Chapter 6
2021 Education & Training Report
July 2021

Disclaimer

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This report was prepared for the Fuel Cells and Hydrogen 2 Joint Undertaking as part of the Fuel Cells and Hydrogen Observatory. Copies of this document can be downloaded from https://www.fchobservatory.eu/

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Executive Summary

The Fuel Cells and Hydrogen Observatory (FCHO) is an ambitious project to collect available valuable sector information in a single go-to source and make it available to all interested stakeholders. The Education and Training module within the FCHO offers a single repository of training and materials in the field of hydrogen and fuel cells available across Europe.

The development and deployment of fuel cells and hydrogen (FCH) in the European market has highlighted the need for a trained and skilled workforce able to conceive, design, repair, maintain and operate the technologies of the sector. As the FCH market moves to commercialization and widescale sector adoption, the requirement for suitable training to provide the necessary skills to meet this market needs is becoming increasingly apparent.

With this idea in mind, the objective of the Education and Training chapter of the Observatory is two-fold. Firstly, it aims to list training offers providing a range of qualifications to assist in working in the FCH ecosystem. This first report evaluates the data collected between March and April 2021 through a survey sent to stakeholders active in the sector. To this date, 177 different training courses are mapped on the FCHO and whilst this mapping is not exhaustive, the ambition over time is to encompass all relevant training within the database.

Training courses included in the mapping refer to the different levels of education: Vocational training, Bachelor, Master, Doctorate and Post-Doctorate programmes. Off-curricula training is also listed, such as summer schools, workshops, or internships, as well as lifelong education opportunities with the professional training category.

Secondly the Education and Training chapter of the Observatory encompasses Education materials publicly accessible for learners and students interested in the field of FCH. The goal is to provide an online library relevant for different level of education, as described by the the International Standard Classification of Education (ISCED), different interests and in different languages.

Purpose:	The Training section of the Education and Training module of the FCHO offers a repository of training available in Europe. In addition to the training programmes, Educational materials which are publicly accessible online, are also available to access on the FCHO. https://www.fchobservatory.eu/observatory/education-and-training
Scope:	The training courses are displayed by location within a map and users can explore the data by selecting the type of training of interest. Two additional filters on the language and the focus of the training are available to refine the search according to user needs. Users of the online tool can be students, professionals and individuals wishing to learn and be trained on FCH. To complement this mapping, a repository of online resources is accessible on the FCHO. Users may retrieve reliable materials available for self-learning.
Key Findings:	Master programmes and professional training courses were the most mapped categories. There is a prevalence of training courses offered by Western European countries in the mapping. The majority of the training courses mapped are targeted at technicians, engineers and doctorate. For Bachelor and Master programmes, FCH is more often an element integrated in a programme than its main focus. “Hydrogen Production” and “Hydrogen end-uses: transports” were the most selected focus of courses among the 11 categories proposed. “Regulations, Codes and Standards” was the least selected focus with only one training out of five tackling these aspects. Professional training is more often focusing on end-uses and safety than Master programmes. Master programmes put a strong emphasis on “Basic electrochemistry”, “Hydrogen production”. European projects are the main source for publicly accessible materials to learn on FCH. Most of the materials listed are available in English. “Hydrogen End-Uses” is the focus category the most common in the materials listed.

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1. Introduction

Despite the global pandemic of 2020, the FCH sector has not experienced a crisis questioning its existence and hindering its development, in fact quite the opposite. On the political stage, several milestones set the European ambitions for the sector: the European Commission[1], the Council of the EU[2], and the European Parliament[3] all adopted their institutional strategy in view of the largescale deployment of hydrogen in the economy.

Furthermore, the launch of the Clean Hydrogen Alliance in July 2020 mobilised stakeholders from all over Europe to coordinate efforts at EU level to create a clear view on investment needs. One of the alliance goals is to "*support the related skills and labour market adjustments where needed*". The question of the need for skills and training courses has also been stressed by the European Parliament's initiative report.

> MEPs called on the Commission "*to adopt an action plan aimed at guiding Member States to develop and maintain dedicated training programmes for workers, engineers, technicians, and the general public and to create multi-disciplinary teaching programmes for economists, scientists and students*"[4]

Considering the challenges to train, reskill and upskill workers for jobs in the hydrogen sector, the training section of the FCHO aims to provide a first tool to assess the supply of training courses available and to list reliable learning materials available online. This database created will be useful for students interested in starting a career in the field of hydrogen, companies wishing to upskill and reskill their workforce to adapt to technological changes, but also to education providers and policy makers, to identify gaps and create new training courses to meet those needs.

