrative responsibilities</td>
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<td>Permitting and authorization H2 projects at municipality and departmental level</td>
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</table>
## Current Hydrogen Occupational Profiles

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<th>Manager</th>
<th>Electrical &amp; chemical</th>
<th>Industrial</th>
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<tbody>
<tr>
<td>Senior executive manager</td>
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<td>Industrial engineer</td>
</tr>
<tr>
<td>Project manager</td>
<td>Electrochemical engineers</td>
<td>Product design engineer</td>
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<tr>
<td>Scientific advisor</td>
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<td>Production engineer</td>
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<td>Technical director</td>
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<td>Design engineer</td>
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<td>Electrical, renewables engineer</td>
<td>Development and integration engineers</td>
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<td>Construction, project manager</td>
<td>High voltage electrical engineer</td>
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<td>Operation project manager</td>
<td>Electrolysers engineers</td>
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<td>Simulation engineers</td>
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<td>H2 and ammonia production engineer</td>
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<td>H2 and fuel cell research and development</td>
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<td></td>
<td>Auxiliary electrical and mechanical equipment engineer</td>
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<td>Physics expert</td>
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<td>Biomass expert</td>
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<td>R&amp;D engineer</td>
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<tr>
<td>Industrial science researcher</td>
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<td>Fires, explosions &amp; contamination expert</td>
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<tbody>
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<tr>
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<tr>
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<td>Welder</td>
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## Missing Hydrogen Occupational Profiles

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<td>Senior executive manager</td>
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<td>Senior technical manager</td>
<td>Industrial project manager</td>
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<td>Knowledge manager</td>
<td>Project engineer</td>
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<td>R&amp;D manager</td>
<td>H2 production project manager</td>
<td>Materials engineer</td>
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<td>H2 business development manager</td>
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<td>Industrial process project manager</td>
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<td>Chemical project manager</td>
<td>Fuel cell engineer</td>
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<td>Green fuel project manager</td>
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<td>Simulation engineer</td>
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<td>Business development manager</td>
<td>Electric and electronics engineers</td>
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<td>Sales manager</td>
<td>High voltage electrical engineer</td>
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<td>Power electronics engineer</td>
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<td></td>
<td>Conversion, instrumentation engineer</td>
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<td>Energy planning engineer</td>
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<td></td>
<td>Electromechanical engineer</td>
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<td></td>
<td>H2 production engineers</td>
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<td></td>
<td>Chemical process engineer</td>
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<td>Chemical production engineer</td>
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<td>Chemical engineer</td>
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<td></td>
<td>Electrolysers researcher</td>
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<td></td>
<td>Fuel cell researcher</td>
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## Experts

- Innovation expert
- H2 production expert
- H2 value chain expert
- Physics expert
- International standards expert
- Marine engines expert
- Biomass expert
- Energy markets expert
- EPC contracting expert
- Sector coupling expert

## Other Engineering

- Infrastructure repurposing engineer
- Backbone construction engineer
- Construction engineer
- Commissioning engineer
- Marine engineer
- District heating engineer
- Biomedical engineer
- CPM engineer
- R&D engineer
- CCUS professionals
- Geologist

## Communication

- Communication specialists
- Permitting specialists
- Marketing professionals
- Administration professional
- Public administration professional

## Policy & Legal

- Administration professional
- International administration staff
- Legal and regulations specialists
- Public relations specialist
- Public strategy specialist

## Economics & Finance

- Economist

## Technicians

- Baseload specialist
- CCUS professional
- Innovation specialist
- Standards specialists
- Special application specialist
- Gas storage & high-pressure specialist
- Energy transition professional
- Operation optimization specialist
- Certifications specialist
### Business Development Professions

- Business development manager
- Business commercial professional
- Commercialization specialist
- Business development specialist
- Technology commercialization specialist
- Marketing manager
- Sales and commercial engineer
- International business developer
- Energy market professional
- International business developer
- Energy market specialist
- Land access & reservation specialist
- Sector coupling specialist
- Ammonia trader

### Funding and Finance Professions

- Funding and finance specialists
- Statistics specialist

### Maintenance Professions

- Maintenance technician
- Mechanical technician
- Electrolysers maintenance technicians
- Service technician
- Construction technicians
- Commissioning technician
- Health and safety technicians

### Operation Professions

- Operation & optimization specialist
- Operation and service technician
- Operation and service technician
- Operation reliability technicians
- Electrolysers operation technician
- System integration Technicians
- Process reliability technician

### Assembler Professions

- Locksmith
- Foreman
- Assembly technician

### Future Hydrogen Occupational Profiles

**Managers**

- Sales Manager
- Project manager
- Finance manager
- Knowledge manager
- H2 Project manager
- Business development manager
- Engineering project managers
- H2 Value Chain Manager
- Communication Manager
- Sales and marketing manager
- Business development manager
- Technology development manager
- Leaders of working groups
- Engineering project managers

**Experts**

- Expert in fuel conversion
- Material expert
- H2 production expert
- H2 global market & trading expert
- Energy storage expert
- Environmental expert
- EPC contracting expert
- International standards expert
- H2 finance experts

**Electrical & Chemical**

- Electrical engineer
- Electrical, renewables engineer
- Power electronics engineer
- Electronics engineer
- Conversion, instrumentation engineer
- Energy planning engineer
- Automation engineer
- System control engineer
- Renewables engineer
- Electrolysers engineer
- Fuel cells design engineer
- Robotics and production engineers
- Chemical engineer
- Chemical process engineer
- Chemical production engineer

