GREEN SKILLS FOR HYDROGEN

White Paper
Updated Reflections on The European Hydrogen Skills Strategy

GreenSkills4H2 project

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1. Executive Summary

The hydrogen market in 2024/2025 is at its lowest point, marked by the cancellation of many projects that had not been feasibly planned. This slowdown in activities has cascaded across the entire hydrogen value chain and stakeholder operations. However, some projects are advancing from announcements to feasibility and engineering studies, as well as project realisation. As such, skills demand is currently lower and has shifted towards practical experience. The most critical competences required concern transferring blueprints and designs from the drawing board to construction sites and ensuring facilities' safe and reliable operation. Given the relative youth of the green hydrogen sector, this proves to be a very difficult undertaking.

The demand for R&D skills is retreating as the market moves towards technology commercialisation and project construction. Demand for operations and maintenance skills is growing as a result of the increasing deployment of H_2 facilities and infrastructure across all industries and sectors. This demand is expected to continue growing as the industry evolves. Project execution and construction remain among the most delicate skill areas, as companies are seeking experienced professionals with reliable expertise to fill these critical roles. Project permitting, authorisation, risk, and safety are still strongly demanded in the market, though no major bottlenecks appear so far.

Development of the H_2 value chain involves its integration into existing infrastructures and energy systems. This requires experts who understand how various systems function: Carbon Capture, Utilisation and Storage (CCUS), renewable energies, alternative fuels, refineries, mobility, etc. Consequently, there is a strong need for cross-cutting expertise and skills encompassing these systems. The market is looking for those experts—solution architects—who can manage the transitional adoption of hydrogen in various industries while addressing technical and economic aspects.

Process engineering, material science, gas and liquid conversion, as well as industrial, mechanical, and electrical engineering, form the backbone of the profiles required by various H_2 value chain actors. There is no specific challenge in securing these specialists; however, competition exists between hydrogen and other renewable energy sectors seeking the same profiles. Several actors have expressed difficulty in attracting IT engineers, who are in high demand. Project feasibility, finance, and economics are identified as crucial yet missing competencies.

The representation of women in the hydrogen industry is weak, as confirmed by interviewees across most European countries. Hydrogen actors have implemented several mechanisms to attract women into their workforce; however, they struggle to find a sufficient pool of candidates. This phenomenon is largely linked to the general perception of engineering jobs as less attractive to women. The low supply of female candidates is associated with the significantly lower number of women than men in technical and engineering schools.

2. Objectives

The European hydrogen sector is in constant movement and development, which requires close documentation and analysis of the evolution of skills demand in line with market dynamics. In 2023, Green Skills for Hydrogen (GreenSkills4H2) published the European Hydrogen Skills Strategy, based on stakeholder interviews conducted between November 2022 and March 2023 across 23 countries. In early 2025, the GreenSkills4H2 consortium conducted an additional interview campaign with hydrogen stakeholders across the European Union (EU) and a literature

review of newly published skills strategies and reports across the EU. This work is intended to capture changes in skills demand and to document trends and new needs in the market. This update aimed to:

