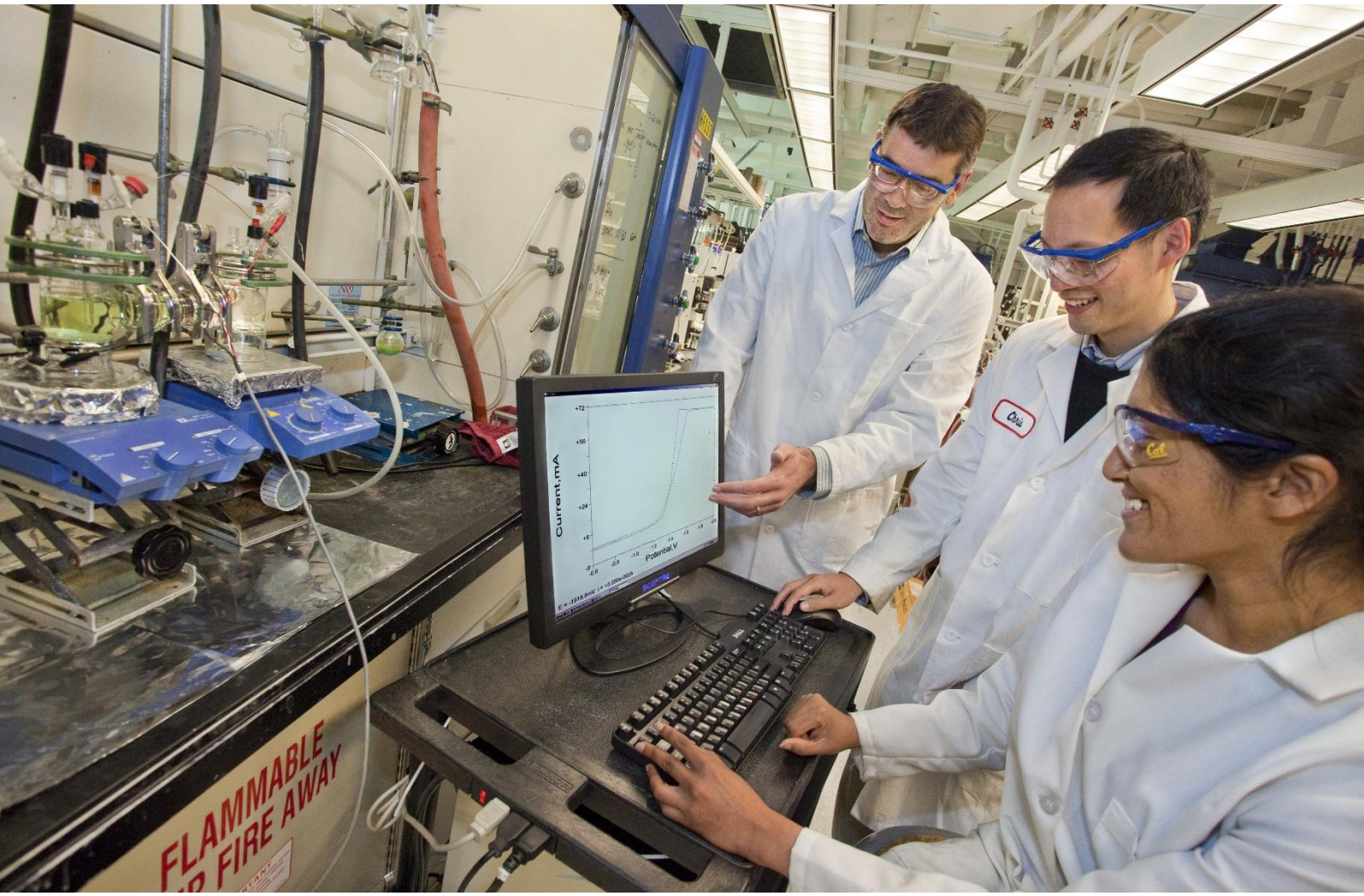
Skills for the Hydrogen Economy - Guidance Documents to Support the Development of Sustainable Hydrogen Workforces

Part 2: Training – International Case Studies

Prepared by the IPHE H2Skills Task Force



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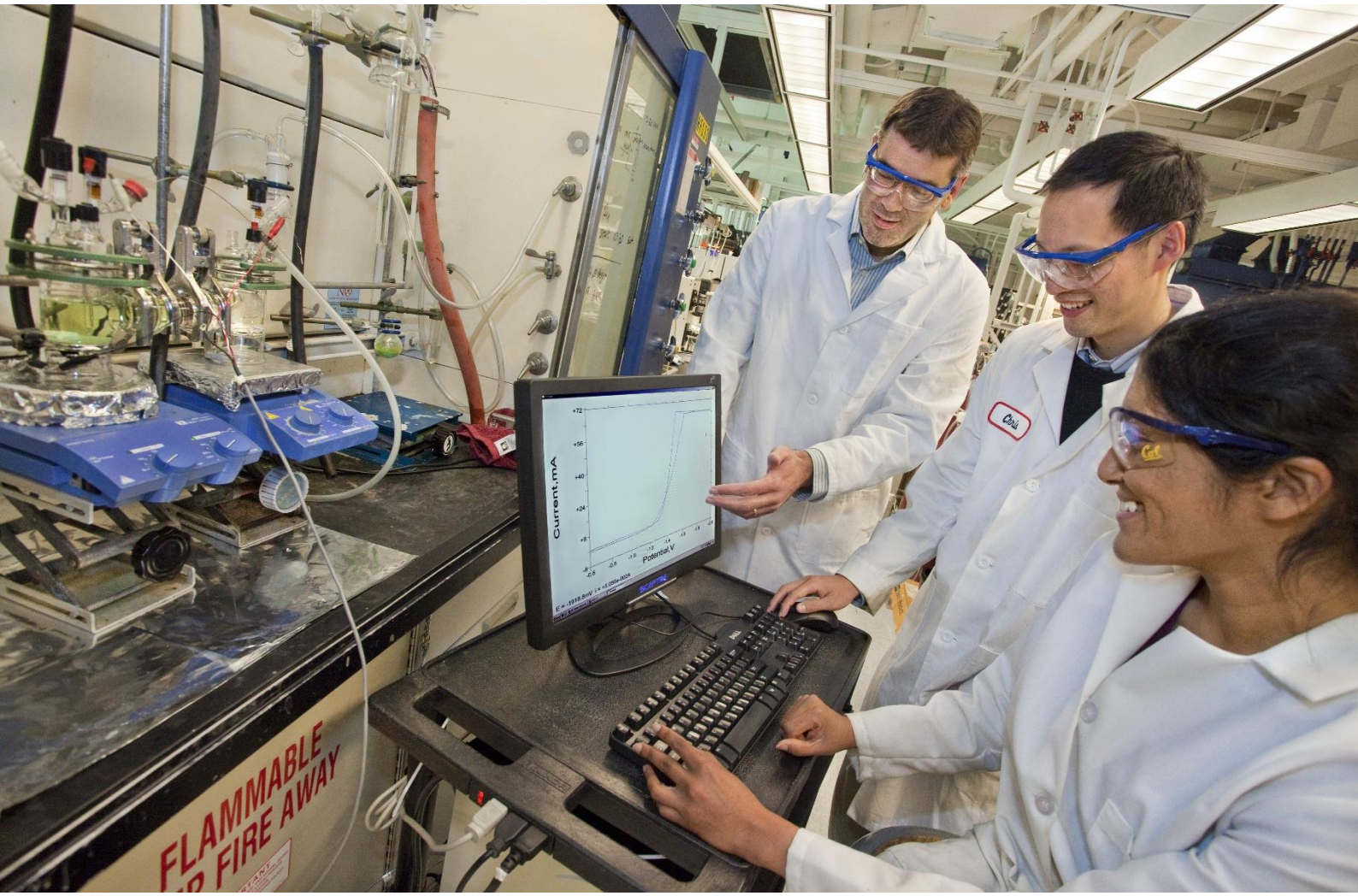

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This guidance document on hydrogen-related training has been developed by IPHE during a period when global policy makers, industry, and various stakeholders are considering hydrogen and other clean energy technologies to meet their climate goals as well as allocate incentives and funding to accelerate deployments.

Nothing in this report should be construed as an indication of future individual determinations regarding the appropriateness of any specific training, or any training- or related policies for any specific purpose. The information herein should be treated as a first version, available to be revised as global hydrogen skills development efforts evolve and further analyses are conducted, not a conclusion or direction of the IPHE, nor of its members.

Acknowledgements

This document was prepared by the IPHE Hydrogen Skills Task Force (H2Skills-TF), which is drawn from interested members of the IPHE. The work was designed and directed by members of the task force, who were also responsible for conducting and coordinating the data collection, analysis and production of the report. The report was discussed and reviewed by all members of the task force, and includes direct contributions from representatives of participating IPHE member countries. The task force was supported by the IPHE Secretariat.

The report benefited from responses to the survey and additional valuable input, comments, and feedback from other experts and representatives training initiatives within the IPHE member countries. The engagement and the insights shared significantly strengthened the quality of this work. Their efforts and contributions are acknowledged with appreciation.

Many experts from outside the IPHE also provided input, including via interviews, discussions and knowledge sharing sessions with the task force. Several of these experts also reviewed relevant sections and offered comments on earlier drafts. These contributions were of great value and are gratefully acknowledged, as are the contribution of photos and diagrams, and permission to include these in the publication.