**Industries**

- H2 production engineers
- H2 and ammonia production engineer
- Materials engineers
- Machine engineers
- Methods engineer
- Design engineer
- Process engineer
- Production, supply engineer
- Application and Process engineer
- Storage engineers
- System integration engineer
- Systems design and retrofit engineer
- Systems installation engineer
- Mechanical engineers

**Environmental, HSE**

- Hazardous materials engineers
- Health, and safety design engineers
- Environment engineers

**Test & Quality**

- Balance of plant specialist
- Interconnections specialists
- Grid operation specialists
- Operation optimization specialist
- Standards specialists

**Electrotechnical**

- Electronic technician
- Electrotechnician
- Mechatronics technician
- Electrical technicians
- Electrical and electronics technician
- Renewables technician
- Electrolysers maintenance technician
- Power electronics technician
- Conversion, instrumentation technician
- Electro-mechanical technician
- Chemical production technicians
- Production technician
- Mechanical technician
- System integration technicians
- Computer science technician
- Laboratory technicians
- Marine technician
- CCUS technicians
<table>
<thead>
<tr>
<th>R&amp;D technical experts</th>
<th>Test engineer</th>
<th>R&amp;D specialists</th>
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<td>Physics expert</td>
<td>Quality engineer</td>
<td>Safety and hazards specialists</td>
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<tr>
<td>Technical experts in H₂ hazards</td>
<td>CPM engineer</td>
<td>Certification, permitting specialist</td>
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<tr>
<td>Research and development expert</td>
<td>R&amp;D engineer</td>
<td>Technology mapping specialists</td>
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<td>Power2X technology specialists</td>
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<td>Marine engines expert</td>
<td>Biomedical engineer</td>
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<td>Biomass expert</td>
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<td>CCUS expert</td>
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<td>Offshore bidding specialists</td>
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<td>Land acquisition specialist</td>
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<td>Energy market specialist</td>
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<td>supply chain specialists</td>
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<td>Permitting specialist</td>
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<td>Communication specialists</td>
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<td>Electrical technician</td>
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<td>Renewable energy technician</td>
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<td>Electromechanical technician</td>
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<td>Electro-chemical technicians</td>
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<td>Electronics technicians</td>
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<td>Chemical production technicians</td>
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<td>Fuel cell technician</td>
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<td>Electrolysers technician</td>
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<td>Mechatronics technician</td>
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<td>Safety technicians</td>
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<td>Risk and safety technicians</td>
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<td>Test technician</td>
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<td>Quality technician</td>
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<td>Infrastructure engineer</td>
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<td>Urban planning engineers</td>
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<td>Marine infrastructure engineer</td>
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<th>Policy &amp; Legal</th>
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<tr>
<td>Economy and finances specialist</td>
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<td>renewable generation specialist</td>
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<td>Funding and finance specialist</td>
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<td>Economist</td>
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<td>Public policy specialists</td>
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<td>Regulatory affairs specialist</td>
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<td>Legal and regulations specialists</td>
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<td>Lawyer</td>
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<td>Service technician</td>
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<td>Electrolysers maintenance technicians</td>
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<td>Operators of refuelling stations</td>
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<tr>
<td>Electrolysers operator</td>
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<td>System operators</td>
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<tr>
<td>Metal carpenter</td>
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<td>Fitting and installation technicians</td>
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<tr>
<td>Production worker</td>
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<td>Welding technician</td>
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<td>Assembly technician</td>
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<td>Pipefitter</td>
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<td>Artificial intelligence specialist</td>
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<td>Cybersecurity specialist</td>
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<td>IT and digitalization engineer</td>
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<td>software Engineer</td>
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<td>Process and material technicians</td>
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<td>System integration technician</td>
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<td>Instrumentation technician</td>
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<td>Compressors technician</td>
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<td>Gas storage technicians</td>
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<td>power electronics technician</td>
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<td>instrumentation technician</td>
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<td>Commissioning technician</td>
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<td>Civil construction technician</td>
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<td>Equipment assembly technicians</td>
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<td>CCUS technician</td>
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Annex 7 – Target Audience of the Main Hydrogen Skills and Knowledge in Demand

### Hydrogen Safety and Hazards Target Audience

| ESCO 112 | Senior executive manager |
| ESCO 132 | Senior operational manager |
| ESCO 132 | Senior technical manager |
| ESCO 214 | Health, and safety design engineer |
| ESCO 214 | Design engineer |
| ESCO 214 | Safety and occupational hazards engineer |
| ESCO 214 | Marine engines expert |
| ESCO 214 | Production, supply engineer |
| ESCO 214 | Risk and safety professional |
| ESCO 214 | Environmental, health and safety specialist |
| ESCO 214 | Design engineer |
| ESCO 214 | Marine engineer |
| ESCO 214 | Project engineer |
| ESCO 214 | Risk and safety professional |
| ESCO 214 | Gas facilities construction Project manager |
| ESCO 214 | Specialist in compression and safety |
| ESCO 215 | Chemical engineer |
| ESCO 215 | Safety construction, operation engineer |
| ESCO 215 | Gas facilities construction Project manager |
| ESCO 215 | Expert in H2 hazards and safety in industrial facilities |
| ESCO 216 | Electrical engineer |
| ESCO 216 | Automation engineer |
| ESCO 216 | Naval architects |
| ESCO 241 | Financiers and modelers |
| ESCO 241 | Local public servants responsible for projects validation |
| ESCO 243 | Communication specialist |
| ESCO 261 | Legal and regulations specialist |
| ESCO 261 | Lawyer |
| ESCO 311 | Health, and safety technician |
| ESCO 311 | Maintenance technician |
| ESCO 311 | Safety technician |
| ESCO 311 | Health and safety technician |
| ESCO 311 | Commissioning technician |
| ESCO 311 | Certifications specialist |
| ESCO 311 | Risk and safety technician |
| ESCO 313 | Operations technician |
| ESCO 313 | Maintenance operator |
| ESCO 313 | Operation and maintenance of electrolysis technician |
| ESCO 313 | Refuelling stations technician |
| ESCO 721 | Mechanical fitter |
| ESCO 721 | Metal carpenter |
| ESCO 721 | Pipefitter |
| ESCO 721 | Welder |
| ESCO 741 | Electrical fitter |
| ESCO 741 | Instrumentation fitter |
| ESCO 741 | Mechatronic worker |
| ESCO 811 | Plant and machine operator |
| ESCO 811 | Plant operator |
| ESCO 818 | Refuelling stations operator |
| ESCO 821 | Assembly line operator |
| ESCO 835 | Lock operator |

