Chapter 6

2022 Education & Training

March 2022

FUEL CELLS AND HYDROGEN OBSERVATORY

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Clean Hydrogen Partnership

Disclaimer

This report is based on data gathered as part of the Fuel Cells and Hydrogen Observatory between January to March 2022. The authors believe that this information comes from reliable sources, but do not guarantee the accuracy or completion of this information. The Observatory and information gathered within it will continue to be revised. These revisions will take place annually and can also be done on a case by case basis. As a result, the information used as of writing of this report might differ from the changing data in the Observatory.

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Executive Summary

The Fuel Cells and Hydrogen Observatory (FCHO) is an ambitious project aiming to collect available valuable sector information in a single go-to source, making 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 second report evaluates the data collected between January and February 2022 through a survey sent to stakeholders active in the sector. To this date, 299 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 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 remain the categories with the most entries. The many different fields of Master programmes mapped shows the cross-sectoral nature of hydrogen in teaching. The question of whether FCH should be taught in a dedicated study programme or integrated to existing curricula is subject to discussions. For Master programmes, FCH is more often an element integrated in a programme than its core focus. The prevalence of training courses offered by Western European countries is still noticeable even though the geographic coverage expanded to 20 countries. “Hydrogen Production” and “Hydrogen end-uses: transports” remain the most selected focus of courses among the 11 categories proposed. “Regulations, Codes and Standards” was the least selected focus but in slight increase in comparison to the data of 2021. Professional trainings and Master programmes diverge in terms of content covered. This is noticeable for the focuses on Basic Electrochemistry; Safety; Regulations, Codes and Standards. Most of the materials listed in the library are available in English and focus on higher ISCED levels, especially levels 6 and 7 which correspond to Bachelor and Master levels. Most of the materials listed have a general focus. The category “Hydrogen End Uses” is then the most common focus in the materials listed. Many projects have developed materials which are no longer available online as the websites were not maintained.

1. Introduction

The question of skills and trainings is high in the political agenda, both at European and national levels. Enabling the development of the hydrogen sector and providing opportunities to up-skill and re-skill workers from declining sector are challenges to address in the EU. Training offers in the field of hydrogen and fuel cells are therefore under the spotlight to try and address these problematics.

The recent publication of the Strategic Research and Innovation Agenda of the Agenda Process for the European Research and Innovative Initiative on Green Hydrogen[1], led by Member States mentions 5 priorities for the field of Education and Skills. Among them developing education for all ages is stated first. Some other priorities are more specific:

- Foster European doctorates on next generation carbon-negative H2 technologies
- Develop a European network for upskilling and reskilling training programmes in the field of hydrogen (e.g. via a digital platform)
- Develop pan-European educational programmes to increase the knowledge of policy makers and public administrations in the field of hydrogen

Such objectives may be monitored within the Observatory which makes this tool all the more relevant.

The information in this report covers the period January 2022 – March 2022 during which the data collection for the update of the Education and Training section of the Observatory was collected.

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.

After a launch of the Observatory in 2020, this update of the education and training section builds on the existing dataset and aims at engaging with further stakeholders. Further training offers are mapped, and new materials developed in European projects are listed in the library section.

This report aims to provide an overview of the data collected between January and March 2022 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] European Research Area, 18th March 2022, *Strategic Research and Innovation Agenda Agenda Process for the European Research and Innovation Initiative on Green Hydrogen.*

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, as done in 2021. Trainings already included in the Observatory did not need to be submitted again in the form, but modifications or deletion were possible.

The 2022 data collection took place over January and February. Organisations were contacted through different networks to reply to the questionnaire. These networks comprehend universities, research centres, companies, public authorities, national associations and regional associations on hydrogen and fuel cells. The questionnaire may have been shared through other networks by responders themselves.

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

Entries sourced from the CNRS Hydrogen Research Federation mapping

In 2021, it was decided to integrate to the Observatory trainings listed in the Parcours Sup[2] database in fields connected to hydrogen (195 entries for two BTS[3]). This approach was not repeated this year as it could be substituted by a more specific mapping carried out by researchers and professors in the CNRS Hydrogen Research Federation (abbreviated FRH2). FRH2 brings together more than 300 permanent researchers (CNRS researchers, university research professors and engineers) from 29 laboratories actively involved in the hydrogen field. It has a dedicated axis to work on trainings. Within this federation, several researchers undertook a mapping of training activities in their regions in the field of FCH. The findings were discussed in an event in Paris on 16 December 2021. Using this mapping realised by experts and including an analysis of the curricula appeared to be a more accurate approach than importing data from the Parcours Sup platform.