Whilst the FCHO does not have the pretention to map all relevant training opportunities in Europe, it does provide a first basis to capture the current landscape for further analysis. With time and growing visibility, the ambition of the FCHO is to encourage training providers to contribute to this mapping and to be a part of this growing community of Education & Training providers.

The initial data collection for training took place in May/June 2020, which provided useful feedback to feed into the latest data collection cycle and refine the objectives and methodology of the activity. The questionnaire which collected the course data, was reviewed to include more categories of training (professional and vocational training courses) and to present additional information on each training which had been identified as important to users. Lastly, further categorization of the training courses ('focus') was included to enable useful filtering, which will be particularly important as the database grows.

This report aims to provide an overview of the data collected between March and April 2021 and an analysis of the main trends.

The second section of this report focuses on the learning materials publicly accessible online. The report provides a general overview on the ones identified and focuses on the breakdowns for each of the filters displayed on the website.

[1] Communication from the Commission on "A hydrogen strategy for a climate-neutral Europe", 8 July 2020
[2] Council conclusions "Towards a hydrogen market for Europe", 11 December 2020
[3] Initiative report of the European Parliament "A European Strategy for Hydrogen", adopted in plenary on 25 May 2020
[4] Ibid., point 30.

2. Training programmes

2.1. Data collection methodology

The data presented on the Observatory was predominantly collected through an online questionnaire sent to stakeholders. The responder could participate via a survey set up on Google Form for each of the training categories identified.

The 2021 data collection took place over March and April. Over 200 organisations were contacted to reply to the questionnaire, amongst those contacted were universities, research centres, companies, and public authorities. Different networks were employed to maximise the number of respondents: Hydrogen Europe Research, the Hydrogen Valleys S3 partnership and Hydrogen Europe's skills working group. Additional organisations were identified through online research. The call to participate was broadly shared in France through a regional network (Régions de France) and the French Research network on Hydrogen energy of the CNRS.

The data collection and update of the existing training courses will be completed annually and will enable an understanding of how the roll-out of fuel cells and hydrogen is supported by the development of appropriate training courses.

Respondents

More than 2/3 of the training courses were provided by universities. Other training providers include RTOs, companies, professional training organisations, training courses from European projects, other higher education organisations, public entities, clusters, etc. This can be seen in the Figure 1 below. The data is shown for all the trainings listed however one contributor may have listed several trainings.

Figure 1 – Training providers for the identified training

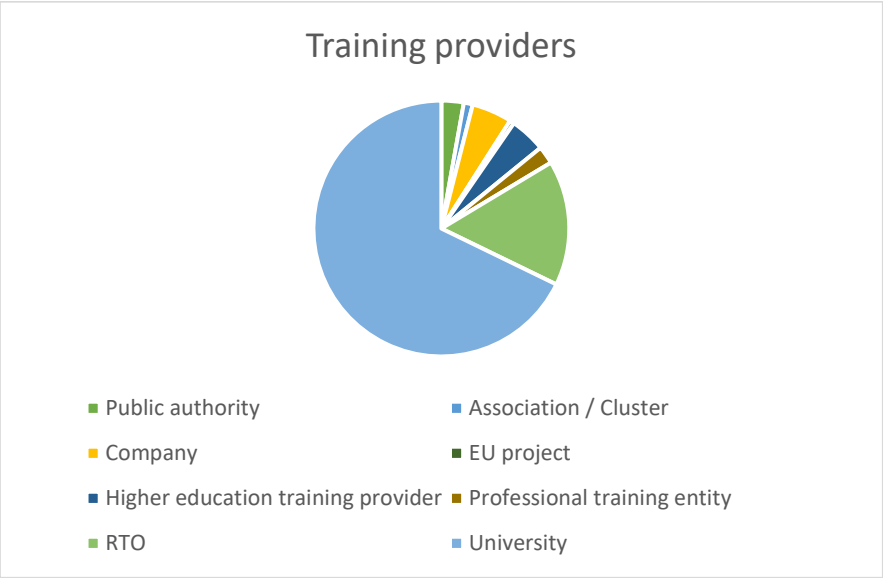


Figure 4 provides an overview of the country participation.

Entries from the French Parcours Sup

Thanks to an exchange with a French expert missioned by the ministry of Higher Education, Research and Innovation to evaluate the supply of training courses in the field of fuel cell and hydrogen in France, several training programmes for students were identified.

Some of them – specifically focusing on hydrogen – were already included in the mapping. Others were added after this discussion using the Parcours Sup database[5]. Two programmes were added with 195 entries corresponding to the different locations where the programmes are taught. These entries matched the vocational training category as they refer to the level 5 of the ISCED classification. Not all the training courses identified by the French expert were included as an educational reform is ongoing on some of the courses identified, and due to time constraints to complement the mapping for this year's annual review.