Preface

The strategic and effective deployment of hydrogen is now a key priority for many national and regional governments, reflected in an expanding landscape of hydrogen strategies and roadmaps.[1] Realising the full potential of hydrogen as contributor to energy security, economic growth, and achievement of environmental objectives will depend not only on technology readiness and infrastructure deployment, but also on the availability of a workforce with the relevant skills.

Recognising that hydrogen is an emerging industry and countries globally are at different stages of development of their hydrogen economies, the Hydrogen Skills Task Force (H2Skills-TF) of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) aims to enable knowledge sharing between countries and to develop resources to help countries streamline and complement their hydrogen skills and workforce development efforts.

To this end, the task force is developing initial series of resources on the following topics:

1. Hydrogen skills needs assessments and workforce estimation, accompanied by a database of hydrogen job roles and skills (launched in September 2025).
2. Hydrogen training (this document).
3. Hydrogen workforce development (forthcoming).

Given the extensive global efforts to develop hydrogen economies and the dynamic nature of these, the intent in developing these resources is not to provide a comprehensive inventory of initiatives, but rather to provide examples from a diversity of contexts to serve as inspiration for replication/adaptation, and to act as a catalyst for regional and international collaboration to accelerate hydrogen skills and workforce development.

We trust that these resources will be of value to those working in government (policy makers and planners), education institutions (management and trainers), industry (management, technical teams and human resources), labour organisations, and agencies working to develop the hydrogen economy and facilitate energy transitions.

We welcome engagement on these resources[2], particularly through sharing of additional examples and insights, to enable them to be updated and expanded.

Hydrogen Skills Task Force (H2Skills-TF)
International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)
October 2025

[1] The IPHE maintains a register of hydrogen strategies and roadmaps on its website: www.iphe.net.
[2] The task force can be contacted via media@iphe.net.

Summary

This report was developed by the Hydrogen Skills Task Force (H2Skills-TF) of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) to provide inspiration and practical guidance for countries and institutions seeking to engage more deeply in the development of hydrogen-related training. By presenting examples from a range of countries, it highlights how training initiatives and ecosystems can be built and scaled.

The examples and insights on hydrogen-related training presented in this guidance document have been developed from a survey of IPHE member countries, complemented by desktop research and interviews. The document does not provide a blueprint, but rather examples of innovative initiatives from a diversity of contexts and illustrates that the development of hydrogen-related training is informed by the realities in the respective countries. Each case study includes some the lessons learned which could be of value to enable adaptation to a different context.

The report is structured into five sections, each addressing a key dimension of hydrogen-related training.

1. Awareness raising and dissemination of training opportunities: How information platforms and awareness campaigns make training visible and accessible.
2. Networks and platforms for trainers: How collaboration between universities, industry, and training providers strengthens both content and reach, additionally highlighting the importance of training the trainers.
3. Training infrastructure for hydrogen: How different physical and mobile learning facilities provide the necessary hands-on experience in a nascent sector.
4. Innovative content delivery: How gamification of learning, the use of digital tools, and novel teaching methods increase engagement and improve the effectiveness of the teaching.
5. Recognition of training: How accredited and non-accredited schemes, from micro-credentials to academic frameworks, ensure that skills are recognised and accreditation of hydrogen-related training expanded.

Training practices covered include ones from Belgium, Brazil, Canada, Costa Rica, the European Union, India, South Africa and the United States. By compiling these international innovative practices, the publication aims to support governments, education and training institutions, and industry actors in designing their own training strategies and initiatives. Partnerships between academia, industry, and government are essential to ensure relevance and recognition. Innovative learning formats can accelerate uptake and reach new audiences, while country-wide recognition systems provide the long-term foundation for career pathways and workforce mobility.

Ultimately, developing robust training systems, including through international collaboration, will be an important factor to enable the hydrogen economy to grow at the pace and scale envisioned by individual countries and the international community.

Contents

Disclaimer ..... **i**
Acknowledgements ..... **ii**
Preface ..... **iii**
Summary ..... **iv**
Contents ..... **v**
List of abbreviations and acronyms ..... **vi**
1 Introduction **1**
2 Overview of the emerging hydrogen training landscape **2**
3 Awareness raising and dissemination of training opportunities **3**
3.1 The European Hydrogen Observatory: A dynamic mapping of training on hydrogen (European Union) 3
3.2 Hydrogen South Africa (HySA): strategic hydrogen training and dissemination (South Africa) 4
4 Networks and platforms for trainers **7**
4.1 The H_2EDGE programme: a collaborative training initiative and network (United States of America) 7
4.2 The HyAcademy: a network of schools and universities (European Union) 9
5 Training infrastructure for hydrogen **11**
5.1 The Hydrogen School: hands on training for local youth (Costa Rica) 11
5.2 EDUCAM training centre: practical training for hydrogen vehicle repairers (Belgium) 13
5.3 GreenSKHy: mobile lab facilities (Countries in North-West Europe) 15
6 Innovative content delivery **17**
6.1 Green Skills for Hydrogen - the Hydrogen Game (European Union) 17
6.2 HyResponder – Training for first responders (European Union) 19
7 Training recognition **21**
7.1 Training institutions: micro credentials in the hydrogen sector (Canada) 21
7.2 Universities: the evolving academic framework for training recognition (Brazil) 23
7.3 National frameworks: recognising hydrogen qualifications on a national level (India) 25
8 Concluding remarks **27**

List of abbreviations and acronyms

AB	Awarding Bodies
ABH2	Brazilian Hydrogen Association
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
COPPE	The Federal University of Rio de Janeiro's Alberto Luiz-Coimbra Institute
DOE	U.S. Department of Energy
EPRI	Electric Power Research Institute
EU	European Union
GIZ	Gesellschaft für Internationale Zusammenarbeit
H2EDGE	Hydrogen Education for a Decarbonized Global Economy
HSSC	Hydrocarbon Sector Skills Council
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
LSSC	Logistics Sector Skill Council
MBA	Master of Business Administration
MME	Ministry of Mines and Energy Brazil
MOOC	Massive Open Online Course
NCVET	National Council for Vocational Education and Training
NGHM	National Green Hydrogen Mission India
NGO	Non-governmental organisation
NIN	Netherlands Innovation Network
NQR	National Qualification Register
NSDC	National Skill Development Corporation
NSQF	National Skills Qualification Framework
PEM	Proton Exchange Membrane
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
PSSC	Power Sector Skill Council
PUC-Rio	University of Rio de Janeiro
PV	Photovoltaic
RPL	Recognition of Prior Learning
SAIT	Southern Alberta Institute of Technology
SCGI	Skill Council for Green Jobs
SSC	Sector Skills Council
STT	Short Term Training
ToMT	Training of Master Trainers
ToT	Training of Trainers
UENF	Universidade Estadual do Norte Fluminense
UFRJ	Federal University of Rio de Janeiro
UNICAMP	Universidade Estadual de Campinas
VR	Virtual Reality

1 Introduction

A workforce with the requisite skills is a fundamental requirement for a successful hydrogen economy. This second in a series of guidance documents to support the development of sustainable hydrogen workforces focuses on hydrogen-related training. The document highlights innovative practices for training drawing on international case studies. It follows on from the first document in the series which covers hydrogen skills needs assessments and workforce estimation and is complemented by a database of hydrogen job roles and skills.

As indicated in the guidance document on hydrogen skills needs assessments and workforce estimation, the skills needed by a hydrogen workforce would be highly dependent on the nature of the specific regional, national or local hydrogen economy (e.g. which stages of the value chain are present and which technologies are used). Whether new training initiatives may be required may depend on a number of factors including how advanced the area may be in terms of hydrogen technology development or adoption.

The innovative practices presented in this document have been identified through a survey of IPHE member countries, complemented by desktop research and, where possible, through engagement with those who have developed and are delivering the specific training interventions.

These international case studies have been grouped according to a range of themes that are all complementary elements of training for the development of hydrogen workforces. The specific themes are:

- Awareness raising and dissemination of training opportunities
- Networks and platforms for trainers
- Training infrastructure
- Innovative content delivery
- Recognition of training

Following a broad overview if the emerging hydrogen training landscape, these themes are presented in the sections that follow. Each section explains why the specific element is relevant and provides a summary of a number of international examples of related initiatives, highlighting lessons learned that may be of value for replication and providing links for further information. It is the intent that these case study examples serve as inspiration for the development of hydrogen training specific to each regional, national or local hydrogen economy, but that it also catalyses international engagement and collaboration to accelerate the development of hydrogen workforces globally.

2 Overview of the emerging hydrogen training landscape

Hydrogen training offerings range from transnational (e.g. HyResponder – European Union) to training targeting the local community (e.g. Hydrogen School – Costa Rica). In the absence of large-scale accredited hydrogen training schemes, industry has initially taken the lead to ensure that people can be trained on skills valuable for the respective companies. This is to be expected for the relatively nascent stage of the sector globally, but a trend to more institutionally accredited and non-accredited training in conjunction with national education bodies can be observed in many locations around the world (e.g. Canada, Brazil, India).

Training formats and tools vary substantially across educational settings. Both in-person and online training can be effective options, depending on the audience and available resources. Examples of innovative training tools that are covered in this publication include tools that can be integrated into various programmes and adapted to different audiences, as well as ones demonstrating new pedagogical approaches (e.g., the Hydrogen Game, HyResponder – both European Union).