### Suggested Content
- Basic understanding of Hydrogen gas, mechanical precision, risk assessment and safety aspects
- Hazards and safety of H2 production, distribution, storage and refuelling
- Risk, hazards and safety procedures of H2 production, storage and transport
- Projects’ safety planning and analysis, process safety, failure simulation
- Legal framework and approval of H2 projects and safety standards
- Hazards and safety of high voltage equipment, monitoring and control
- Risk, safety, regulation, certification, and approval of industrial H2 projects
- High pressure equipment, power electronics, norms and standards of gas facilities
- Explosion, jet fire modelling, testing, test facility management, deep knowledge of H2 hazards, risk profiles of H2, H2 transport fuel, bunkering, storage,
- Transition to ammonia powered engines, safety using ammonia in refuelling vessel, Work with transition of marine engines like Wartsila, safety methanol engine
- Refuelling stations, safety, H2 production technologies
## Hydrogen Systems Target Audience

**ESCO 112**
- **CEO**

**ESCO 210**
- Project manager

**ESCO 211**
- Physicist
- Fuel cells design engineer

**ESCO 214**
- R&D specialist
- H2 mobility engineer
- System control engineer
- Systems design and retrofit engineer
- Biochemical engineer
- Mechanical engineer
- Chemical production engineer
- System Integration engineer
- System Engineer
- Drilling engineer
- Maintenance engineer
- Pipeline engineer
- Reservoir engineer
- Electrochemical engineer
- Industrial engineer
- Operation and maintenance engineer
- Quality engineer

**ESCO 215**
- Electrochemistry engineer
- Electrical engineer
- High voltage electrical engineer
- System integration, operation reliability engine

**ESCO 241**
- Energy market expert
- Economist
- Statistics professional

**ESCO 243**
- Energy market professional

**ESCO 311**
- Fuel cell mobility technician
- Maintenance technician
- Electrician
- Electromechanical technician

**ESCO 313**
- Operations technician
- System operation and maintenance technician
- System integration, operation reliability technician
- Process technician

### Suggested Content
- Energy systems integration and infrastructure repurposing
- Design/building an integrated RES coupled with Electrolysers
- Innovative technologies
- Industrial process, Hydrogen as an energy gas and mechanical boundaries of gas systems
- Industrial engineering, quality management system, good understanding of product specifications
- Intermittent power profiles, optimisation of energy systems, co2 prices, etc
- Certificate trading, H2 pricing, modelling of energy scenarios
- Understanding of Hydrogen production equipment and systems design
- Control systems and intelligence (linear, time variant)
- High voltage and renewable energy systems synergies experience
- Power electronics, high and low voltage, fuel cell systems
- Management of Hydrogen systems manufacturing, installation, and commissioning
- Fuel cells manufacturing, testing, power systems, retrofit and back up
- Refuelling stations, storage, transport, Fuel cells, H2 propulsion systems
Hydrogen Regulations, Certification, and Permitting Target Audience

**ESCO 210**
- Project Manager
- Development and deployment project manager
- Project developer
- EPC Project manager

**ESCO 214**
- Chemical Engineer
- Industrial Engineer
- Compliance engineer
- Health and safety engineer
- Health and safety officers
- Permitting, authorization and approval professional
- Environmental expert
- Project execution and delivery
- Construction and infrastructure engineer
- Maintenance engineer

**ESCO 242**
- Public servants responsible for permitting
- Authorization and permitting local public servants
- Public affairs and regulations specialist

**ESCO 243**
- International relation specialist
- International business developer
- Communication and permitting specialist

**ESCO 261**
- Certification specialists
- Regulatory affairs specialist
- Legal affairs specialist
- Lawyer
  - Certification, permitting and regulations specialist

**Suggested Content**
- Knowledge on legal aspects of permits and authorisations procedures specific to Hydrogen
- Regulations, permitting, liabilities and approval procedures of industrial facilities
- Local and international regulation, permitting and certification of gas projects
- Authorisation, permitting and certification of renewable energy projects
- Granting and validation of permits (environmental, social, construction)
- Civil and industrial project construction, EPC, specifications, regulations, permitting
- Risk and safety standards and requirements of H2 projects
- Environmental and social impact assessment

Hydrogen Production Target Audience

**ESCO 112**
- Directors
- General manager

**ESCO 121**
- Plant Manager

**ESCO 122**
- Business development manager

**ESCO 210**
- H2 project manager
- Green Fuel project manager
- Development & deployment project manager
- Experienced & junior project management profile

**ESCO 211**
- Industrial, and processes engineer
- Material and process engineer
- Research and development expert

**ESCO 214**
- H2 and ammonia production engineer
- Chemical processes engineer
- Mechanical engineer
- Construction engineer
- Material science engineer

**ESCO 215**
- Electrochemical engineer

**ESCO 241**
- Economist

**ESCO 243**
- Land access and reservation specialist

**ESCO 261**
- Certification specialists

**ESCO 311**
- Health, and safety technician
- Production technician
- Test technician
- Electrical technician
- Mechanical technician
- Maintenance technician
- Mechatronics technician
- Assembly technician
- Chemical and materials technician
- Compressors, gas storage technician