A number of actions have been identified as potential ways to increase the stakeholder participation in the annual survey:

- The use of Parcours Sup will be further explored for the next update. Identifying similar databases in use in other countries will be of added value to grasp a comprehensive view of the educational system across Europe.
- Get in touch with human resources and training organisations working in the field of hydrogen and fuel cells.
- Identify on a national basis the actors implementing continuous professional development and vocational training courses.
- Find online databases publicly accessible at national or regional level and identify there relevant training courses.
- Use social media outreach from the FCHO / FCHJU communications activities as a 'call to participate'

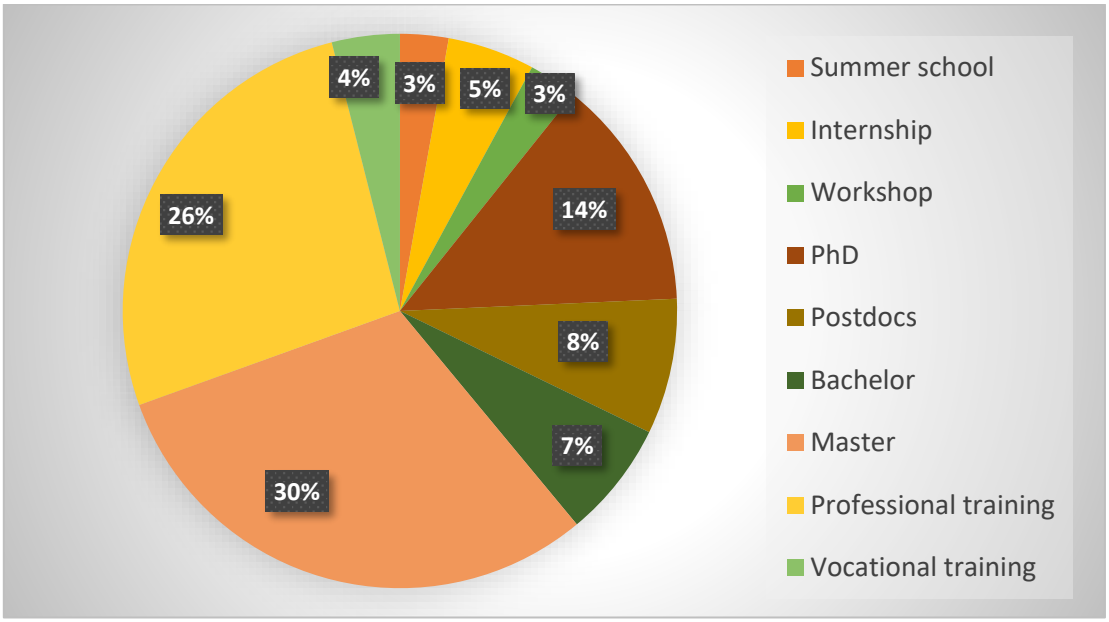
2.2. Analysis of responses received

2.2.1. Focus on the training categories

177 training courses are currently listed on the FCHO (two of which are French programmes with a further 195 discrete training courses in different locations). In the following analysis, only the 177 training courses will be considered.

[5] The Parcours Sup database is a web platform designed to collect and manage the assignment wishes of future students in French higher education.

Figure 2 - Share of training courses by category[6]



Bachelors and Masters

- Bachelor and Master programmes account for over 1/3 of the training courses mapped. As these programmes are harmonised across Europe thanks to the Bologna system, it makes them more easily comparable from one country to another.
- All but one of the Bachelor and Master programmes listed aim at training engineers.
- Only a few Masters provide training courses specifically on FCH; more often FCH is part of a broader curricula such as Chemical engineering, Mechanical engineering, or Materials Sciences.
- The Bachelors programmes listed remain general and do not focus on FCH.

Professional Training courses

- The scope of professional training courses range from general to specific. For example, training courses on a specific electrolysis process can be found.
- The professional training courses captured mainly target engineers and technicians. However, some of them reach out to a non-expert audience (e.g. decision makers).
- Most training courses can be taken online or organised in different locations.
- About 4/5 of the training courses listed are available in English.

Vocational Training courses

- Only 7 different training courses[7] were listed in this category. Three of them provided by the same entity put an emphasis on maritime and shipping.
- The diversity of vocational training system across Europe makes it difficult to capture the different nuances existing at national level in a one-size-fit all questionnaire. The functioning may greatly differ when it comes to the length of the training, the target audience, the level of qualification required and the likely jobs functions, from one region to another.
- Having a closer look into the national systems of vocational training courses and assess if subcategories are necessary might be beneficial to give a more accurate picture of European training courses in this category.