I. Capture changes in demand for H_2 occupational profiles after 2023.

II. Understand how demand is evolving qualitatively and quantitatively.

III. Provide a clear picture of current and future market needs.

IV. Identify key required profiles as well as the knowledge and expertise required.

V. Build a comprehensive outline of current and future occupational profiles in demand.

VI. Highlight bottlenecks and shortages to be addressed through training programmes.

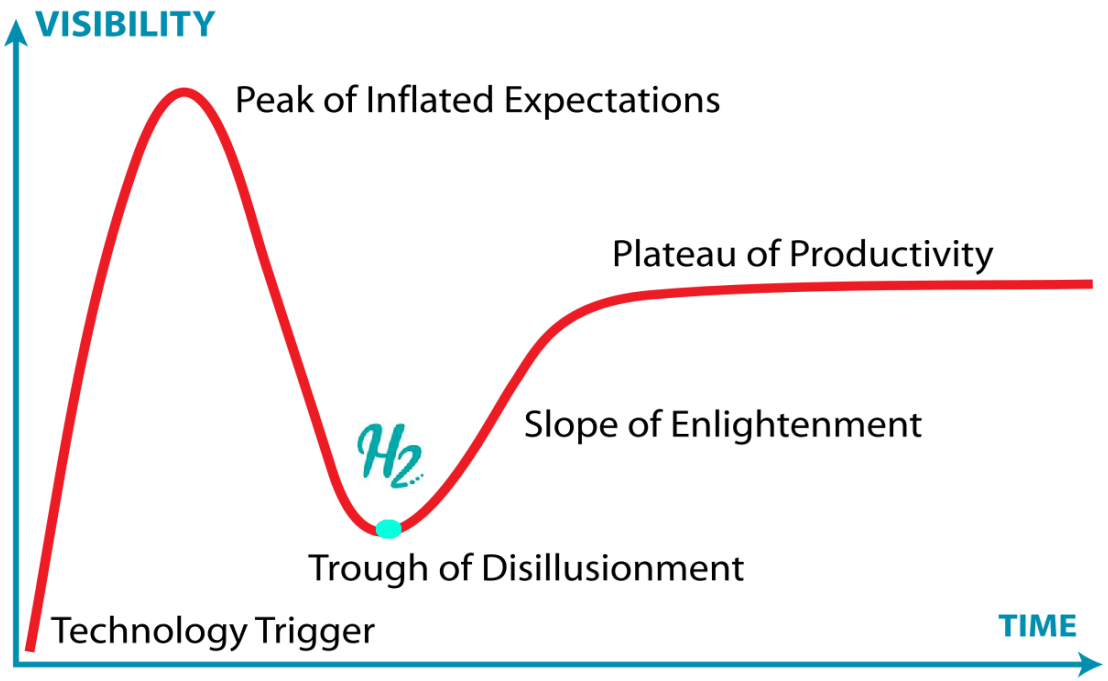
VII. Compile recommendations for other GreenSkills4H2 work packages to address any required adaptations.

3. Dynamics of the current demand for professionals

The hydrogen sector is experiencing a slowdown across the whole value chain reflected in slower and more limited project realisation and the deployment of infrastructure and technologies, compared with projection scenarios. As such, demand for occupational profiles is not experiencing the shortage expected two years ago. Demand is shifting from R&D to project construction, manufacturing and commercialisation. Companies are looking for experienced profiles who can lead projects through the phases of construction and operation, addressing various risks and navigating complexities of hydrogen projects. Additionally, understanding the interlinkages and dependencies of a range of energy systems is essential for the successful integration of hydrogen into existing industries. Several actors project gradual development of hydrogen projects and a transition to maturity in the coming years, when more projects become operational. At that point, operation and maintenance technicians and engineers will become extremely important. Gender diversity is positively perceived by companies but the low proportion of women in technical domains remains a barrier.

Job demand is shifting from oil and gas to renewables, thus offering a supply of experienced and trained personnel who need to be upskilled. Internal training is aimed at equipping new staff with knowledge and skills specific to hydrogen, while basic domain knowledge remains the same. As the hydrogen sector matures—where project realisation has not seen the exponential growth previously expected—there is no critical quantitative shortage of professionals. Additionally, the restructuring or bankruptcy of several hydrogen companies has provided a pool of experienced hydrogen profiles who have found attractive positions in other companies. In a few years, the demand for operation and maintenance profiles is expected to grow as more hydrogen projects become operational.