**ESCO 313**
- Operation technician
- Steel manufacturing Process engineer
- Health, and safety design engineer
- Production engineer
- Electrolysers & fuel cell R&D
- Production engineer
- Machine engineer
- Operation optimisation specialist
- Quality, operation, equipment maintenance specialist in compression and safety
- Service engineer
- Safety, health and environmental engineer
- Construction and installation technicians
- Process technician

ESCO 721
- Welder
- Riggers
- Pipefitter

ESCO 811
- Plant operator

ESCO 813
- Machine operator

ESCO 821
- Assembly worker

Suggested Content
- Insights on h2 production, economies, risks, technology, renewables and scaling
- Permitting and certification of chemical production facilities
- Investment analysis, economics, and legal aspects of RE projects development,
- RE projects development, process engineering, petrochemical industrial production
- Development, construction and operation of H2 production facilities
- Energy production projects, environmental and social impact analysis, regulations, permitting
- Public relations and engagement, international networking
- H2 process design, production, storage and transport
- Production of green e-fuels
- Chemical production, processing, electrode, catalysts
- H2 production and consumption in refineries and fertilizers
- H2 production, electrolysis, blending with NG, plant management
- H2 and its derivatives production processes in fertilizers, stell, chemicals, etc
- High pressure processes, chemical production facilities, monitoring
- Optimisation and operation of energy production facilities, and economic energy arbitrage
- Petrochemical production facilities, refuelling, gas storage facilities and transportation
- Process quality, gas production facilities operation and maintenance
- Hazards and safety of H2 production, distribution, storage and refuelling
- Risk and hazards of H2 production and transport facilities
- Monitoring and maintenance of production, transportation, and storage refinery's facilities
- Vessel's operation, h2 and ammonia production facilities, electrical facilities

Hydrogen Electrolysis Target Audience

ESCO 112
- Technical department manager

ESCO 122
- Sales and marketing manager

ESCO 210
- H2 production manager
- Project manager
- Project development manager

ESCO 211
- Material science engineer
- Research and development expert
- Physicist

ESCO 214
- H2 expert
- Production engineer
- Technology mapping specialist
- Chemical process engineer
- H2 and ammonia production engineer

ESCO 242
- Electrical engineer
- electrolysis engineer
- Electrical design engineer – electrolyzers

ESCO 242
- Renewables engineer
- Fuel cells, electrolyzers engineer
- Electrochemical engineer

ESCO 210
- Financiers and modelers

ESCO 210
- electrical and electrochemical technician

ESCO 313
- Operation and maintenance technician
- R&D engineer
- Chemical engineer
- Material science engineer
- Industrial engineer
- Mechanical engineer

**Suggested Content**

- Regulation standards - Minimum insight into ASME/API
- Various electrolysis technologies, advantages, limitations and economics
- High temperature electrolysis (SOEC) for steam, CO2 and co-electrolysis
- Electrochemical engineering, understanding of electrodes, membranes and electrolysis processes
- Electrolyzers and fuel cells design and operation, and maintenance
- Knowledge of Hydrogen production machines and tools, including their designs, uses, repair
- Design/building an integrated RES - Electrolyser system
- H2 production and blending with NG, plant management
- H2 storage facility and refuelling station
- Electrolysers and fuel cell technologies and H2 mobility applications
- Materials engineering, knowledge on materials used in electrolysers electrodes: appropriate mechanical properties and high corrosion resistance
- H2 value chain, Technical – Integration of fuel cell and basic knowledge of storage and electrolyses
- CCUS, Synthetic fuels, Biogas, Electrolysis, fuel cells, renewables
- Ammonia production, storage, and transportation
- Piping, storage, liquification, safety and security,

**Hydrogen Facilities Operation Target Audience**

**ESCO 210**
- H2 project manager

**ESCO 211**
- Reservoir engineer
- Storage engineer

**ESCO 214**
- Marine infrastructure engineer
- Planning, design, process engineer
- Operation optimisation specialist
- Marine engineer
- Test engineer
- Safety engineer
- Mechanical engineer
- Quality, operation, equipment maintenance engineer
- Robotics and production engineer
- CCUS professional

**ESCO 215**
- Electrolysis engineer
  - Electrical design engineer – electrolysers
  - Engineer specialised in electrolysers, fuel cells
  - Electrolysers engineer
  - Engineer of system integration, operation reliability, process

**ESCO 210**
- Port bunkering, storage & support technicians
- Laboratory technician
- Installation and operation technician
- Electrical technician
- Mechanical technician
- Maintenance storage technician
- Safety and risk technician
- CCUS technician
- Compressors, gas storage technician

**ESCO 313**
- Operation and maintenance technician
- Operation storage technician
- Electrolysers operation and maintenance technician
- Technician for power electronics & instrumentation
- Technician of system integration, operation reliability,

**ESCO 811**
- Plant operator

**ESCO 813**
- Operator of refuelling stations, H2 production facilities
- Machine operator

**ESCO 818**
- Refuelling stations operator

**ESCO 821**
- Construction and assembly technician
ESCO 835
- Sailor

Suggested Content
- Development, construction and operation of H2 production facilities
- Port infrastructure operation, bunkering, storage, and support logistics
- Refuelling stations operation and H2 in mobility application
- Health, safety and risk of chemical facilities construction and operation
- Optimisation and operation of energy production facilities
- Operation maintenance and monitoring of gas infrastructure
- Health and safety of gas production, storage and operation
- Electrolysis technologies, operation and maintenance
- Electric system integration, operation and maintenance
- Life cycle operation and routine maintenance
- CCUS technology engineering, integration, operation, and maintenance
- Vessel's operation, H2 and ammonia production facilities, electrical facilities
- Operation and maintenance of fuel cells systems and powertrains
- Operation of valves, pipes and wells
- Operation and maintenance of chemicals production facilities
- Operation of H2 production facilities, high compression, explosion, firefighting, automation
- High pressure equipment, handling, operation and maintenance