[6] *195 vocational training courses are counted as 2 in this analysis*

[7] This accounting the 195 French vocational training courses as two entries.

- Furthermore, these training courses are sometimes defined by national or regional authorities in charge of education and in collaboration with stakeholders from the sector. A top-down approach might be preferable to a bottom-up approach in this case. Identifying the relevant curricula rather than sending a questionnaire to entities that might be providing vocational training courses in the field of FCH could help to create a more comprehensive mapping.

PhDs, Postdocs and Internships

- A few of the PhD schools listed specifically address FCH, whilst the majority of them have a broader focus, for example on energy or mechanical engineering.
- The approach chosen to identify postdoctoral positions and internships was to list organisations providing such opportunities on a regular basis without describing in detail the offer. The relevance of these categories for users should be confirmed and a more systematic approach could be taken by asking members of different associations whether they provide such opportunities and wish to participate on the FCHO. Only a limited number of details could be shown there, including the focus of the training proposed.

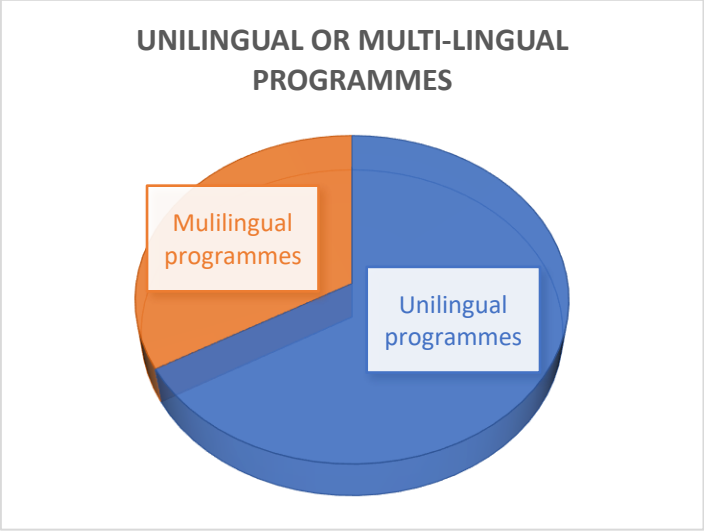
Summer Schools and Workshops

- By including Summer Schools and Workshops, the goal is to map regular learning opportunities for the FCH community.
- For the moment, 10 recurring events are listed. This information may be useful for students but also for professionals.

2.2.2. Focus on the languages of the programme

As shown in Figure 2, about two thirds of the programmes mapped are unilingual against one third being multilingual. This doesn't necessarily mean that both languages must be spoken but rather indicates the possibility to choose the language of teaching.

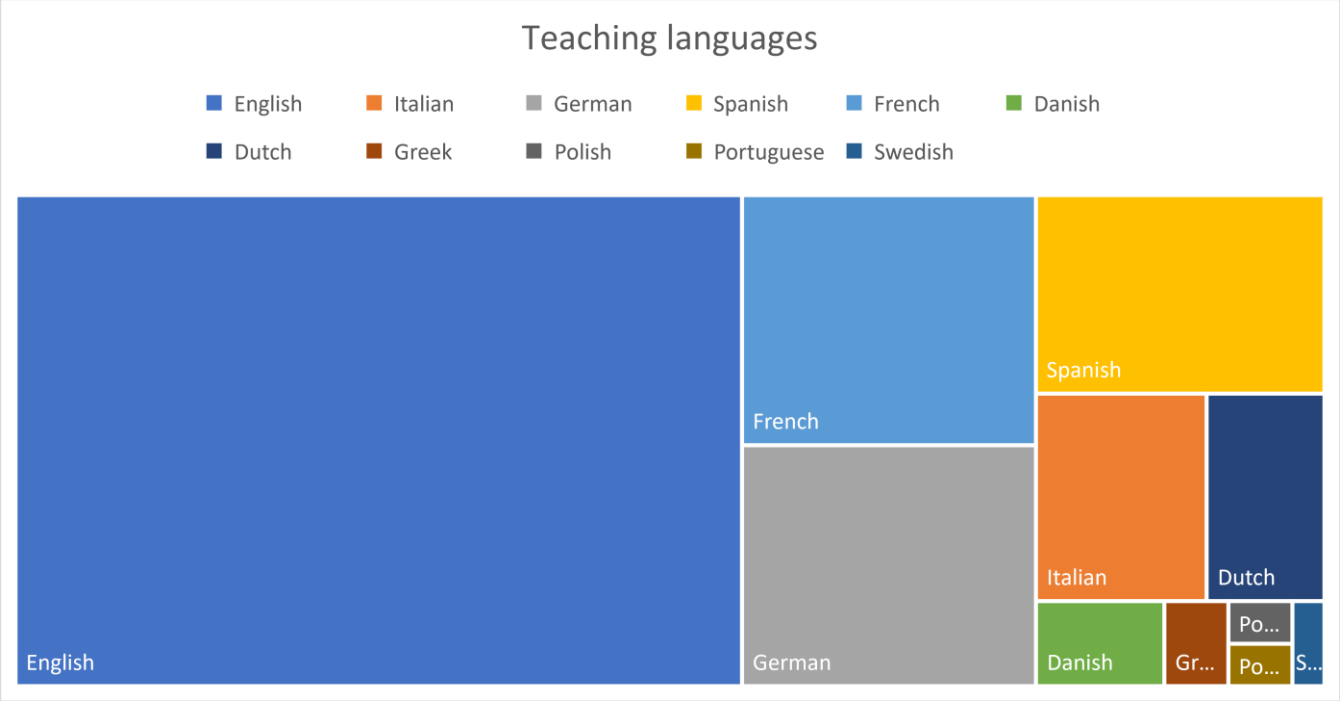
Figure 3 – Share of unilingual and multilingual programmes