To achieve proficiency in hydrogen technologies in certain job roles, hands-on training is essential. Dedicated facilities or on-the-job experiences provide the necessary environments for, for example, applying safety protocols and practical skills effectively. Facilities like the Hydrogen School (Costa Rica) and the EDUCAM Hydrogen Ready Training Facility (Belgium) serve as valuable models for this purpose. Additionally, mobile training labs, as demonstrated by the GreenSkhy project (France, Netherlands, Germany, Luxembourg, Belgium, and Switzerland), represent an innovative model for enabling more affordable access by trainees at multiple institutions.

The audience for hydrogen training is diverse, including communicators, technical experts, decision-makers, operators, instructors, inspectors, and permitting authorities responsible for approving hydrogen projects. This broad audience may require upskilling and reskilling which may be done by various trainers who themselves need to learn about hydrogen. Therefore, "Train the Trainer" initiatives are essential for multiplying training capacity and expanding outreach. Developing networks to facilitate collaboration among trainers is crucial for achieving this multiplier effect (e.g., H2EDGE – United States).

Effective communication about training opportunities is an important enabler for access to training opportunities and to create an enabling environment for the growth of the hydrogen economy. Repositories and awareness-raising campaigns thus play an important role for disseminating information (e.g., European Hydrogen Observatory, awareness initiatives in South Africa).

As training programs develop, the recognition, standardisation, and accreditation of new formats and topics become increasingly important for both workers and employers. The use of micro-credentials (e.g. Canada) and recognition of qualifications (e.g., Brazil and India) as well as the establishment of internationally recognised certifications will help streamline the requirements of the emerging hydrogen industry, enabling more consistent practice and greater workforce mobility.

3 Awareness raising and dissemination of training opportunities

Interest in hydrogen-related training has grown substantially in recent years, driven by its growing deployment worldwide, advancements in hydrogen technologies and continuing growth of new applications for hydrogen. However, there is a need for greater awareness-raising initiatives to inform individuals about the existing opportunities in the hydrogen sector and to effectively disseminate information on available training programmes. The efficient communication of training opportunities is essential for both individuals and public or private organisations searching for relevant skills development offerings. Developing a comprehensive training inventory can serve as a key resource for streamlining access to these opportunities.

Active promotion is enabled through in-person events, online channels and education or lifelong learning agencies. A well-organised inventory can also help to identify gaps in existing training offerings, highlighting areas where new programmes are needed to address specific skills needs. By tracking the evolution of these training opportunities over time in a given geography, local stakeholders can better align workforce development with the needs of the diverse industrial sectors involved in the evolving local hydrogen value chain.

3.1 The European Hydrogen Observatory: A dynamic mapping of training on hydrogen (European Union)

The European Hydrogen Observatory is a data hub sharing information on the European hydrogen ecosystem. Funded by the Clean Hydrogen Joint Undertaking (Europe), this initiative features a range of training programmes related to hydrogen, which can be visualised on an interactive map indicating their locations. Users of the website can filter these training opportunities by type, focus (e.g., hydrogen production, safety), and preferred language.

The platform catalogues a diverse array of training options, including vocational and professional programmes, summer/winter schools, and Bachelor's or Master's degree courses. Training providers submit the information for these programmes by completing a questionnaire. For a training to be listed, a minimum set of information and references are required in order to allow its posting, ensuring consistency and quality.

While new training listings occur three times a year, users can submit information about newly established or modified programmes via the online questionnaire at any time of year. Submitted information undergoes a quality check before being published.

Lessons learnt and recommendations

- **Offer dynamic content that can be continuously updated**
  - The issue often faced by this type of mapping is that the content collected can become obsolete soon after publication, when such listing is not living document. A one stop-shop presenting a mapping with dynamic content can help overcome this issue. The latest inputs are added to the mapping without the need to republish a document.
- **Facilitate inputs and engagement**
  - Low response rate from training providers can be a challenge hindering the identification of hydrogen training and develop a comprehensive mapping. To foster engagement, it has been found to be more effective to enable the possibility to share inputs all year long rather than during limited time frame during which inputs are collected for periodic updates. In addition, outreach campaigns to invite submissions can be carried out all year long.
- **Create and maintain a community feeling**
  - The information collected can be used as a basis for the development of additional activities and networks that will further aid in the development of a community feeling among those listing training offerings. Such actions do not necessarily take place within the network, but can be developed based on this first step of creating the training inventory. This could also benefit a sense of ownership of the training inventory and motivation for keeping entries updated.

Further information

- https://observatory.clean-hydrogen.europa.eu/learn-about-hydrogen/training-programmes
- https://observatory.clean-hydrogen.europa.eu/

3.2 Hydrogen South Africa (HySA): strategic hydrogen training and dissemination (South Africa)

A more active dissemination approach is the case of a strategic hydrogen programme in South Africa. While hydrogen jobs in South Africa are limited today, the country is preparing for significant growth in this sector over the coming years. Several training programmes and initiatives are being developed to equip the current and future workforce with the skills needed for hydrogen technologies. A core element of this is Hydrogen South Africa (HySA) – a strategic research, development and capacity-building programme.

The HySA programme was launched in 2008 by the then Department of Science and Technology (now Department of Science, Technology and Innovation). The HySA programme's three HySA Centres of Competence (HySA Catalysis, HySA Systems and HySA infrastructure) have become vital hubs for knowledge transfer and as such play a significant role in educational and training activities. Three complementary approaches to awareness raising and dissemination of training opportunities have been implemented that could serve as models for other countries preparing their workforce for hydrogen-related activities:

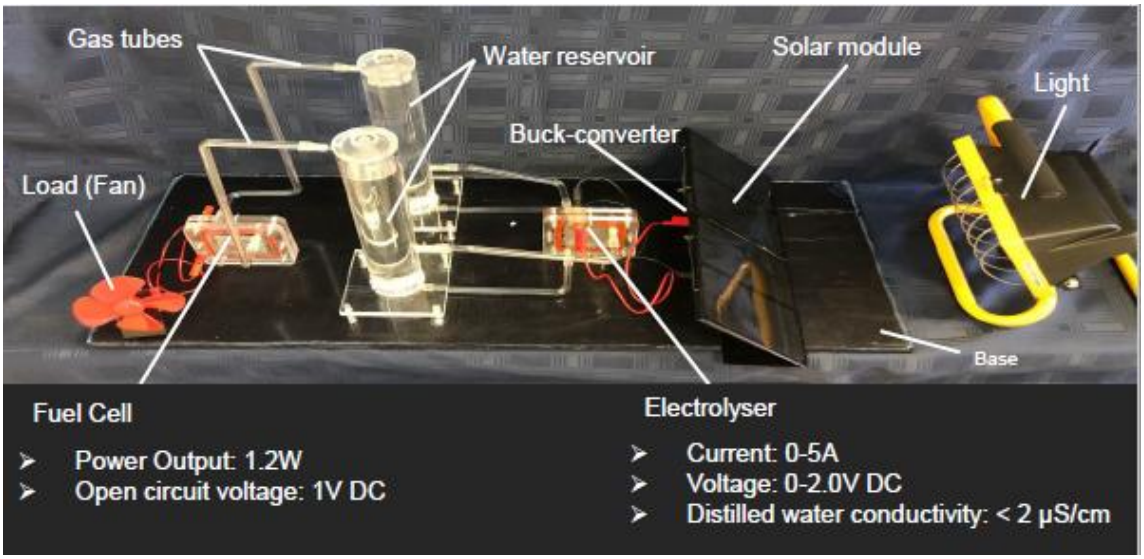
1. **Community awareness programmes**: Raising awareness about hydrogen is essential for generating interest among potential future workers. Informing the public about job opportunities in the hydrogen sector and available training is a core element of this. For example, the Careers Expo programme in the Cape Town metropolitan area targets school

students in grades 8 to 10 to spark their interest and understanding of hydrogen technologies.

2. **Decision maker training**: Equipping decision-makers with knowledge about the emerging hydrogen industry is key to securing support for hydrogen projects. The German development agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), in collaboration with the University of the Western Cape, sponsors a two-day training programme across South Africa aimed specifically at decision makers in national, provincial and local government, as well as the private sector. This programme provides them with insights into renewable and low-carbon hydrogen technologies across the hydrogen value chain, thus supporting the ongoing development of the hydrogen economy.
3. **University collaboration and continuous education**: Preparing the workforce involves both initial and continuous education. The HySA centres collaborate closely with universities, providing internships and research opportunities for graduates. Centre staff also offer courses at universities to enhance students' awareness of hydrogen sector activities in fields like chemical engineering and materials science. This top-up of existing education with a hydrogen enhancement is a step to spreading hydrogen knowledge more widely. Additionally, continuous education programmes, such as the University of Western Cape's two-day course on Hydrogen Technologies and Safety, are essential for upskilling existing workers.

Picture: HySA Catalysis: University of Cape Town team explaining hydrogen technologies to high school learners at the Masia Village exhibition in Limpopo in 2024

In these training initiatives, practical training materials and hands-on learning experiences are crucial. Engaging with tangible objects enhances understanding. A demonstrative kit has been developed, which includes a PEM electrolyser, water tanks, a PEM fuel cell, a solar module, and an electric load fan. This kit is designed to teach key concepts such as the operation of electrolysers and fuel cells, renewable energy integration, energy storage and conversion, and safety practices.