FIGURE 1. ADAPTATION OF GARTNER'S TECHNOLOGY HYPE CURVE

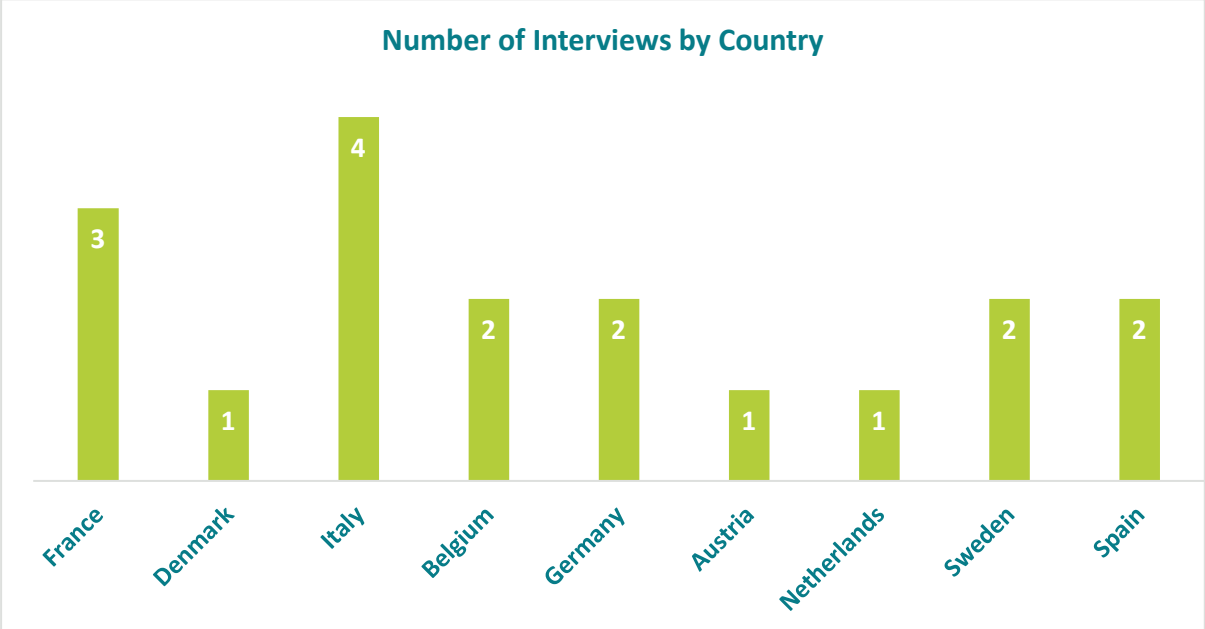


4. Analysis

The interview campaign took place between February - April 2025 and was aimed at active hydrogen industrial actors to capture the overall industry demand. In addition, universities' graduates, industry clusters, and associations were involved in interviews to represent the wider landscape. Interviewees were also targeted primarily in EU countries engaged in varying segments of the hydrogen value chain. The questions were designed to identify important trends, developments, challenges, potential, and defining characteristics of the current and future demand for hydrogen skills.

FIGURE 2. INTERVIEWS DISTRUBUTION BY TYPE OF ACTORS

FIGURE 3. INTERVIEWS DISTRIBUTION BY COUNTRY



The hydrogen sector continues to be in its infancy and is moving more slowly than expected in developing the market, which has resulted in no notable changes to date. The transition to hydrogen will use existing skills developed in related sectors, plus on-the-job training to develop some specific skills. There is a cohort of expertise now as jobs are gradually transitioning from oil

and gas to renewables, but many professionals will still require further skills development. Companies will need professionals who understand the interconnections between renewable energies, hydrogen derivatives, and CCUS, though understanding will vary depending on the company's core business. There will be a need to adapt existing curricula and to develop coursework that can also communicate key concepts to non-specialists, to raise broader awareness of synergies across all relevant industry areas.

Compared with three or four years ago, the current market slowdown has relieved pressures on the job market compared to three or four years ago, and the growth of skill gaps from Research and Development to operation has been slower than anticipated. Hydrogen is now regarded as an ecosystem requiring not just technical experts, but also solution architects who redesign the process in terms of identifying value—for example, where hydrogen can create value in efficiency, cost reductions, and performance improvements. Most employers do not know what specific competency gaps exist, even when thinking about unfilled roles. There are still gaps in project feasibility, finance and economics, but employers are also increasing the need for professionals with transferable skills.