Most of the programmes mapped are taught in English (55%). French and German are then the most common teaching languages (about 11% for each), followed by Spanish (9%), Italian (6%), Dutch (4%), Danish (2%). Other languages include Greek, Polish, Portuguese and Swedish (less than 1% of the trainings each).

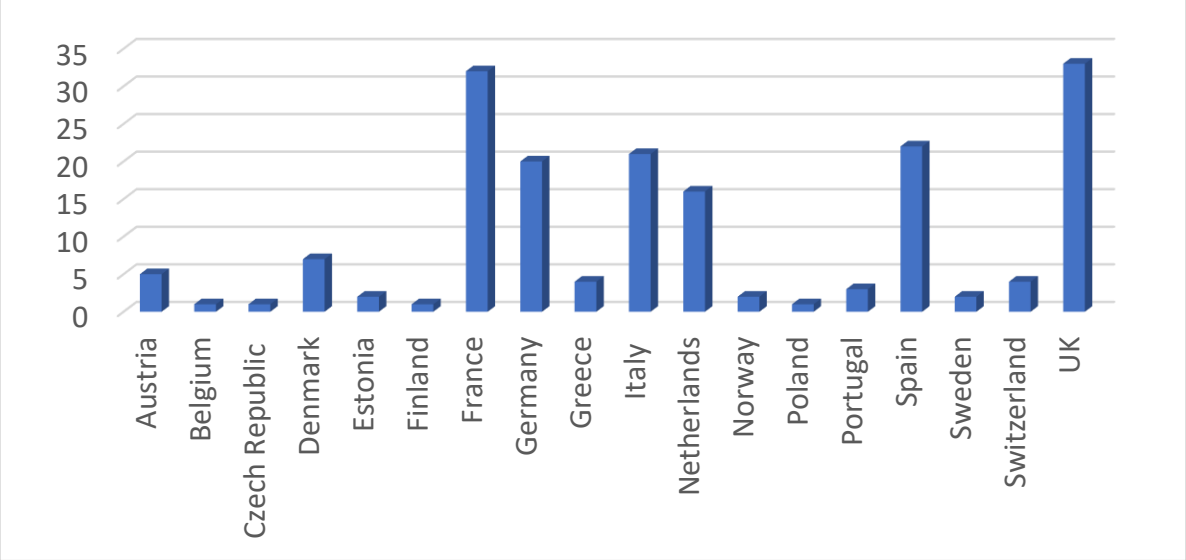
Having a majority of training programmes taught in English mapped on the Observatory makes sense, as the website itself is in English and the data collection was organised in English.

Figure 4 – Overview of the teaching languages



2.2.3. Focus on the geographic spread

Figure 5 - Training courses by country[8]



[8] This accounting the 195 French vocational training courses as two entries.

18 countries are included in the mapping and offer training opportunities in the field of FCH. However, this does not mean that countries not mentioned here do not offer relevant opportunities.

One may note there is a prevalence of Western European countries, both in numbers and in share of training courses offered. However, Czechia, Poland and Estonia are also included in the mapping.

Together, 6 countries (FR, DE, IT, NL, ES, UK) account for more than 4/5 of the training courses entered. These countries either have a dedicated hydrogen strategy/roadmap and/or have publicly given their support to the development of a FCH market. Of course, these countries are also the most populated ones in Europe and as such a high number of training courses might be expected.