Picture: University of the Western Cape renewable hydrogen demonstration kit,

Lessons learnt and recommendations

- **Engage various audiences on hydrogen technologies**
  - Engaging various audiences will help not only developing expertise, but also fostering awareness, interest and support for hydrogen technologies. The training content must be tailored to the audience level and formatted according to its availability for attending training.
- **Enhance existing educational programmes**
  - Instead of starting from scratch to develop new specialised training, a low hanging fruit would be to add specialised modules for students pursuing degrees related to the hydrogen sector.(The IPHE database of hydrogen job roles and skills can be used as a starting point for determining which qualifications would benefit from such augmentation and some guidance of the scope of such augmentation.)
- **Organise hands-on workshops helping visualisation**
  - Hands-on workshops are needed when working on the technologies, but can also be helpful to improve the visualisation of the hydrogen value chain for non-expert audiences. Participants can use objects and models to conduct experiments on a simple scale and better comprehend the connection between hydrogen technologies and the energy system as a whole.

Further information

- https://www.hysasystems.com/
- https://pillar7uwc.ac.za/courses/hydrogen-technologies-and-hydrogen-safety-cid33

4 Networks and platforms for trainers

The incorporation of hydrogen as a subject into broader educational programmes is on the rise across various fields of study internationally. A range of initiatives enable teachers, trainers, and professors to familiarise themselves with hydrogen-related content, thus enabling them to integrate new information and update their knowledge with the latest advancements.

To facilitate this process, and to promote standardisation and replication of successful pedagogical tools and approaches, building a network of trainers can be highly beneficial. Such a network would allow for the sharing of ideas, best practices, and expertise. Sharing of experience on how to establish these networks and on the types of activities that are most relevant to different audiences can be relevant for countries seeking to implement similar initiatives.

4.1 The H_2EDGE programme: a collaborative training initiative and network (United States of America)

The Hydrogen Education for a Decarbonized Global Economy (H_2EDGE) initiative, led by the Electric Power Research Institute (EPRI) and supported by the U.S. Department of Energy's (DOE) Hydrogen and Fuel Cell Technology Office and the Low-Carbon Resources Initiative, brings together over 20 universities and 20 industry stakeholders in the United States. This initiative aims to connect stakeholders to deploy training materials for university students and energy sector professionals focused on hydrogen. The initiative has developed, shared, and tested seven university modules and five professional short courses tailored for a range of knowledge levels and key subject areas. Feedback from participants has been used to enhance the content.

The collaboration between academia and industry in the H_2EDGE programme was modelled on other EPRI-led initiatives such as GridEd, the Center for Grid Engineering Education. By engaging professors and industry leaders, these initiatives foster the creation of educational resources that effectively bridge theory and practice, reflecting the latest developments in the sector. Rather than employing a top-down approach, the co-creation of content – where each participant contributes their expertise – better suits this type of university-industry educational collaboration. This model empowers trainers to take ownership of the content by actively participating in its development.

Because the H_2EDGE initiative is funded by the DOE, the programme aims to make all materials publicly available for maximum reach and impact. Additionally, the first annual workshop was held in July 2024, and served as a platform for academic, industry, government, and community stakeholders to convene, assess progress, and engage in discussions about educational advancements and workforce development in the hydrogen field. A workshop summary and all presentation materials are available for download through the H_2EDGE website. Moreover, this expert network cultivates connections and collaborations that extend beyond the project's immediate goals. The industry-academia collaboration proposed here is also beneficial for students, as it familiarises them with this type of partnership which is a crucial driver of innovation.

Lessons learnt and recommendations

- **Promote co-creation, mentorship, applied learning, and peer-reviews when developing educational content with multiple academic and industry stakeholders**
  - Supplying educational content alone does not lead to uptake by academics – the content must be coupled with deployment support, such as mentorship and workshops.
  - Lack of time and other resources can hinder faculty's ability to engage with new content so initiatives should budget for flexible funding to support professional development activities – this is especially impactful for teaching universities, which offer the greatest opportunity to impact the emerging workforce.
- **As the energy system becomes more complex, challenges related to outdated educational content and scarcity of subject-specific expertise becomes more pressing**.
  - Gaps assessments show significant workforce deficiencies across the energy sector.
  - Many key aspects of the energy transition are not commonly incorporated into university curricula, such as incorporating a cost of carbon, societal impacts of energy systems, lifecycle assessment methodology, process engineering for industrial coupling, and electrochemistry.
  - A more coordinated approach to sharing educational content and advancements in educational technology could assist in addressing these issues.
- **With the rapid pace hydrogen development, many stakeholders are unaware of other experts working in similar areas:**
  - Networks and events that facilitate the exchange of information will improve the effectiveness of collaboration and increase expertise across disciplines and sectors.
  - Design deliverables and information platforms that that are centralised, accessible, adaptable, and easily updated.
  - Connect with complementary initiatives, centres, and associations to broaden reach and deepen awareness of the practical aspects of workforce development.

Further information

- https://hydrogen.epri.com/en/h2edge.html
- https://www.epri.com/research/sectors/lcri
- https://grided.epri.com/

4.2 The HyAcademy: a network of schools and universities (European Union)

HyAcademy, the European Hydrogen Academy, funded by the Clean Hydrogen Joint Undertaking, is working to build a broad educational ecosystem for hydrogen technologies. Its goal is to connect over 100 universities offering degrees, certifications, and specialised programmes in the field, alongside more than 500 schools that will incorporate hydrogen-related teaching into their science education. To support this effort, HyAcademy is making free teaching resources available in multiple European languages, enabling teachers to deliver the necessary content effectively. The network will also feature practical, hands-on training facilities. Additionally, a central online platform will guide prospective students to accurate, up-to-date information on learning opportunities.[3] One of the project's core missions is to lay the foundation for a future European Net-Zero Hydrogen Academy, which is intended to consolidate European efforts on hydrogen skills development.

Outcome 1: Internet Platform

The HyAcademy internet platform will serve as a central hub for hydrogen-related education to offer an extensive online library of free teaching materials for schools and universities. It will act as an access point for detailed information on courses, programmes, and teaching resources. This will help guide students, pupils, and educators to relevant opportunities. Beyond being a repository of educational content, the platform will also foster community-building among learners and teachers across Europe. The intention is to have 5,000 platform users in 2026 and 6,000 in 2028.

Outcome 2: Teaching Material

To support a streamlined education in hydrogen and its related technologies HyAcademy will provide comprehensive and free teaching resources. This includes a series of 12 e-textbooks covering the full scope of hydrogen and fuel cell technologies, as well as dedicated materials for schools, such as teacher guides and student workbooks. Innovative teaching methods will also be developed, primarily for schools but adaptable for use in universities.

Outcome 3: Network of Schools and Universities

To constantly improve and refine its offering, HyAcademy is aiming to build a network of over 140 universities and 650 schools across Europe by 2028. The networks will support the development of hydrogen-related modules, provide access to translated teaching materials, and facilitate the exchange of best practices. Universities and schools which are already offering, or are planning to offer hydrogen-related education, are invited to join and benefit from free resources, including a shared repository of educational content.

Outcome 4: Network of Teaching Labs

Beyond the support in theoretical knowledge, HyAcademy is developing a network of teaching laboratories to address the growing need for practical hydrogen training. Given the high investment costs, the initiative focuses on identifying labs (from their network) willing to share their facilities and activities with other universities. By pooling resources, institutions

[3] HyAcademy focusses on schools and universities, whereas the Hydrogen Observatory (section 3.1) also includes vocational education and training (VET) and industrial training opportunities.

can collectively access hands-on training infrastructure and expand practical learning opportunities across the network. By 2028 this infrastructure should entail 10 laboratories.

Outcome 5: The Net-Zero Hydrogen Academy
As indicated, a key task of HyAcademy is to develop a foundation for the future Net-Zero Hydrogen Academy, a web-based educational tool aimed at reaching over 100,000 users with hydrogen knowledge. HyAcademy covers the conceptualisation and curriculum design, as well as the development of interactive online learning tools. Further development of the Net-Zero Hydrogen Academy will follow, pending additional funding.

Lessons learnt and recommendations

- **There is a barrier to officialise network participation**
  - Universities and schools showed interest to be involved in the network, but formalising an engagement seems to be a hurdle for many.
- **The availability and access to laboratories is a strength of a university network**
  - Organising courses with embedded mobility i.e. courses which enable learners to be educated by different institutions within the same programme is an innovative means of enabling access to training infrastructure, but it remains a challenge for universities to deliver such courses.
- **For a fairly new subject of teaching, such as hydrogen, an accreditation support for universities, which helps staff to build and pitch a programme to their universities has been well received by network participants.**

As the project is in its the second year at the time of writing, more lessons learnt can be expected once the project has been completed.