Hydrogen Fuel cell Target Audience

ESCO 210
- Group leader

ESCO 211
- Physics expert
  - Fuel cells design engineer
  - Research and development expert
- Electrolysers and fuel cell Research, development

ESCO 214
- Research, development specialist
- emerging technology specialist
  - Mechanical engineer
  - Process engineer
  - Production engineer
  - H2 mobility engineer
  - Chemical engineer
  - Technology mapping specialist
  - Chemical engineer
  - Material science engineer
  - Engine development engineer
- Hydraulic engineer

ESCO 215
- Electrical engineer
- Electrochemistry engineer
- Renewables engineer
- Fuel cells, electrolyzers engineer
- Electronics engineer

ESCO 216
- Vehicle architect

ESCO 243
- Communication specialist

ESCO 311
- Electrolysers and fuel cell technician
- Mechanical technician
- Operation and service technician
- Maintenance technician
- Certifications specialist

ESCO 818
- Test band operator
Suggested Content

- Fuel cells in mobility application, refuelling stations
- Fuel cells manufacturing, testing, power systems, retrofit and back up energy generation
- Design, test, operate and maintain electromechanical equipment
- CAD and other computer design software
- Assembly, installation, repair and wiring of electric systems
- Operation and maintenance of fuel cells systems and powertrains
- Retrofitting of automotives (transport, refuelling and fuel cells)
- Supper capacitors,
- Power electronics, high and low voltage, fuel cell systems
- CCUS, Synthetic fuels, Biogas, renewables

Hydrogen Storage Target Audience

<table>
<thead>
<tr>
<th>ESCO 112</th>
<th>ESCO 215</th>
</tr>
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<tr>
<td>Technical department manager</td>
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</tr>
<tr>
<td>ESCO 210</td>
<td>ESCO 241</td>
</tr>
<tr>
<td>Project manager</td>
<td>Financiers and modelers</td>
</tr>
<tr>
<td>ESCO 211</td>
<td>ESCO 243</td>
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<tr>
<td>Production engineer</td>
<td>Energy market specialist</td>
</tr>
<tr>
<td>ESCO 214</td>
<td>ESCO 311</td>
</tr>
<tr>
<td>Material engineer</td>
<td>Installation and operation technician</td>
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<tr>
<td></td>
<td>Electromechanical technician</td>
</tr>
<tr>
<td></td>
<td>Compressors, gas storage technician</td>
</tr>
<tr>
<td></td>
<td>Maintenance technician</td>
</tr>
<tr>
<td></td>
<td>ESCO 313</td>
</tr>
<tr>
<td></td>
<td>Operation and maintenance technician</td>
</tr>
<tr>
<td></td>
<td>ESCO 721</td>
</tr>
<tr>
<td></td>
<td>Welder</td>
</tr>
<tr>
<td></td>
<td>Riggers</td>
</tr>
<tr>
<td></td>
<td>Pipefitter</td>
</tr>
<tr>
<td></td>
<td>ESCO 813</td>
</tr>
<tr>
<td></td>
<td>Operator</td>
</tr>
<tr>
<td></td>
<td>ESCO 818</td>
</tr>
<tr>
<td></td>
<td>Refuelling stations operator</td>
</tr>
</tbody>
</table>

- Design and construction of gas production and storage facilities
- Design, production of metal structures related to the production, storage and transportation
- H2 production, transport and storage and refuelling stations
- Process automation, energy storage
- Chemical process design, refinery, gas handling, storage, and transport
- Port infrastructure operation, bunkering, storage, and support logistics
- Marine and energy production, storage and transport construction
- Petrochemical production facilities, refuelling, gas storage facilities and transportation
- Piping, liquification, safety and security
- Installation, operation and maintenance of gas and liquid h2 storage and transport facilities
- Compressors, change of state, gasification, pipelines and storage tanks
- Risk, hazards and safety procedures of h2 production, storage and transport
- Explosion, jet fire modelling, testing, test facility management
- H2 hazards, risk profiles of h2, h2 transport fuel, bunkering
## Hydrogen Maintenance Target Audience

**ESCO 211**
- Physicist

**ESCO 214**
- Design engineer
- Energy storage expert
- Marine engineer
- Mechanical engineer
- Operation and maintenance engineer
- Quality, operation, equipment maintenance engineer
- CCUS professional

**ESCO 215**
- renewables engineer
- Electrical design engineer – electrolyzers
- Electrical engineer
- engineer specialised in electrolysers, fuel cells
- Electrolysers engineer
- engineer of system integration

**ESCO 311**
- Port infrastructure operation, bunkering, storage, fuel cell mobility technician
- Electrical technician
- Mechanical technician
- Service technician
- Safety and risk technician
- Ship technician
- Operation and maintenance technician
- Maintenance technician
- Installation and operation technician
- Compressors, gas storage technician

**ESCO 311**
- Electrolysers operation & maintenance technician
- Power electronics & instrumentation technician
- Technician of system integration & process reliability