2.2.4. Focus on the subjects of the training

When describing a training offer, the responder was always asked to identify the relevant 'focus' for the relevant course. There were no limits in terms of number of focus categories that could be selected. You can find below the categories proposed and the explanations of the different items:

a) Basic Electrochemistry *refers to chemistry on the interrelation of electrical and chemical changes caused by the passage of current.*
b) H2 Production *refers to the different means to produce hydrogen (electrolysis, gasification, biomass, etc.)*
c) H2 Storage, Transport and Distribution *refers to the methods used to store, transport and distribute hydrogen (e.g. storage in salt cavern, transport via pipelines, etc.)*
d) H2 End-uses: transports *refers to vehicles using hydrogen or hydrogen derivative synthetic fuels in fuel cells or ICE. All transport sectors are included: road, maritime, aviation, rail and off-road.*
e) H2 End-uses: industry *refers to hydrogen used in some industrial processes (e.g steel manufacturing, chemicals, etc.)*
f) H2 End-uses: buildings *refers to electrical, heating and cooling applications including fuel cells, CHP, boilers, etc. using hydrogen, hydrogen derivative synthetic fuels, biomass or biogas, etc.*
g) H2 End-uses: energy, power generation *refers to the production of electricity using hydrogen, hydrogen blends or ammonia in turbines and/or fuel cells*.
h) Regulations, Codes, Standards *refers to the development and use of harmonized performance-based standards for FCH appliances and systems.*
i) Safety *refers to the safe production, handling and use of hydrogen, particularly hydrogen gas fuel and liquid hydrogen.*
j) Life Cycle and Social Assessment, eco-design, recycling, *refers to environmental and sustainability aspects of FCH.*
k) Technical-economic evaluation *refers to training courses at the crossroad of business and engineering to evaluate the technical possibilities of the technology whilst considering its economic cost.*

As the 'focus' filter is common to all training categories, it provides a relevant tool of analysis to see the topics that are most widely taught within the training courses listed.

Table 1 below provides an indication of the most often encountered training focus categories, however, it does not indicate how central the focus category on a given topic is. For example "Safety" could be either one of the areas tackled in a programme or the main focus category of the training.

Table 1 – Breakdown by focus for all training courses

Coloured in grey you may see the focuses that are tackled in more than half of the training courses.

Training Focus	Percentage of training indicating the focus category
Basic Electrochemistry	51%
H2 Production	**64%**
H2 Storage, Transport and Distribution	57%
H2 End-uses: energy, power generation	56%
H2 End-uses: industry	38%
H2 End-uses: transports	62%
H2 End-uses: buildings	33%
Safety	45%
Regulations, Codes, Standards	**19%**
Life Cycle and Social Assessment, eco-design, recycling	29%
Technical-economic evaluation	32%

About two thirds of the training courses tackled the topic of "H2 production" (64%) and/or "H2 End-uses: transports" (62%). They were the most selected areas of focus across training courses. The least selected focus was "Regulations, Codes and Standards" (RCS), which was only tackled in about 1/5 of the training courses mapped.

As professional training courses and Master programmes have had a significant number of entries, a comparison for these two training categories can be made. The results are presented in the Table 2.

Table 2 – Breakdown by focus for professional training courses and Master programmes
Coloured in grey you may see the focuses that were picked to describe more than half of the training courses in the corresponding category.

Training Focus	Percentage of professional training courses indicating the focus category	Percentage of Master programmes indicating the focus category
Basic Electrochemistry	51%	72%
H2 Production	49%	**74%**
H2 Storage, Transport and Distribution	47%	67%
H2 End-uses: energy, power generation	45%	37%
H2 End-uses: industry	34%	**12%**
H2 End-uses: transports	**57%**	33%
H2 End-uses: buildings	40%	22%
Safety	45%	22%
Regulations, Codes, Standards	32%	13%
Life Cycle and Social Assessment, eco-design, recycling	**9%**	20%
Technical-economic evaluation	26%	19%

The focus categories of the training courses tend to be more diverse for professional training courses than for Master programmes.

A shift in the focus from Master programmes to Professional training courses

Professional training courses more often tackle end-uses than Master programmes. The latter are more emphasising on basic electrochemistry, hydrogen production and hydrogen storage, transport and distribution focuses.

About 3/4th of the Master programmes mapped focus on basic electrochemistry (72%) and hydrogen production (74%) and this indicates that these are central elements of the programmes proposed. Comparatively, only half of the professional training courses listed focus on these same topics (49% for production and 51% for basic electrochemistry). These numbers remain high respectively to the percentage indicated for the professional training category.