If this mapping is already an important milestone to be integrated to the Observatory, one should note that it does not cover all training opportunities. Building an exhaustive mapping is difficult exercise. What has already been spotted as relevant trainings gives a good overview of existing initiatives. Some programmes are in development and should be integrated in the coming years.

The mapping of existing trainings that was done in France would be interesting to see in other countries and a relevant resource for the Observatory.

2.2. Analysis of responses received

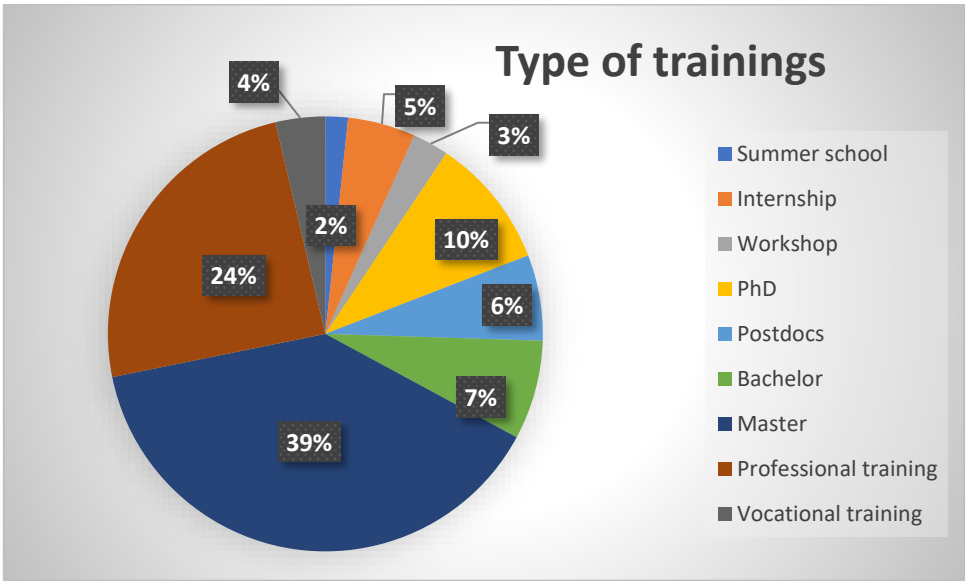
2.2.1. Focus on the training categories

299 training courses are currently listed on the FCHO. This is 122 more trainings that were added in this yearly data collection, without counting the Parcours Sup entries from 2021.

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

[3] BTS (*Brevet de Technicien Supérieur*) corresponds to senior technologist's certificate, it is a national diploma of higher education in France earned in two years.

Figure 1: Share of training courses by category



Master programmes

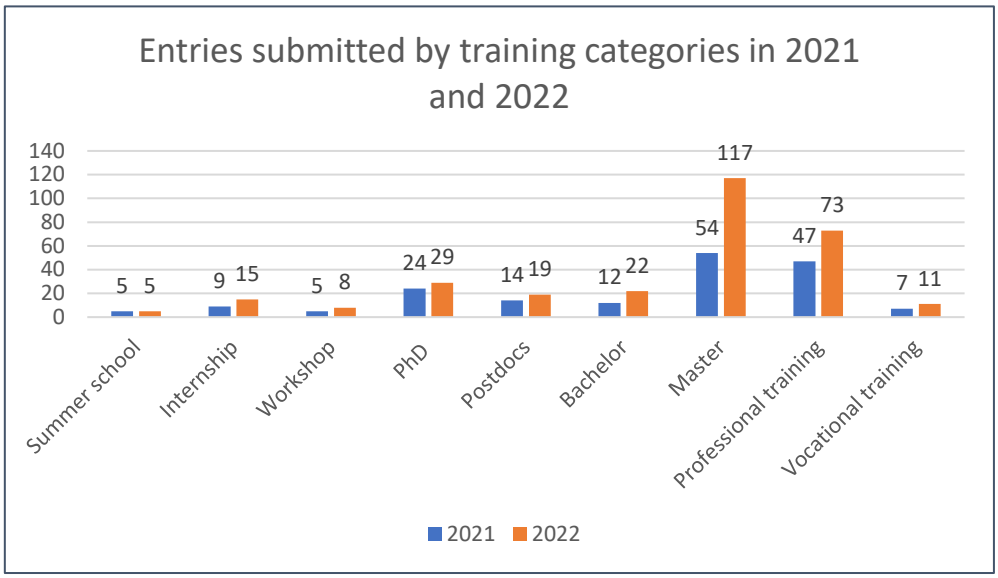
When looking at the evolution of the training categories mapped, one may notice that the Master category is increasingly represented. 39% of the trainings mapped are Masters. This could be interpreted in different ways:

- The portal is mainly used by university teachers and higher education students and tend to orientate towards a mapping of higher educational activities. This could be explained by the fact that the portal is entirely in English and the core database of contacts contributing to the mapping is made up of researchers and teachers in universities or researchers.
  and/or
- Currently the offer of trainings in the field of hydrogen is more likely to focus on higher education and for longer studies than vocational trainings (4% with 11 entries).

The Masters included in the mapping are often engineer degrees. The variety of Masters including a hydrogen dimension in their programme shows the cross sectoral nature of hydrogen and its potential across many fields. If we look at the data submitted by one Spanish University, we may see that degrees in engineering can be focused on Energy (general, marine renewable, renewables), Transport systems (Naval and Oceanic, Aeronautical, Automotive), Environmental studies, Industrial engineering or Buildings. The topic of hydrogen is however tackled to different levels in these Masters, from dedicated courses to a simple part of a course.

This observation is part of a debate among the trainers' community to define whether FCH should be taught in a dedicated programme or whether integrating a hydrogen dimension to existing trainings would be a suitable approach. To this date, only few Master programmes have a focus on fuel cells and hydrogen only, 12 are listed in the current mapping (in the UK, France, Spain, Denmark, the Netherlands Czech Republic, and soon in Germany).

Figure 2: Evolution of the entries submitted by training categories



Professional trainings

In comparison the category of professional training has relatively decreased (from 26% in 2021 to 24% this year), but the number of professional trainings mapped has increased (47 to 73). The display of these trainings on a map is not always the more suitable as some of them may take place online or in different locations.

The usual target audiences remain engineers and technicians. Some other audiences are addressed such as sales or public authorities for example, but it is not the case for the majority of the trainings which are more technically focused.

Vocational trainings

6 new vocational training courses were added and 2 were removed. The limits of the questionnaire approach for this type of trainings should be overcome with dedicated outreach campaign or with a more detailed mapping of vocational education systems across Europe.

Bachelors, PhDs, Postdocs and Internships

The Bachelor categories is steadily growing with 10 new entries in 2022. Regarding PhDs, Postdocs and Internships some 16 entries were added. Doctoral schools on hydrogen and fuel cells are an interesting data to spot universities and labs active in the field of FCH.

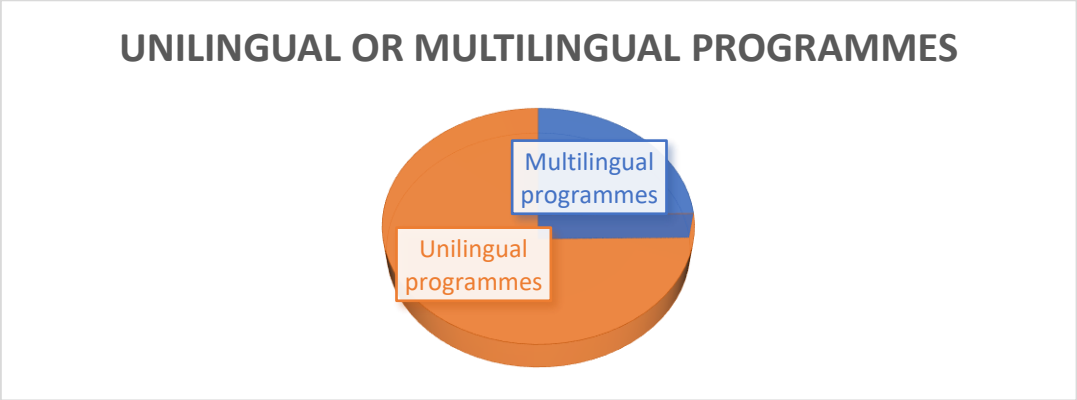
Summer schools and workshops

Some workshops were added with this new update (+3). There were no new additions to the section on summer schools, but the continuation of the existing activities should be noted.