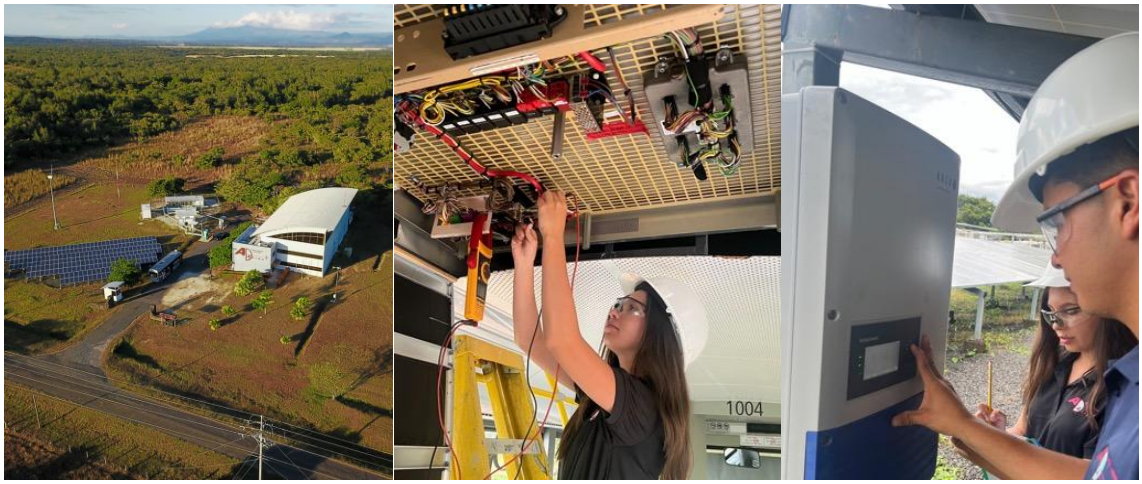
Further information

- https://hyacademy.eu/aboutus/

5 Training infrastructure for hydrogen

For many hydrogen-related jobs, technical expertise is essential and requires practical training. Effective training infrastructure is crucial for teaching the necessary skills and safety protocols. A well-designed pedagogical framework will enable learners to practice safely and develop the competencies needed for the workplace. The industry's role in clarifying work expectations and assisting in the development of this infrastructure is vital, as they possess the real-life experience needed for their development. Examples of such infrastructure can be found across the world, and come in various shapes and forms, as detailed below.

5.1 The Hydrogen School: hands on training for local youth (Costa Rica)



Picture: Costa Rica Hydrogen School, Ad Astra Rocket Company & Estrategia Siglo XXI

The Hydrogen School in Costa Rica is an example where training infrastructure has been set up deliberately to provide practical hands-on experience as a core element of training. The concept emerged in 2022, when it became clear that companies faced challenges in finding qualified personnel, particularly technicians, experienced in the hydrogen sector. While engineers were available, many lacked the hands-on experience necessary for the roles needed to expand Costa Rica's hydrogen activities. Moreover, as opposed to formal university education, the training concept is deeply practical and hands-on, more closely resembling nuclear reactor or flight training, where operators or pilots are trained to safely and effectively handle complex and hazardous technology or machines without the need for an advanced degree in nuclear engineering or aerodynamics.

In a labour market context, many young people in Costa Rica do not pursue higher education after secondary school, often opting to seek employment instead. This demographic represents a valuable pool of potential trainees interested in a shorter format of post-secondary education.

To address the industry's needs and to build on the younger generation's desire for alternative educational pathways, the Hydrogen School was developed. The initiative brought together the NGO Estrategia Siglo XXI (ESXXI), Ad Astra Rocket Company, and the W. K. Kellogg

Foundation. Funding was secured through the foundation, while Ad Astra provided the infrastructure for the school on its premises in Guanacaste, Costa Rica.

In the Hydrogen School, instruction often occurs on a one-to-one basis, hence presenting a highly individually adapted learning opportunity, but making it difficult to "mass produce" those technicians. The training lasts 4 to 5 months, during which students receive scholarships to support themselves fully and focus on their education. Each cycle attracts many applications. A preference for local youth from the Guanacaste region is applied in line with the intent to strengthen the local skills and economy.

In terms of infrastructure, minimal adaptations were necessary, as much of the required equipment was already available at Ad Astra. A donation of a fleet of fuel cell buses from AC Transit of Oakland, California further enhanced resources to teach on real-life applications. Between each teaching cycle, breaks are scheduled to recondition the facilities and to replenish consumables.

At the present scale of the operation, the cost per student is approximately $30,000 per cycle. The Hydrogen School ran its fourth cycle in 2025, historically enrolling two students per cycle, with a goal to increase this to four. Plans to expand the school geographically or by educational level are under consideration, including the possibility of replicating the model in various locations across Latin America and the United States, contingent on available funding. Additionally, there are plans to integrate higher-level students and young engineers who would be able to work more independently and be interested in experimental practical projects. As there are as yet no formal accreditation for hydrogen training in Costa Rica, the reputation of the company for its experience in hydrogen deployment plays a role in terms of the recognition of the training done at the Hydrogen School.

Lessons learnt and recommendations

- **The existence of hydrogen activities and industry stakeholders in the country of establishment of a hydrogen school is precondition.**
  - Producing hydrogen is a precondition to the establishment of a hydrogen school based on a similar model. Effective training requires access to real hydrogen systems and infrastructure for hands-on experience, rather than just theoretical instruction.
  - The industry plays a crucial role in implementing such training initiatives, as it has a demand for skilled workers and the necessary infrastructure to provide practical training.
  - Without pre-existing accredited hydrogen education in a country, industry needs take on the responsibility of an "educator" to ensure that critical employees are equipped with the necessary skills.
- **A sustainable funding mechanism is a prerequisite to sustain the functioning of a Hydrogen School.**
  - Funding can be a bottleneck for these initiatives. Engaging with companies and potential funders is key to strengthening the financial sustainability of a practical training facility.

Further information

- https://www.oecd.org/content/dam/oecd/en/about/programmes/cefim/green-hydrogen/ad-astra-case-study.pdf/_jcr_content/renditions/original./ad-astra-case-study.pdf
- https://peninsulapapagayo.com/hydrogen-school/
- https://ticotimes.net/2023/08/03/costa-rica-launches-hydrogen-school-to-train-youth-in-clean-energy
- https://knowablemagazine.org/content/article/technology/2023/green-hydrogen-latin-america
- https://ticotimes.net/2024/09/03/costa-ricas-green-hydrogen-initiative-to-boost-decarbonization

5.2 EDUCAM training centre: practical training for hydrogen vehicle repairers (Belgium)

Picture: EDUCAM hydrogen vehicles training facility

EDUCAM is a sectoral organisation based in Belgium that focuses training and sectoral support for the automotive sector. As a response to an anticipated shift in the market, it developed a qualification structure that trains and certifies personnel to work on and repair hydrogen fuel cell vehicles. In order to provide trainees engaged in certification with the hands-on skills required to occupy these roles in the future, EDUCAM commissioned two purpose-built training workshops. These labs, located in Belgium, were built as model workshops to closely emulate the working conditions for automotive technicians, while maintaining a safe learning environment. These model workshops contain not only the equipment that trainees will encounter in the workplace, but also visual aids and sub-systems, such as fuel cells to provide trainees with a better understanding of the equipment.

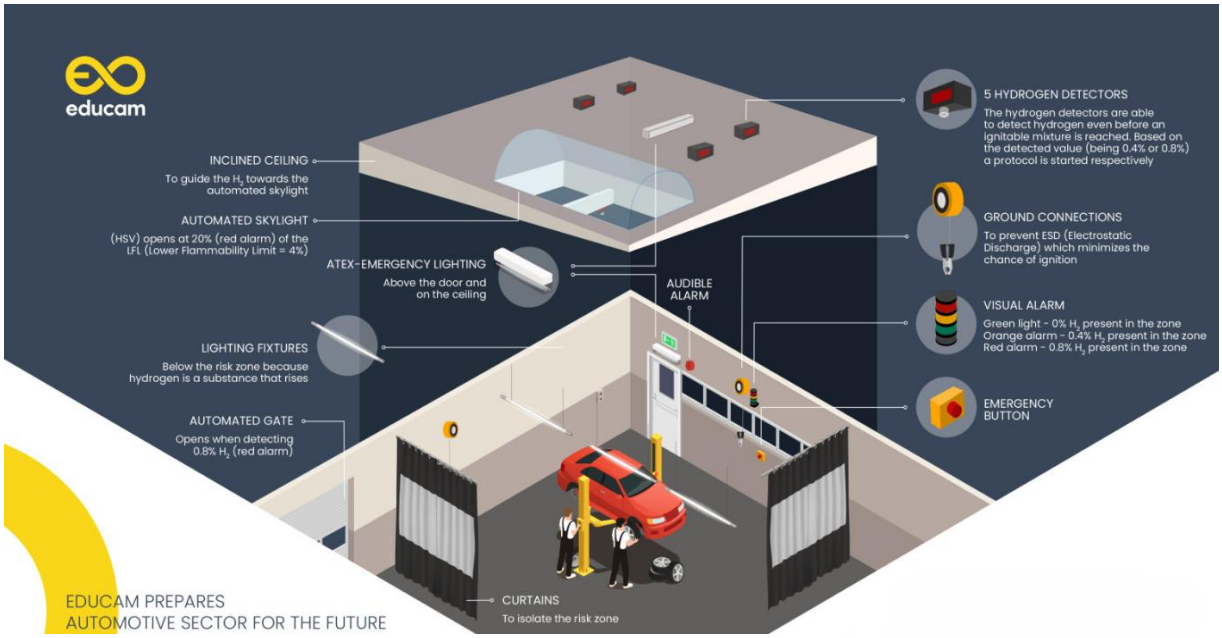
The workshops are used to train workers at three levels of hydrogen expertise:

1. HY 1: This level targets workers who deal with hydrogen vehicles but do not work directly on hydrogen-related components. The training focuses on raising awareness about how their tasks relate to and may impact the hydrogen components of the vehicle. Examples of their tasks include,
   a. work on auxiliary systems for hydrogen,
   b. work on cooling systems,
   c. maintenance,

d. monitoring and calibrating hydrogen sensors underneath the vehicle.