Industry end-uses

Within the end-uses, the industry focus was the least selected for both Master programmes and professional training courses. Having a closer look at the university path to work, for example, in the steel or in the chemicals industries could provide some elements of answers this figure. Furthermore, investigating how hydrogen is taken into consideration in the training of workers in this area could be relevant to analyse this aspect from a qualitative perspective.

Safety, RCS, Technical-economic evaluation

The topics of Safety and of RCS were more often chosen as a focus for professional training courses than for Master programmes. One possible explanation could be that skills needed on these particular thematic are taking a new dimension in a given work context. Master programmes might choose to put less emphasis on these issues that may vary from one workplace to another.

Technical-economic evaluation is also a more chosen topic for professional training courses than Master programmes, but the difference is low. The topic was generally not broadly chosen compared to others. This may be explained by the fact that a majority of the training courses mapped were targeted at engineers and/or technicians, for whom the technical-economic evaluation might not be relevant. It could be interesting to reach out to more business centred training provider (e.g. business schools) to understand the offers they have in relation to hydrogen including techno-economic evaluation.

LCSA eco-design and recycling

Finally, LCSA eco-design and recycling is generally the least selected category. It was more often chosen for Master programmes than for professional training courses. This could indicate that these questions are at an earlier stage of development than the other that were included in the questionnaire and may be less interesting for professionals.

2.3.Areas for future consideration in the Training section

Areas for consideration in improving the data collection and analysis are mentioned throughout the report. On the data collection and how to reach out to more training providers, several ideas are discussed in the data collection methodology section.

After the publication of a White paper on skills and professions in the hydrogen sector[9] and a repository of jobs and skills[10] by France Hydrogène,, some new conceptualisation tools could be implemented to better analyse and map training courses.

A list of suggestions that could be considered are as follows:

1. Adding a colour code to describe how much the training focuses on hydrogen or on a given topic. This could translate into percentages for each training.

e.g. Safety could be the main focus of a training (100%) or be a smaller aspect tackled throughout other problematics (10%).

2. Providing an indicator to describe the activities to which the training is targeting.

e.g. conception, manufacturing, installation, operation, maintenance, etc.

3. Specifying the type of job function/role the training is addressing.

e.g. engineers, technicians, sales, etc.

[9] Livre blanc des compétences et métiers de la filière hydrogène, France Hydrogène, avril 2021
[10] Référentiel des métiers et compétences, France Hydrogène, avril 2021

3. Education materials

The Education materials module of the Observatory lists courses and education materials publicly accessible online. This section is meant to act as an online library on FCH learning materials. 241 reliable materials may be retrieved on the platform. It is conceived as a go-to-resource gathering materials developed in the framework of European projects and will be periodically updated.

Several filters are available in the library to refine the search of users according to their needs. It is possible to select the ISCED level (ranging from 2 to 8), the course focus, the language, or the source. The materials listed were created between 2006 and 2020. Most of them are slides or text documents. Some exercises, videos, games, or experiments are also available.

3.1. Focus on sources

The materials listed were collected through pre-identified European projects. 8 different sources are currently included. The 8 source projects are the following:

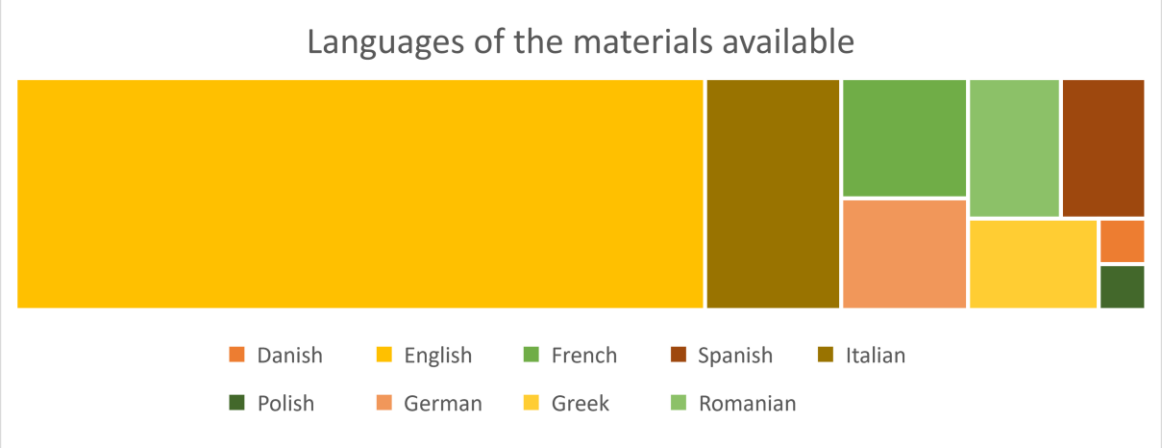
- TrainHy
- CertifHy
- FCHGO
- H2 Training
- HyFacts
- HyResponse
- NET-Tools
- PACE

The approach chosen was to list materials developed by European projects as their ownership is usually clear and the project results benefit from advertisement. Therefore, only materials created with the goal of being public were shared in the library.