2.2.2. Focus on the languages of the programme

As shown in Figure 3, about three quarters of the programmes mapped are unilingual against one quarter being multilingual. Multilingual usually means bi-lingual, in English and the language of the country where the training takes place. In comparison to the 2021 mapping, there are fewer multilingual programmes.

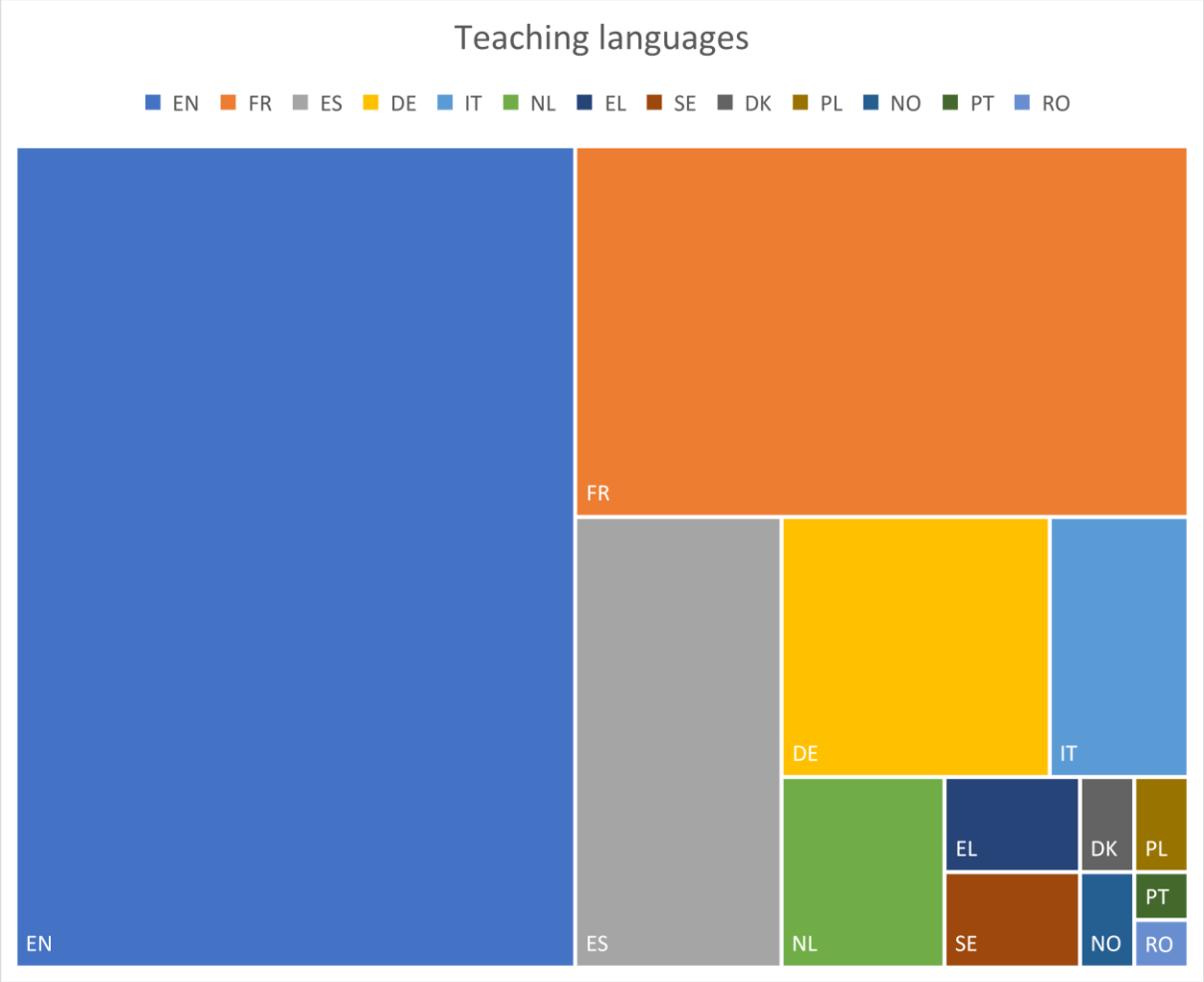
Figure 3: Share of unilingual and multilingual programmes



The majority of the programmes mapped are taught in English (60%). About one third of the programmes are taught in French (30%) and one sixth in Spanish (12%). German comes then (9%) followed by Italian and Dutch (respectively 4% each). Other languages are also included and represent two percent or less of the trainings mapped. For example, Greek, Polish, Portuguese and Swedish, which were also included in the past year, and a new entry of a programme in Romanian can be spotted. Not all the countries in which trainings are taking place have programmes taught in their language. Some of them are in English as part of schemes such as Erasmus Mundus Masters for example.