2. HY 2: At this level, workers are trained in technical work for both hydrogen and non-hydrogen related components of the vehicle, but only when these components are depressurised and free of hydrogen. Therefore, depressurising and validating that all hydrogen was removed, is a critical part of this training. In reverse, the technicians are trained to pressurise the hydrogen system and perform a check on leak detection. While the theoretical teaching in HY1 and HY2 are identical, HY2 is focused on practice.
3. HY 3: This advanced level is still under development at the time of writing. It aims to qualify graduates as hydrogen risk experts, allowing them to work on the vehicle even when there are risks associated with handling hydrogen components.

Ensuring that the workshops expose trainees to good practices for workplace safety, and that trainees can safely engage with the equipment to learn effectively, safety was a key element in their design (see picture of training facility below). Industry partners were also instrumental in the design of the workshops and also played a role in providing some of the necessary equipment. With the lessons learned by designing their training facilities, EDUCAM also developed and published a "Hydrogen in the automotive repair sector - Good Practices Guide" in 2022, which is available upon request. Key elements highlighted as being necessary for a safe workshop were a reduction of risks in the work zone, H2 detection, providing alerts for problems, and effective evacuation of hydrogen from the facility.



Picture: Schematic of EDUCAM hydrogen vehicles training facility highlighting the key safety features

Lessons learnt and recommendations

- **Hands-on training is most effective when purpose-built training infrastructure is paired with an environment that closely resembles the working environment**
  - While safety is of utmost importance both in the workplace and in training environments, training infrastructure with an excess of safety measures can drive the costs of setting up a facility to the point of being unfeasible/unaffordable, but also

leaves trainees less prepared to enter the workforce due to the differences between an operational repair workshop and the training facility.
    - Targeted, thought-out, and specific safety measures can provide trainees with a training environment that is safe while adequately preparing them for the working conditions they will face in industry.
- **The current lack of standards in this nascent industry poses challenges for developing training facilities**
    - When developing training facilities, the insights and lessons learned such as those recorded in "Hydrogen in the automotive repair sector - Good Practices Guide" are valuable to both industry and other training providers.

Further information

- https://www.educam.be/fr/hydrogene-infrastructure

5.3 GreenSKHy: mobile lab facilities (Countries in North-West Europe)

Picture: Containerised mobile lab facility of GreenSKHy

Green Skills and Knowledge for Hydrogen (Green SKHy) is a project under the European territorial cooperation programme, Interreg North-West Europe. Green SKHy aims to advance clean hydrogen adoption by focusing on training initiatives that address barriers to the recognition of skills across the region and support the creation of new transnational training programmes. As a transnational consortium, Green SKHy consists out of 17 partner organisations from France, the Netherlands, Germany, Luxembourg, Belgium, and Switzerland.

An innovative approach to hands-on training being trialled is the use of mobile training labs. Along with the network of traditional H2 training labs within the network, there are also two mobile training labs that are in the process of being trialled and developed. This is an innovation in teaching infrastructure, as the labs are brought to the trainees rather than the trainees needing to find and travel to scarce hydrogen training labs.

The first operational lab is a containerised solution that will cycle between the cities of Mulhouse and Metz in France. It was commissioned by French agency, AFPA, which assists jobseekers by operating vocational training and providing other assistance revolving around career development. Trainees using the lab will undertake a nine-month course aimed at jobseekers with a level 4 of qualification on the European Qualifications Framework[4], with some existing technical skills and knowledge. Trainees are educated on how to handle pressurised systems, the cooling and compression of hydrogen, maintenance skills, hydrogen safety and production optimisation. This course will allow graduates to work in more autonomous roles at facilities such as renewable hydrogen production/storage/distribution facilities, or hydrogen refuelling stations. The skills and exposure provided to electrical, mechanical and pneumatic machinery also allows graduates to work in other chemical industries, building a foundation beyond a career in hydrogen. This provides flexibility to participants and does not restrict them to a career in one specific sector.

The mobile training lab contains a full suite of equipment associated with the production, compression, and storage of hydrogen as well as its usage in fuel cells. To illustrate the entire electrolyser-based hydrogen production pathway, solar PV panels also form part of the training equipment. As a complement to the technology situated inside the mobile lab, additional diagrams are transported with the lab but can be situated within the permanent training facility for the duration of the training, further adding value to trainees. Compared to traditional training facilities, the use of a mobile lab is beneficial since it allows the equipment to be utilised by a wider group of geographically dispersed trainees. It can save costs for training institutions to share the infrastructure and improves its rate of utilisation. As the equipment that requires the highest degree of safety-consciousness confined to the container, it also mitigates safety concerns arising from unsuitable building specifications.

Lessons learnt and recommendations

- **Mobile training labs allow for training institutions to have access to important hands-on training equipment without investing in a permanent facility which may only be used by a portion of the trainees enrolled at the facility.**
  - Costs for a mobile lab can be shared between training institutions.
  - Trainees are spared the expense of travelling to access training infrastructure.
  - For containerised mobile training labs, host institutions are allowed to facilitate the training with having to undergo the potentially extensive safety adaptations required to make their buildings compatible with the use of hydrogen.
- **Although mobile training labs offer the opportunity to share resources between training institutions, their scale is limited as the larger the lab, the costlier it is to move it.**

Further information

- https://greenskhy.nweurope.eu/
- Video: https://www.youtube.com/watch?v=Iw_WnShgAVQ

[4] EQF Level 4 usually denotes someone who has completed upper secondary education e.g. certain high school diplomas, technical or vocational education

6 Innovative content delivery

Innovative training schemes offer fresh approaches to learning and teaching by transforming how content is delivered. These tools enhance learning experiences and facilitate skill acquisition. Examples include gamification and virtual reality, among others. The ease of replication and the openness of the initiatives described below make them particularly relevant for consideration.

6.1 Green Skills for Hydrogen - the Hydrogen Game (European Union)

Picture: Green Skills for Hydrogen - Icons of the Hydrogen Game

The Hydrogen Game is an innovative teaching tool developed to help accelerate the development and implementation of high-quality teaching and education about hydrogen. The game has been developed in the context of the EU-project *Green Skills for Hydrogen*, where more than 34 partners in 15 countries are exploring and developing the frontiers of hydrogen education.

The Hydrogen Game aims at addressing some of the key challenges faced when teaching about hydrogen. Firstly, the diverse range of learners' prerequisites in a classroom can complicate the overall quality of learning and discussions. Second, instructors must navigate the tension between focusing on intricate technical details and broader systemic concepts. Finally, the emerging nature of hydrogen technology makes it difficult for learners to fully grasp the subject.

To tackle these challenges, the Hydrogen Game proposes a pedagogical approach based on visible learning, using icons and a drawing board for interactive activities. All elements are accessible, printable and adjustable for various contexts and budgets. This is associated with dialogic pedagogy, allowing learners to engage with new concepts in their own language through group discussions and interactions with the teacher. The diversity of icons encourages interaction for both new and experienced hydrogen learners, enabling the teacher to tailor the instruction to meet classroom expectations and individual needs.

By building on learners' prior knowledge, both as individuals and groups, the Hydrogen Game enables high quality learning. Instead of passively listening, learners explore concepts and cases together, thus co-creating the knowledge in the classroom with relevant feedback from the hydrogen trainer. Additionally, cases and input can be adjusted flexibly to the needs of, for example, local authorities, businesses, and educational institutions. In that way, practice implementation is at the core of the didactic design. The game has been tested on several occasions, in both purely online and in fully offline contexts. In both settings, the game has been very well received. The game is being tested through a number of pilot trainings and there is an ongoing feedback loop with educators to improve the effectiveness in teaching about the hydrogen supply chain.

Lessons learnt and recommendations

- **Pedagogical tools that promote engagement and discussion enhance learning about hydrogen.**
  - Hydrogen teaching need to equip learners with skills to flexibly discuss both the system and the details in a hydrogen energy system and economy. The game facilitates meaningful dialogue that encourages exploration of complex energy systems as a whole.
  - Innovative tools like the Hydrogen Game significantly boost participation and enthusiasm among students, including in online settings.
  - Making students' understanding visible through collaborative activities enhances comprehension and provides teachers with valuable feedback on student learning.
- **These pedagogical tools can be designed with varying levels of complexity to suit different audiences.**
  - Well-designed educational resources can be scaled and adapted across different contexts, effectively supporting hydrogen education throughout different levels and different stages of the educational journey.

Further information

- www.greenskillsforhydrogen.eu

6.2 HyResponder – Training for first responders (European Union)

Picture: HyResponder - virtual reality (VR) training videos for first responders

The HyResponder project, funded by the Clean Hydrogen Partnership, has developed a sustainable and scalable train-the-trainer programme in hydrogen safety for emergency responders across Europe. A focus on first responders is needed urgently as hydrogen technologies scale up. HyResponder integrated digital methods and tools to deliver impactful and adaptable training for diverse national contexts. By directly involving responders in the permitting and emergency response chain, the project aimed to improve both operational readiness and public confidence in hydrogen and fuel cell technologies.

At the core of this training is the use of virtual reality (VR) tools, modern e-learning platforms, and updated operational guidance that reflect the latest developments in hydrogen safety, including more futuristic scenarios such as the transportation of liquefied hydrogen. The project is enables the updating of the European Emergency Response Guide and training of a new generation of hydrogen safety instructors from at least 10 countries. These instructors form a Pan-European Network of responder trainers, equipped with translated, state-of-the-art materials specific to the regional context. The training content is available in eight languages and is expected to be continuously refined based on real-world feedback, ensuring its relevance and adaptability.