3.2. Focus on languages

Materials in 9 different languages are currently listed in the library. Most of them are in English language (61%). Materials in Italian language are then the most common ones (12%), followed by French (6%), German (5%), Romanian (5%), Spanish (5%), Greek (5%), and then Polish (less than 1%) and Danish (less than 1%).

Figure 6 – Breakdown of the materials by languages



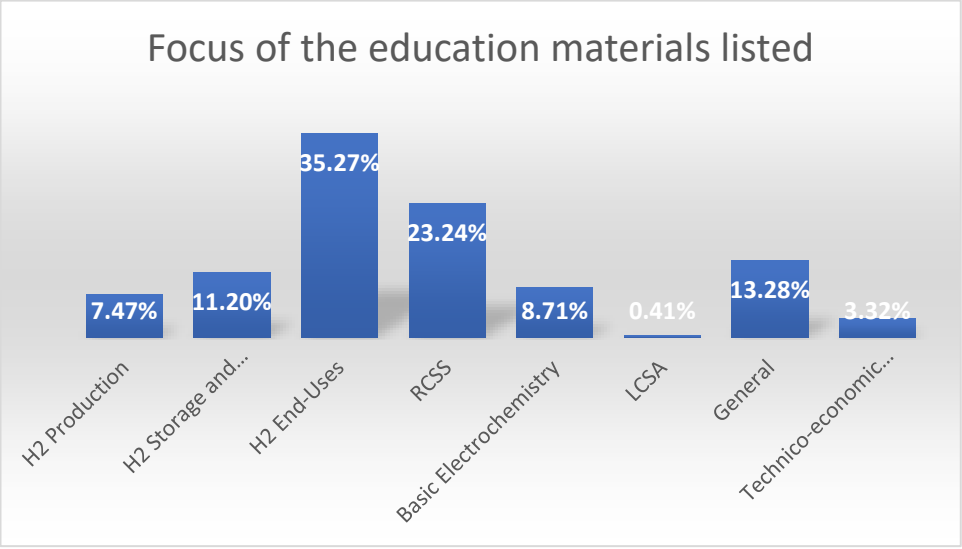
3.3. Focus on the course topic

Several categories have been defined to classify the materials on the website and allow users to retrieve courses on a given topics. The following categories were identified:

- General refers to information remaining at a broad level of understanding, not going into technical details
- H2 Production refers to the different means to produce hydrogen (electrolysis, gasification, biomass, etc.)
- H2 Storage and Distribution refers to the methods used to store, transport and distribute hydrogen (e.g. storage in salt cavern, transport via pipelines, etc.)
- H2 End-Uses refers to hydrogen usages in transport, industry, buildings or to generate power.
- Regulations, codes, standards and safety (referred to as RCSS in Figure 6) refers to the development and use of harmonized performance-based standards for FCH appliances and systems and to the safe production, handling and use of hydrogen, particularly hydrogen gas fuel and liquid hydrogen.
- Basic Electrochemistry refers to chemistry on the interrelation of electrical and chemical changes caused by the passage of current.
- Life Cycle and Social Assessment, eco-design, recycling (referred to as LCSA in the Figure 6) refers to environmental and sustainability aspects of FCH.
- Technico-economic evaluation refers to courses at the crossroad of business and engineering to evaluate the technical possibilities of the technology whilst considering its economic cost.

Over one third of the materials listed tackle H2 End-uses and about a quarter of them focus on RCSS. The European projects tackled greatly these two areas. LCSA is the least tackled focus category in comparison with only one material focusing on this specific issue.

Figure 7 – Focus of the education materials listed



3.4. Areas for future consideration in the Education materials module

1. Implementing an automatic reporting for materials developed in European projects

Implementing an automatic reporting between European projects on FCH developing materials and trainings on hydrogen and fuel cells and the FCH Observatory team would be of great added value to

develop the library. All materials developed as part of project could automatically be added to the website. The responsible project partners could be able to download from the website a template to list and classify their materials as required. This would help overcome the language barrier when listing learning materials in foreign languages and ensure that the different categories are filled in appropriately by the authors.

2. Expand the scope of listed materials

The scope of what is included in the library could be expanded to include more documents, such as studies and reports on FCH development or on a particular assessment of the FCH sector. A dedicated category outside the ISCED scope might need to be established if this change is pursued. Expansion of the materials section would need to be in line with appropriate copyright law.