**ESCO 818**
- Refuelling stations operator
- construction and assembly worker

### Suggested Content
- RES - Electrolyser system maintenance and service
- H2 for grid balancing, H2 safety
- Batteries technologies, design, construction, and maintenance
- Electrical infrastructure maintenance
- Gas facilities operation and maintenance
- Refuelling stations maintenance and service
- Process quality, gas production facilities operation and maintenance
- Life cycle operation and routine maintenance
- Fuel cells systems and powertrains maintenance
- Maintenance of gas and liquid H2 storage and transport facilities
- Risk, safety and maintenance of electrolyzers
- H2 EV service, maintenance and repair
- High pressure equipment, handling and maintenance,
- CCUS technology engineering, integration, operation and maintenance
Hydrogen Transport Target Audience

ESCO 210
- Project manager
ESCO 214
- Production engineer
- H2 mobility engineer
- Service engineer
- Machine engineer
- Construction engineer
- Chemical engineer
- H2 mobility expert
- Industrial engineer
- Risk and safety engineer
- Material science engineer
- Health, and safety design engineer
- H2 and ammonia production engineer
ESCO 215
- Electrochemical engineer

ESCO 311
- Health, and safety technician
- Installation and operation technician
- Electromechanical technician
- Maintenance technician
- Mechatronics technician
- Production technician
- Safety technician
- Compressors, gas storage technician
ESCO 313
- Operation and maintenance technician
ESCO 721
- Welder
- Riggers
ESCO 813
- Operator
ESCO 818
- Refuelling stations operator

Suggested Content
- Safety standard and risk of H2 production, transport and fuelling facilities
- Production, transport and storage of green H2
- Refuelling stations, storage, transport,
- Fuel cells, H2 propulsion systems
- Electrolysis, ammonia production, storage, and transportation
- Engineering, planning, grid design, material science, transporting gas
- Marine transport, bunkering, storage of Hydrogen
- Chemical process design, refinery and gas handling
- H2 storage, transportation, and high-pressure equipment
- Petrochemical production facilities
- Installation of metal structures related to the production, storage and transportation of Hydrogen
- Automovies and marine H2 refuelling, storage and transportation

Hydrogen Refuelling Target Audience

ESCO 210
- Project manager
- Junior and senior Project Manager
ESCO 211
- Physicist
ESCO 214
- Design engineer
- Safety and occupational hazards engineer
- Planning, design, process engineer
- H2 mobility engineer
- Marine engines expert
- Chemical engineer
- R&D expert
- Refuelling stations engineer
ESCO 818
- Refuelling stations operator
ESCO 833
- H2 bus driver
ESCO 835
- Lock operator
Suggested Content

- H2 production, transport and storage
- Refuelling stations, safety, H2 production technologies
- Design/building an integrated RES with refuelling stations, constructions,
- Maintenance and service, H2 for grid balancing, H2 safety
- Hazards and safety of H2 production, distribution, storage and refuelling
- Retrofitting of automotives (transport, refuelling and fuel cells)
- Fuel cells in mobility application, refuelling stations
- Operation, maintenance and safety of refuelling stations
- Refuelling a tugboat and marine vessels
Annex 8 – Interview guide T2.3

Introduction

Goals of the interview:
- Identifying the existing or foreseen hydrogen trainings in the country / region
- Characterise the evolutions of these trainings and the gaps in the supply
- Understand how new hydrogen curricula / modules could be integrated in national educational systems, especially if introduced for the first time

1. Can you describe your organisation?
2. What are your organisation’s activities in the field of Hydrogen / education to Hydrogen?
3. What is your role/position in your organisation?

Training offered by the organisation

Objective: Define the training offer of the interviewee and/or identify the intentions to develop training.

1. Describe your current or foreseen training offers on Hydrogen (EQF level, target audience, skills developed through the training, number of students per year, length of the training, need for external expertise).
2. Since when does the training(s) exist? What led to its development?
3. How does the attendance to the training / interest for this programme has developed over time?
4. Have there been notable evolutions in the content taught in the training over time?
5. What are your students/learners becoming?
6. Do you have any partnership with industry for the training(s) that you organise or foresee? If yes, how does this work?

Perspectives on training offers

Objective: Get the interviewee assessment on the situation on FCH education in the country.

1. How would you assess the offer of Hydrogen training in your country?
2. Do you notice specific gaps in terms of level covered, occupational profiles that are tackled?
   What improvements could be proposed?
3. Do you know about other training on Hydrogen in your country/region? What level is targeted and what does the training focus on?
4. Do you notice specific trends in the evolution of Hydrogen training offers in the past 5 years?
5. According to you, what are essential subjects/skills that should be taught in a VET programme for fuel cells and hydrogen specialists?
6. According to you, should there be dedicated VET for Hydrogen profiles OR should Hydrogen modules be integrated to existing VET? OR both?
VET system and accreditation

Objective: Gather knowledge on the national specificities of the VET system and on the accreditation process for future trainings from GreenSkills4H2.

1. Can you give a general overview of IVET and CVET in [country]?f?

2. Are there accredited IVET / CVET preparing for Hydrogen profiles in [country]?

Conclusion

1. Do you have additional comment or information that you would like to share with us?

2. Do you have any useful contact that you can share with us? (Name, institution, email, telephone)

3. Is there a national / regional mapping or analysis about trainings & skills for Hydrogen that you know of? If yes, what is the name and link?
Annex 9 – List of identified trainings fully focused on hydrogen and/or fuel cells

Please note that this list is not comprehensive and only includes training dedicated to hydrogen and fuel cells identified through discussions and with a link to find more information on the offer.