National Training Clusters have been created to connect the hydrogen industry with local responder communities, helping embed this expertise at national and local level. Additionally, an international e-forum connects trainers and responders to create a collaborative learning environment. Through its use of digital tools, multilingual access, and cross-border coordination, HyResponder is supporting the filling of a critical skills gap and helping to set a new standard for how hydrogen safety training is developed and delivered across Europe and potentially beyond.

Lessons learnt and recommendations

- **At the project outset a "one size fits all" online training module or course was the goal, but this needed to be revised as too many regional differences were encountered.**
  - Training approaches for fire fighters across Europe vary significantly. Many French firefighters are volunteers from a range of backgrounds; in Belgium many have engineering degrees.
  - Thus, materials were developed that could be first delivered to a trainer from a region. The trainer then adapted how these were delivered, to ensure that they complemented existing local or regional training and were fit for purpose.
  - This approach makes the project outcomes a good fit to serve as basis for any location that has not yet developed hydrogen-related training for first responders.
  - Training materials in hydrogen safety are freely available in 8 languages (Czech, Dutch, English, French, German, Italian, Norwegian, Spanish).
- **Regarding innovative and virtual training:**
  - A series of VR training activities was created and trainers undertook these in person, alongside hands-on operational training. These were very positively received. However, the hands-on operational training was deemed key for firefighters.
  - Due to the pandemic a series of "training sequences" was produced. These were videos created from both the operational and VR exercises with an accompanying activity document for each set of videos. These are intended to be used primarily by trainers, who have undertaken the in-person training.
  - The HyResponder website includes an online e-laboratory in hydrogen safety, which is a useful tool for estimating, for example, hazard distances. This was used to underpin the teaching materials in HyResponder.

Further information

- https://hyresponder.eu/
- Training videos: https://hyresponder.eu/e-platform/training-materials/virtual-reality-training/

7 Training recognition

Consistent with the emerging and evolving nature of hydrogen economies, particularly those utilising renewable and low-carbon hydrogen, the majority of training is done by industry. This has benefits in terms of enabling training to be in line with demand, both in the scale and the specific skills required, and also enables access to practical- and work-relevant experience. However, particularly where rapid growth of the hydrogen sectors is expected, there will be substantial demand for new skills and updated training, and a need for mechanisms for recognising various learning pathways. In this context, training recognition is describing the process by which learning achievements are validated and made visible to future employers.

There are challenges to keeping traditional degrees (e.g. Bachelor/Master) and vocational qualifications updated to keep pace with innovative technologies like hydrogen production, storage, or safety systems. Moreover, such formal training can be less attractive to many, due to, for example, the cost, time commitment or line of sight to immediate job opportunities.

For the hydrogen sector, there are still many uncertainties in terms of the nature of implementation, pace of growth and jobs needed in any particular region or country. This makes it difficult for governments and education institutions to commit to an investment in formal accredited education and training. Micro-credentials are an option that provide a form of accredited training, while leaving lower budget flexibility to adapt to changing realities. Another benefit of micro-credentials is that these can bridge the gap of knowledge for people that are already employed in a related industry, through enabling up- and reskilling. Examples include the renewable energy sector and the oil and gas industry, where many skills can be a valuable foundation for hydrogen sector jobs as well.)

7.1 Training institutions: micro credentials in the hydrogen sector (Canada)

As Canada's hydrogen sector continues to grow, there is an increasing demand for skilled workers across various industries, including energy, manufacturing, transportation, and chemicals. One innovative approach to addressing this skills gap has been the development of micro-credentials, which are short, targeted courses designed to provide specialised training. Micro-credentials have emerged as a flexible, accessible solution for workers seeking to enhance their skills or transition into new roles within the hydrogen economy.

Initially, micro-credentialing in Canada was closely tied to industry-provided training at exhibitions, conferences, and regional hydrogen hubs. These offerings often focused on hands-on training and were delivered through collaborations between industry, academia, and other stakeholders. However, the rise of online learning has shifted the focus toward digital platforms and continuing education formats, allowing micro-credentials to reach a wider range of workers across multiple sectors. This shift has proven particularly valuable as the hydrogen economy expands into regions traditionally dominated by fossil fuels, such as the Prairie provinces.

Canadian institutions like the Southern Alberta Institute of Technology (SAIT), Mohawk College, and Lambton College have taken the lead in developing hydrogen-focused micro-credentials. These programmes typically have a shorter duration than traditional courses, are aligned with industry standards, and often have few or no prerequisites. This makes them

accessible to a broad range of learners, from recent graduates to seasoned professionals looking to upskill. In many cases, competency-based testing ensures that workers can apply the knowledge they have gained directly to their roles in the hydrogen sector.

The offerings include general awareness raising courses in addition to more technical course. For example, SAIT offers a course entitled "Low-Carbon Hydrogen: What Canadians Need to Know," a free massive open online course (MOOC) aimed at raising awareness and building foundational knowledge of hydrogen technologies. The more technical courses, which focus on core competencies like hydrogen production, handling, and safety, are designed to provide both essential information and to bridge the gap between current and future hydrogen-related job roles to prepare the workforce for the energy transition. In addition, centralised platforms like Quick Train Canada are helping to streamline access to these programmes, offering a single point of entry for workers and students across various industries. Continued support from federal, provincial and territorial governments is considered essential to leveraging the full potential of micro-credential programmes such as these to build the skilled workforce required for Canada's multi-faceted hydrogen economy.

Lessons learnt and recommendations

- **Flexibility and accessibility of micro-credentials are key to develop the hydrogen sector.**
  - Micro credentials offer short, targeted courses with minimal prerequisites, hence providing pathway for workers from various industries to upskill or transition into the hydrogen economy.
- **Online format of training increased the reach of programmes**.
  - Although the educational content might need to differ from in-person training, online availability allows more participants to attend the courses. This format is particularly useful for the theoretical content.
- **Alignment with industry standards is crucial to ensure the content is relevant for the work life.**
  - Competency-based testing ensures that workers are ready to apply their skills immediately in practical settings.

Further information

- https://www.sait.ca/continuing-education/courses-and-certificates?type=Micro-Credential%20Courses
- https://quicktraincanada.ca/

7.2 Universities: the evolving academic framework for training recognition (Brazil)

Picture: Centre of Excellence in Professional Training for Hydrogen from electrolysis in Brazil. SENAI-RN

Brazil has a long history of hydrogen production and consumption, particularly in oil refineries, which has created a strong foundation in training personnel in related fields. Educational institutions have been building expertise in this area for decades. For instance, the Universidade Estadual do Norte Fluminense (UENF) established Brazil's first Petroleum Engineering undergraduate course in 1993, after the introduction of Master's and postgraduate programs at other universities such as the Universidade Estadual de Campinas (UNICAMP). The Federal University of Rio de Janeiro's Alberto Luiz-Coimbra Institute (Coppe) also launched a professional MBA in Oil and Gas in 1998, marking a significant step in professional training for the energy sector.

Currently, petroleum and gas engineering Bachelor's degree programs are available at approximately eight public and at least seven private universities nationwide. These five-year programs, typically requiring 3,600 to 4,000 hours of coursework, cover areas such as refining, chemistry, and occupational health and safety. This foundation is highly relevant for low-emission hydrogen production pathways, including those using biogas and ethanol. Some institutions, including the Federal University of Rio de Janeiro (UFRJ) and the Pontifical Catholic University of Rio de Janeiro (PUC-Rio), also provide postgraduate training in carbon capture and storage (CCUS), an important element of decarbonisation strategies linked to hydrogen.

Despite this robust background, low-emission hydrogen remains relatively new and is rarely integrated into standard curricula. To address this gap and promote hydrogen as a key energy vector, the Brazilian government launched the National Hydrogen Programme (PNH2) in 2021, making human resources training a core component. A key example is the H2Brasil project, led by GIZ in partnership with the Ministry of Mines and Energy (MME), which focuses on electrolysis-based hydrogen and explicitly promotes the development of a new academic and

training framework for hydrogen. This evolving framework underpins Brazil's approach to training recognition, ensuring that hydrogen-related skills and qualifications are progressively embedded into higher education and vocational systems.

H2Brasil has promoted knowledge exchange, developed new course content, and established training laboratories. Central to this approach is the training of "multipliers", teachers and trainers, who then pass knowledge on to wider groups. Over 1,500 professionals have completed more than 1,200 hours of hydrogen-focused courses, boosting Brazil's capacity to train a workforce for the energy transition. Executing partners include universities across the country. Increasingly, universities are offering postgraduate and short hydrogen courses, typically lasting 6 to 40 hours, signalling a growing recognition of hydrogen as a distinct training field. In an absence of a nation-wide recognition system, reputable universities can play a big role in providing credible training recognition.

Regional initiatives are also shaping this academic framework. For example, the Brazilian Northeast, especially Ceará, has strong renewable potential for hydrogen production. Here, the "Education and Skills for the Future" project connects the Ceará Industry Observatory, the State Government, and the Pecém Complex to align curricula with local hydrogen industry needs.

In 2024, the Brazilian Hydrogen Association (ABH2) and the Netherlands Innovation Network (NIN) published a mapping of Brazil's hydrogen R&D and training landscape. It highlighted Brazil's opportunities in bio-based hydrogen and power-to-X, and pointed to synergies between academia and industry. This shows how Brazil's evolving academic framework is not only expanding training provision but also aligning recognition of hydrogen skills with broader workforce development.