5. Findings

FIGURE 4: CHANGES OF PROFILES DEMANDS IN 2025 COMPARED TO 2023

Current profiles	Missing profiles	Future profiles
• **Managerial/Admin:** *Largely similar profiles* *Some profiles are no longer missing* ▪ Business development & management ▪ Commercialisation & marketing ▪ Energy market • **Experts:** ▪ Physics & nanotechnology experts not mentioned • **Engineering:** *Some new profiles appear* ▪ Compressors engineer ▪ Infrastructure engineer ▪ Methane pyrolysis engineer ▪ Design and optimisation engineer ▪ Test engineer	• **Managerial/Admin:** *Several profiles are no longer missing or haven't been mentioned in the small sample* ▪ Finance manager ▪ Knowledge manager ▪ Technology development manger • **Experts:** *Largely similar with a new profile appears* ▪ Logistics expert • **Engineering:** *Largely similar with some new profiles appearing* ▪ Commissiong engineer ▪ Energy Systems engineer ▪ High temperature process engineers *Some profiles disappear from the new list (might be due to small sample)*	• **Managerial/Admin:** *Several profiles are no longer missing or haven't been mentioned in the small sample* ▪ Industrial, chemical & gas project manager ▪ Business development manger ▪ Senior technical manger ▪ R & D manger • **Experts:** *Largely similar with a new profile appears* ▪ Mobility infrastructure expert ▪ H2 logistics and transport expert • **Engineering:** *Largely similar with some new profiles appearing* ▪ Compressor engineer ▪ Solid carbon engineer

▪ Application and Process engineer ▪ Reservoir and drilling engineer ▪ Pipeline and maintenance engineer • **Specialist:** *Similar profiles with focus on* ▪ Safety & risks ▪ Logistics • **Technician:** *new profile appears* ▪ Solid Carbon technicians *Focus on* ▪ Testing, Operation & maintenance • **Workers & Operators:** *No changes*	▪ Infrastructure repurposing engineer ▪ Backbone construction engineer ▪ Geologist • **Specialist:** *Similar profiles with focus on* ▪ Safety & risks • **Technician:** *Largely similar profiles* *Focus on* ▪ Construction, installation, Testing & maintenance ▪ Health, safety & risks • **Workers & Operators:** *No Profiles identified as missing in the update campaign*	*Some profiles disappear from the new list (might be due to small sample)* ▪ Fuel cells engineer ▪ Retrofit engineer ▪ Geologist • **Specialist:** *Similar profiles with focus on* ▪ Safety & risks ▪ H2 certification ▪ Construction, installation and commissioning • **Technician:** *Largely similar profiles* *Focus on* ▪ Construction, installation, Testing & maintenance ▪ Health, safety & risks • **Workers & Operators:** *Similar profiles*

FIGURE 5: KEY EVOLUTIONS OF OCUPATIONAL PROFILES DEMAND IN 2025

Outline of changes in profile demand
• Lower demand for R&D. • Lower production and market uptake targets. • Greater focus on capturing available business opportunities. • More operation and maintenance specialists needed once projects are online. • IT specialists are hard to find & retain. • Commissioning engineers & technicians are in high demand. • Solid Carbon *(CO_2 in a solid state easier to store) is a new field, and new skills required to handle it. • Industrial processes, ammonia, methanol and SAF are quickly gaining momentum. • H2 specifications (purity, pressure, contaminants, etc.) specialists. • Industrial and electrical Engineers are the most requested professions. • Risk, safety and hazards retain their position as critical disciplines. • Permitting and authorisation remain important areas of demand.