<table>
<thead>
<tr>
<th>Country</th>
<th>Category</th>
<th>Training organisation</th>
<th>Training / Project</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>Continuous</td>
<td>Educam</td>
<td>Safety certification on hydrogen for automotive technicians</td>
<td>Link</td>
</tr>
<tr>
<td>Belgium</td>
<td>Project</td>
<td>Belgian Hydrogen Council</td>
<td>Mapping of hydrogen training</td>
<td>Link</td>
</tr>
<tr>
<td>Belgium</td>
<td>Continuous</td>
<td>Université Libre de Bruxelles</td>
<td>University Certificate in Hydrogen Applications and Technologies</td>
<td>Link</td>
</tr>
<tr>
<td>Denmark</td>
<td>Continuous</td>
<td>Fredericia School of Marine Engineering</td>
<td>Diploma on Power-to-X technologies maintenance</td>
<td>Link</td>
</tr>
</tbody>
</table>
| Finland   | Initial and continuous | Cluster of Finnish universities       | Hydrogen Economy training modules:  
- Hydrogen end-use and infrastructure  
- Catalytic processes and materials in sustainable hydrogen production  
- Hydrogen production and storage  
- Hydrogen as fuel in combustion engines  
- Introduction to hydrogen economy | Link |
| France    | Initial           | University of Franche Comté            | Master's degree in engineering, Hydrogen Energy Efficiency                           | Link |
| France    | Continuous        | Afpa - National Agency for adult professional training | Training schemes for workers impacted by hydrogen developments and for jobs in tension in companies (metal, industry maintenance, production and production and distribution of maintenance units, energy transport, heavy duties) | Link |
| France    | Initial and continuous | Université Technique Belfort Montbéliard | Specialised Master on Hydrogen Energy  
- Introduction to hydrogen energy  
- Functioning of fuel cells  
- Fuel Cells vehicles  
- Electrolysis and hydrogen storage | Link |
| France    | Continuous        | INSTN                                   | Specialised training on hydrogen  
- Fuel Cells  
- Hydrogen Sector  
- Hydrogen as a vector of the ecology and energy transition | Link |
<p>| France    | Initial and continuous | IFP School                             | Hydrogen for mobility                                                               | Link |
| France    | Continuous        | Bureau Veritas                          | Risk Safety Training Academy                                                        | Link |</p>
<table>
<thead>
<tr>
<th>Country</th>
<th>Category</th>
<th>Training organisation</th>
<th>Training / Project</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Project</td>
<td>DefHy</td>
<td>Project on skills, professions and training for the hydrogen sector.</td>
<td><a href="#">Link</a></td>
</tr>
<tr>
<td>France</td>
<td>Project</td>
<td>GenHyo</td>
<td>The Genhyo project, Génération hydrogène Occitanie, aims to encourage the emergence of talent and accelerate the adaptation of training courses (from CAP to PhD) to the skills needs of the low-carbon hydrogen industry.</td>
<td><a href="#">Link</a></td>
</tr>
<tr>
<td>Germany</td>
<td>Initial and continuous</td>
<td>TU Dresden</td>
<td>Master on Hydrogen technology and economy</td>
<td><a href="#">Link</a></td>
</tr>
<tr>
<td>Germany</td>
<td>Continuous</td>
<td>University of Oldenburg</td>
<td>C3L – Certificate of advanced studies about Hydrogen</td>
<td><a href="#">Link</a></td>
</tr>
<tr>
<td>Germany</td>
<td>Continuous</td>
<td>BNW - Bildungswerk der Niedersächsischen Wirtschaft gemeinnützige GmbH</td>
<td>Hydrogen Basics</td>
<td><a href="#">Link</a></td>
</tr>
<tr>
<td>Germany</td>
<td>Continuous</td>
<td>Oldenburg Chamber of Industry and Commerce</td>
<td>Expert for Hydrogen Applications</td>
<td><a href="#">Link</a></td>
</tr>
<tr>
<td>Germany</td>
<td>Continuous</td>
<td>Heinze Akademie GmbH</td>
<td>Hydrogen Technology Specialist Experts Qualification Hydrogen Systems</td>
<td><a href="#">Link</a> <a href="#">Link</a></td>
</tr>
<tr>
<td>Germany</td>
<td>Continuous</td>
<td>DVGW - German Technical and Scientific Association for Gas and Water Vocational Education and Training</td>
<td>Hydrogen Training courses - including certificate courses for H2 professional competencies</td>
<td><a href="#">Link</a></td>
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<tr>
<td>Germany</td>
<td>Continuous</td>
<td>Renewables Academy (RENAC) AG</td>
<td>Green Hydrogen and Renewable Power-to-X Professional</td>
<td><a href="#">Link</a></td>
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<tr>
<td>Germany</td>
<td>Continuous</td>
<td>Carl von Ossietzky University of Oldenburg, Leibniz University Hannover and Fraunhofer Institute IWES</td>
<td>Hydrogen for specialists and executives</td>
<td><a href="#">Link</a></td>
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<tr>
<td>Germany</td>
<td>Continuous</td>
<td>Fraunhofer IST and TÜV Rheinland with partner companies</td>
<td>Practical energy transition – expertise for your switch to hydrogen</td>
<td><a href="#">Link</a></td>
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<td>Germany</td>
<td>Continuous</td>
<td>LifteH2</td>
<td>Hydrogen Knowledge &amp; Personnel qualification</td>
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<td>Country</td>
<td>Category</td>
<td>Training organisation</td>
<td>Training / Project</td>
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<tr>
<td>Greece</td>
<td>Initial and continuous</td>
<td>University of Western Macedonia</td>
<td>Master in Hydrogen sciences and technologies</td>
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<tr>
<td>Italy</td>
<td>Continuous</td>
<td>RINA</td>
<td>Certification of hydrogen expert personnel:</td>
<td>Link</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Expert in plant design and management of H2 based projects</td>
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<td></td>
<td></td>
<td></td>
<td>- Expert in Operation &amp; Maintenance simple or complex H2 base systems</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Inspector/tested of plants equipment, artifacts and complex H2 based systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Installer/maintainer of systems artifacts and complex H2 based systems</td>
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<tr>
<td>Italy, Netherlands, Norway, Spain</td>
<td>Initial</td>
<td>Consortium of universities</td>
<td>Joint Master on Hydrogen Systems and Enabling Technologies</td>
<td>Link</td>
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<tr>
<td>Netherlands</td>
<td>Continuous</td>
<td>New Energy Coalition</td>
<td>Hydrogen's Role in the Energy Transition Intensive Course Hydrogen Masterclass Hydrogen</td>
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<td>Norway</td>
<td>Continuous</td>
<td>Western Norway University of Applied Sciences</td>
<td>Hydrogen Technologies (from Introduction to level II)</td>
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<td>Norway</td>
<td>Continuous</td>
<td>Western Norway University of Applied Sciences</td>
<td>Training for specific sectors paid for by the ministry (oil &amp; gas, maritime)</td>
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<td>Poland</td>
<td>Initial</td>
<td>Gdansk University of Technology</td>
<td>Engineering degree on Hydrogen technologies and electromobility</td>
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<tr>
<td>Poland</td>
<td>Initial</td>
<td>College Humanum and TUV SUD</td>
<td>MBA on Hydrogen Technology Management</td>
<td>Link</td>
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<tr>
<td>Portugal</td>
<td>Continuous</td>
<td>INEGI</td>
<td>Hydrogen technologies and economies</td>
<td>Link</td>
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<tr>
<td>Spain</td>
<td>Initial and continuous</td>
<td>Consortium of Spanish universities and training organisations</td>
<td>Inter-University Master's Degree in Hydrogen Technologies</td>
<td>Link</td>
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<tr>
<td>Spain</td>
<td>Continuous</td>
<td>CNH2</td>
<td>Course on Hydrogen technologies</td>
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<td>Spain</td>
<td>Continuous</td>
<td>Escuela de Organización Industrial (EOI)</td>
<td>Executive Programme in Renewable Hydrogen</td>
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<td>Sweden</td>
<td>Initial</td>
<td>Iris YH</td>
<td>Hydrogen Engineer</td>
<td>Link</td>
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<td>Sweden</td>
<td>Continuous</td>
<td>Yrkes Akademin</td>
<td>Green hydrogen – application and development</td>
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<td>Country</td>
<td>Category</td>
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<td>UK, Czech Republic</td>
<td>Initial and continuous</td>
<td>UCT Prague, University of Birmingham</td>
<td>TeachHy Master – Modules also delivered in CPD.</td>
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<tr>
<td>United Kingdom</td>
<td>Initial</td>
<td>University of Birmingham</td>
<td>Fuel Cell and Hydrogen Technologies Masters/MSc</td>
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<tr>
<td>United Kingdom</td>
<td>Continuous</td>
<td>Kiwa</td>
<td>Hydrogen and the Natural Gas Network Hydrogen Training for Decision Makers Hydrogen Awareness Training Hydrogen Vehicles Basics Hydrogen Vehicles Technician</td>
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<td>United Kingdom</td>
<td>Continuous</td>
<td>Belfast Met &amp; Northern regional college</td>
<td>EQF 3 Course Development - H2 Gas Safe</td>
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<tr>
<td>United Kingdom</td>
<td>Initial and continuous</td>
<td>Queen's University Belfast and College Belfast Met</td>
<td>PGCert Hydrogen Energy Systems</td>
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<tr>
<td>United Kingdom</td>
<td>Initial</td>
<td>University of Birmingham</td>
<td>Hydrogen, Fuel Cells and their Applications MRes</td>
<td>Link</td>
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<tr>
<td>Various</td>
<td>Continuous</td>
<td>On demand training</td>
<td>UTBM, Bulgarian FC Association, INSTN, Office of Technical Inspection Poland, Fundacion Hidrogeno Aragon, CNH2, Technifutur / Uni Liège, AUTH/CPERI-CERTH, INEGI, HyCenta/ TU Graz, RISE, BHAM, Polito</td>
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</table>
Annex 10 – List of educational modules currently being developed by European projects