Lessons learnt and recommendations

- The **engagement of student-workers** is contingent upon the company's initiatives to encourage active participation and presence in their respective courses.
- **Practical, in-person training is essential**, as it provides students with the opportunity to safely engage in the production and application of hydrogen within a real-world context.
- **Formation of social media groups** where students can communicate their experiences from new courses at their home institutions enhances the training and engagement of emerging professionals.

Further information

- https://coppe.ufrj.br/tour-captura-carbono/
- https://ccec.puc-rio.br/site/Folder?nCurso=ccs%3A-fundamentos-de-sequestro-geologico-de-carbono&nInst=CCE
- https://www.gov.br/mme/pt-br/assuntos/noticias/mme-apresenta-ao-cnpe-proposta-de-diretrizes-para-o-programa-nacional-do-hidrogenio-pnh2/HidrognioRelatriodiretrizes.pdf
- https://www.observatorio.ind.br/observatorio-da-industria-ceara-inicia-projeto-educacao-e-competencias-para-o-futuro-na-tematica-de-hidrogenio-verde
- https://www.gov.br/mme/pt-br/programa-nacional-do-hidrogenio-1/iii-planejamento-energetico/chamada-publica-de-hubs-de-h2

7.3 National frameworks: recognising hydrogen qualifications on a national level (India)

India has emerged as a leading example in the formal recognition of hydrogen-related skills through a structured, government-backed ecosystem that goes beyond micro-credentialing. While 19 micro-credential-style courses have been launched covering topics from *Concepts of Green Hydrogen* to *Instrumentation and Control for Green Hydrogen Plants*, India's approach includes a wider adoption of formally approved qualifications. This model was designed to ensure scalability, alignment with industry, as well as control in long-term workforce planning.

As of July 2025, 43 approved qualifications in "green hydrogen" have been listed on India's National Qualifications Register (NQR), managed by the National Council for Vocational Education and Training (NCVET), which is the country's skills regulator. These qualifications were developed in close consultation with industry by four dedicated Sector Skill Councils (SSCs) and Awarding Bodies (ABs), namely the Hydrocarbon Sector Skill Council (HSSC), Skill Council for Green Jobs (SCGJ), Power Sector Skill Council (PSSC) and the Logistics Sector Skill Council (LSSC). The qualifications span multiple National Skills Qualification Framework (NSQF) levels and target various parts of the (green) hydrogen value chain.

Once qualifications are approved, the SSCs/ABs develop detailed training content and implement Training of Master Trainers (ToMT) and Training of Trainers (ToT). By July 2025, 81 Master Trainers and 335 Trainers had been certified and are now delivering hydrogen training across India under the national framework.

Training is being delivered primarily through the Pradhan Mantri Kaushal Vikas Yojana (PMKVY), the Indian Government's flagship scheme for skill development, which operates two components:

- Short Term Training (STT): 200–600 hours
- Recognition of Prior Learning (RPL): 30–132 hours

Under PMKVY, training centres are accredited and affiliated via the Skill India Digital Hub, ensuring quality and national-level visibility of certifications. As of July 2025, approximately 5,627 individuals had received training and been certified in renewable hydrogen job roles, mostly under the RPL stream, with some training also supported by industry and multilateral partnerships.

India's National Green Hydrogen Mission (NGHM) is also contributing by funding training at industry premises (e.g., refineries) and exploring the establishment of five Centres of Excellence (CoEs) for practical, hands-on hydrogen training.

India has formalised the role of trainers within its national recognition framework. The ToMT and ToT programmes are not only capacity-building tools, but also recognition pathways. Trainers who complete the programme and pass the assessment receive official certification by their SSC/AB and the National Skill Development Corporation (NSDC), giving them national-level recognition as Certified Master Trainers or Trainers. These certifications validate their ability to deliver training aligned with NSQF-approved qualifications and increase their employability within the national skill ecosystem.

Training under PMKVY and NGHM ends with a formal assessment and certification process, ensuring that only successful candidates receive recognised qualifications. While employment remains a core objective, the renewable hydrogen's nascent stage means that large-scale job placements are not yet fully integrated with training programmes. However, SSCs/ABs and training providers are developing dedicated placement platforms and industry outreach tools to improve alignment over time.

India is currently drafting a national strategy to scale hydrogen training until 2030, with plans to train significant numbers of candidates annually and up to a total of 600,000. New qualifications are being developed in collaboration with sector bodies such as the Indian Iron and Steel Sector Skill Council, Rubber, Chemical & Petrochemical Skill Development Council, and international partners like the American Society of Mechanical Engineers. The intent is that training reflects the evolution of hydrogen-related roles across industry sectors.

Lessons learnt and recommendations

- **Increase industry engagement at decision-making level**: Successful roll-out demands sustained and high-quality engagement from relevant industry stakeholders – especially senior decision-makers. Their active involvement is critical to align the industry's operational needs with the value proposition offered by government-led skilling initiatives.
- **Establish a centralised skill demand portal**: A common digital platform aggregating skilled workforce requirements from industries, ports, and ancillary sectors in the green hydrogen value chain enables targeted interventions. This demand-driven approach ensures resources are channelled efficiently towards priority skill gaps in the emerging sector.
- **Ensure access to high-end training infrastructure**: High-quality practical training in an industrial environment is essential for both upskilling and reskilling personnel. Availability of advanced, sector-relevant infrastructure (e.g. in a Center of Excellence) significantly enhances workforce readiness.
- **Institutionalise industry advocacy platforms**: Continuous advocacy for skill development in the renewable hydrogen sector need to be undertaken through structured platforms such as advisory groups (with nominated industry leaders), thematic workshops, and industry-led roundtable meetings, conferences and events. Such initiatives build ownership and long-term commitment to skill ecosystem creation.

Further information

- Ministry of New and Renewable Energy (Hydrogen Division), "Guidelines for scheme on skilling, up-skilling and re-skilling under the National Green Hydrogen Mission", India, 2024
  https://mnre.gov.in/en/notice/guidelines-for-skill-development-under-the-national-green-hydrogen-mission/

8 Concluding remarks

This publication covered five hydrogen training dimensions of the global hydrogen training landscape that revealed a diversity of innovative practice to prepare the respective workforces for a hydrogen future.

Awareness and dissemination to lay the foundation

The important step in building a hydrogen-ready workforce, which can tend to be underestimated, is ensuring that training opportunities are visible and easily accessible. Strategic promotion is key to reach important allies and target audiences. The European Hydrogen Observatory has begun this process in Europe by integrating education and training information into a single platform, while efforts in South Africa are focused on raising community awareness, informing decision makers, and collaboration with schools and universities. This demonstrates the importance of proactive outreach in contexts where hydrogen is still nascent. These initiatives highlight that skills development begins not in the training centre, but in the public imagination. Without widespread understanding and interest, even the best training programmes may fail to reach their intended audiences.

Networks and platforms for trainers to multiply impact

Collaborative platforms can act as amplifiers in the hydrogen training ecosystem. Programmes such as H2EDGE and HyAcademy demonstrate that when trainers, institutions, and industry actors are connected through structured networks, they can rapidly and effectively share knowledge and develop aligned curricula. These platforms also support continuous professional development for educators, which ensures that hydrogen teachers are equipped with the latest content and pedagogical tools. The importance of "training the trainers" cannot be overstated in a field where expertise is still both scarce and highly specialised.

Training infrastructure to enable physical learning opportunities

The development of fit-for-purpose training infrastructure emerged as a third pillar. Facilities like the Costa Rican Hydrogen School, the EDUCAM hydrogen vehicle repair training centre, and the GreenSKHy mobile labs show the diversity of approaches. They vary from centralised institutions to mobile learning hubs and share a commitment to hands-on learning to bridge the gap between theoretical knowledge and practical experience.

Innovative training schemes to discover and use more effective ways of teaching

Innovation in content delivery is equally important. Tools such as The Hydrogen Game, which uses gamification to teach about the hydrogen value chain, and examples from HyResponder, which prepares emergency responders through simulation and scenario-based learning provide examples of innovation for content delivery. As the hydrogen workforce will come from diverse backgrounds, training methods need to be adaptable to meet learners where they are and inspire them to go further.

Training recognition to create clear career pathways

Different national systems are working on training recognition for the rapidly evolving hydrogen economy. Canada’s micro-credentials, Brazil’s integration of hydrogen content into university curricula and India’s formal vocational qualifications, all reflect efforts to enable

hydrogen training to be incorporated within existing qualification frameworks. Accreditation systems offer clarity to learners and confidence to employers. Each case illustrates a different route toward recognition (modular, academic or formal) but all share the goal of making hydrogen competencies credible and career-relevant at national level.

These pillars cannot stand alone, as their effectiveness and enhancement depends on internal coordination and international collaboration, especially as hydrogen training needs to evolve and adapt in parallel with technological advancement and local and international market growth and dynamics. Countries with a hydrogen sector- and training development experience are encouraged to share expertise and tools that can then be adapted to the specific local context to build capacity in countries with emerging hydrogen economies and training landscapes. It is the intent that the catalogue of training initiatives and practices around the world summarised in this publication serve as foundation for new training initiatives, and a catalyst for international engagement and collaboration to develop the human side of the rapidly evolving hydrogen economy locally, nationally, regionally and globally.