FIGURE 6: SECTORS SYNERGIES & TRANSFERABLE KNOWLEDGE

Sectors with high synergies	Transferable Know-how
• Hard-to-abate sector: steel, refineries, cement, glass • Carbon Capture, Utilisation and Storage • Renewable power generation: solar & wind • Synthetic fuels: ammonia, methanol & SAF • Transport: automotives, marine, air	• Process Engineering • Industrial engineering • Material Science • Fire & Explosion Safety • Automation • Electrical Engineering • Gas compression

6. Challenges

The hydrogen field is facing various interrelated challenges, particularly the lack of multi-system approaches with renewables, grid, and water infrastructure coming together. While it's feasible to create new business models to replace fuel-based processes in industry with hydrogen, it remains highly complicated. The shortage of professionals to oversee deployments and poor commissioning skills and expertise add to the lagging change. It is particularly challenging to transition from planning and digital design, into construction and commissioning of systems, especially with other sectors of the energy transition competing for the same talent pool. As the hydrogen sector undergoes this transitional change, acquiring talent is becoming increasingly difficult, and the slowdown in the hydrogen sector discourages students from new programs, or some institutions cannot attract enough prospective applicants into these programs.

7. Critical Needs

FIGURE 7. CRITICAL KNOWLEDGE AND COMPETENCES NEEDS

8. Strategies to address market needs

Companies are adopting several strategies to address the mismatch between their demand and the supply of occupational profiles:

- Delegating unavailable expertise to third parties.
- Relying on equipment suppliers for adequate execution.
- Building their own internal training academies (e.g. Symbio, Atawey, HRS, Air Liquide).
- On-the-job learning (most companies).
- Looking for external training providers.
- Employ people with the closest skill set mainly from oil, gas and chemical industries.
- Small companies have difficulties to access sufficient pool of specialists.

9. Gender Equity

Women continue to be significantly underrepresented in engineering, technical, and other roles compared to men in most countries—typically at about 25 % or less. This imbalance is partly rooted in the supply issue, which directly reflects the low engagement of women in the technical or engineering education system. Also, the firmness of social and family expectations makes such careers situationally less appealing to women.

Nonetheless, companies are becoming more open and encouraging women to apply for any and all positions—including engineering, technical, and managerial positions—that typically have less female representation. More organisations are using targeted activities to encourage female applicants, which has led to some incremental increases in women across the hydrogen sector value chain, from managerial roles, and technical roles, to engineering functions.

Compared to industry roles, women have relatively better representation in academic and R&D roles; however, representation in leadership roles is still low both from fewer women qualifying for technical roles and generating visibility of role models among women in technical and engineering positions. Despite being a challenge, women's representation is getting better as more women transition into some management roles, but in aggregate women still represent the minority.

10. Recommendations

- **Focus on cross-cutting skills and competencies** that are transferable across multiple technologies, ensuring adaptability in a rapidly evolving energy sector.
- **Develop dedicated upskilling programmes** tailored to oil, gas, and electricity professionals, leveraging their existing technical knowledge and experience to fast-track hydrogen proficiency.

- **Integrate hydrogen-related knowledge** into academic and professional training programmes, ensuring curricula reflect the latest industry advancements and demands.
- **Design transitional upskilling pathways** for technical professionals and experts, building on their domain expertise to facilitate a smooth shift into hydrogen-related roles.
- **Strengthen industry collaboration** in training programme development to ensure alignment with real-world needs and enhance workforce readiness.
- **Prioritise competencies** in commissioning, operation, and maintenance, as these are critical and highly sought-after skills in the hydrogen sector.
- **Equip H_2 professionals with holistic knowledge of energy systems**, enabling them to understand interdependencies and seamlessly integrate hydrogen into existing infrastructure.
- **Incorporate synergies** with renewables, synthetic fuels, and carbon capture, utilisation and storage (CCUS) into training curricula to prepare future professionals for a multi-technology energy landscape.

11. Recommendations –European H2 skill strategy

1. **Expand modular training to related technologies**

Broaden the scope of modular training programmes to encompass technologies that have significant synergies with hydrogen, ensuring a holistic approach to workforce development.

2. **Emphasise practical outcomes in hydrogen training standards**

Design hydrogen training standards with a strong emphasis on real-world application and the practical implementation of acquired skills and knowledge.

3. **Prioritise continuing education for professionals**

Make access to continuing education a top priority, particularly for professionals transitioning from other sectors who possess relevant and transferable expertise.