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<th>Title of module or infrastructure</th>
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<td>HySkills</td>
<td>Hydrogen Basics</td>
<td>EN, DE, GR</td>
</tr>
<tr>
<td>HySkills</td>
<td>Hydrogen Safety, Risks, Standards and Regulation</td>
<td>EN, DE, GR</td>
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<tr>
<td>HySkills</td>
<td>Hydrogen High-Pressure Fittings and Connections</td>
<td>EN, DE, GR</td>
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<tr>
<td>HySkills</td>
<td>Hydrogen Storage</td>
<td>EN, DE, GR</td>
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<td>Operation and Maintenance of Electrolysers and Fuel Cells</td>
<td>EN, DE, GR</td>
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<td>HySkills</td>
<td>Hydrogen Transportation and Delivery</td>
<td>EN, DE, GR</td>
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<td>HySkills</td>
<td>Hydrogen Combustion</td>
<td>EN, DE, GR</td>
</tr>
<tr>
<td>HySkills</td>
<td>Hydrogen Sensors, Detectors and Monitoring</td>
<td>EN, DE, GR</td>
</tr>
<tr>
<td>HySkills</td>
<td>Train the trainer handbook</td>
<td>EN, DE, GR</td>
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<td>Hydrogen equipment, inspection operation and maintenance</td>
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<td>Safety protocols and provisions related to hydrogen storage</td>
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<td>First aid, emergency and response procedures</td>
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<td>Detection and diagnosis faults in H2 vehicles</td>
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<td>Detection and diagnosis faults in HRS parts</td>
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