4. **Strengthen the hydrogen online community as a central resource**

Further develop the hydrogen online community to serve as the primary platform for accessing both past and current hydrogen training resources and programmes, with a special focus on EU-funded initiatives.

5. **Enhance and promote mobility programmes**

Expand and promote mobility programs to ensure sufficient student enrolment in hydrogen-related courses and co-developed educational programs.

6. **Promote the sector's attractiveness to diverse talent pools**

Increase efforts to highlight the appeal of the hydrogen sector, targeting both transitioning professionals and young students. Promotional activities should communicate hydrogen's pivotal role as a long-term transitional energy vector, not just a short-term solution.

About the European Hydrogen Skills Alliance

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 . This growth presents a significant economic and environmental opportunity for Europe, but it also creates considerable labour market challenges.

Green Skills for Hydrogen (GreenSkills4H2) is a four-year project, started in July 2022, bringing together partners from 15 European countries and co-funded under the EU's Erasmus+ Programme. Its primary objective has been to design and implement a highly innovative, effective, and sustainable Hydrogen Skills Strategy for Europe to ensure the skills needs of the rapidly expanding and evolving hydrogen value chain can be met over the short, medium and long term. It has also generated a blueprint to address the skills needs of workers in declining sectors and transition regions, offering them upskilling and reskilling pathways into hydrogen-related roles.

To date, the project has delivered three core training programmes aligned with EU qualification standards, implemented more than 41 training sessions reaching over 2,000 learners, and participated in more than 12 major dissemination events engaging key hydrogen stakeholders. It has also established the European Hydrogen Skills Community, a network of 5,000 professionals and students.

Building on these achievements, GreenSkills4H2 has helped establish a long-term partnership between industry and education: the European Hydrogen Skills Alliance, created to scale and adapt the training programmes across Europe.

Members of the European Hydrogen Skills Alliance

European Hydrogen Skills Alliance is led by Karlsruher Institut für Technologie (KIT) and Hydrogen Europe Research, bringing together key Industry and Education stakeholders from across the hydrogen sector. Its members are presented in the following tables.

Partners	Acronym
Adecco Formazione / Mylia	**Mylia**
Advent Technologies	**Advent**
Austrian Institute of Technology	**AIT**
Cluster of Bioeconomy and Environment of Western Macedonia	**CluBE**
CP Europe	**CP**
Danmarks Tekniske Universitet	**DTU**
Foundation for the Development of New Hydrogen Technologies in Aragon	**FHA**
Hydrogen Europe Research	**HER**
Enerdata	**Enerdata**
Institute of Electrochemistry and Energy Systems	**IEES**
Karlsruher Institut für Technologie	**KIT**
National Research and Development Institute for Cryogenics and Isotopic Technologies ICSI Rm. Valcea	**ICSI**
National University of Ireland Galway	**NUIG**
NHL Stenden University of Applied Sciences	**Stenden**
Nuovo Pignone Tecnologie / Baker Hughes	**Baker Hughes**

Partners	Acronym
Politecnico di Torino	**Polito**
Region Auvergne Rhone Alpes	**AURA**
The Danish Institute of Fire and Security Technology	**DBI**
Regional Pomeranian Chamber of Commerce	**RIGP**
ROC Drenthe College	**Drenthe**
Skillnet Ireland	**Skillnet**
SNAM	**SNAM**
Tallinn University of Technology / EMERA	**TalTech**
Tartu Vocational Education Centre	**Tartu VEC**
University of Perugia	**Uni Perugia**

Associated partners	
Association Française pour l'Hydrogène et les Piles à Combustible	**France Hydrogène**
Epia Solarpower Europe	**EPIA**
Industriall	**Industriall**
Tartu Regional Energy Agency	**TREA**
Trakiyski Universitet / Institute for Sustainable Transition and Development	**ISTD**
WindEurope	**WindEurope**
Subcontractors	
University Politehnica of Bucharest	**UPB**
Green Tech Skillnet (Green Tech)	**Green Tech Skillnet**
Schuman Associates	**SA**

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