As observed in 2021, having most 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[4]



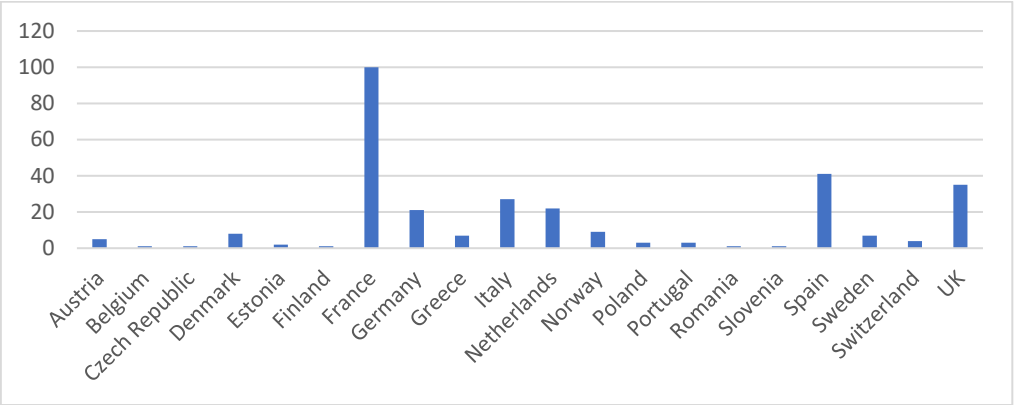
2.2.3. Focus on the geographic spread

As shown in the figure 5, the training courses mapped are predominantly located in Western Europe. This is in line with the trainings already mapped in 2021. About one third of the trainings are taking place in France, followed then by Spain (14%) and then the UK (12%). Between 5 and 10% are found Italy (9%), the Netherlands (7%) and Germany (7%). This could be understood as a general tendency that trainings in the field of fuel cells and hydrogen are more importantly provided in Western Europe. However, one should keep in mind that this mapping is not comprehensive, and further qualitative investigations would help complementing this data. For example, the study path to become an engineer or a technician in the field of fuel cells and hydrogen in some countries not well represented here could be investigated, as well as national systems and practices for upskilling and reskilling workers on the job.

The number of countries covered in the Observatory mapping of trainings raised from 18 to 20, with the addition of Slovenia and Romania. The fact that other countries are slowly integrated in the mapping tends to show that the outreach of the questionnaire is improving and/or that trainings in the field of FCH are expanding to new countries. For example, some of these initiatives are Erasmus Mundus taking place in several universities in Europe.

[4] The abbreviations used in this figure refer to the country codes used by Eurostat and available here: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Country_codes

Figure 5: Training courses by country



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.*

The user may then retrieve trainings filtering the results depending on the focus he/she is interested in.

With the table below, it is possible to see at a general level what focuses were the most and the least picked by responders to map the trainings, as well as the evolution compared to the

Table 1: Breakdown by focus for all training courses for the data in 2022 and 2021

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

Training Focus	Percentage of training indicating the focus category - 2022	Percentage of training indicating the focus category - 2021
Basic Electrochemistry	57%	51%
H2 Production	**67%**	**64%**
H2 Storage, Transport and Distribution	64%	57%
H2 End-uses: energy, power generation	55%	56%
H2 End-uses: industry	37%	38%
H2 End-uses: transports	64%	62%
H2 End-uses: buildings	31%	33%
Safety	43%	45%
Regulations, Codes, Standards	**22%**	**19%**
Life Cycle and Social Assessment, eco-design, recycling	26%	29%
Technical-economic evaluation	29%	32%

In comparison between both years, we may see that the additional trainings listed follow the same trends than in 2021. There are no important variations between both years. The most picked category remains "H2 production" (67%) followed by "H2 End-uses: transports" (64%). Both shares have increased in comparison to the overall number of trainings. The least picked category remains "Regulations, Codes and Standards" (RCS), which is only tackled in about 1/5th of the training courses mapped, and the trend tends to decrease.

Making a comparison of the different focuses between professional trainings and Master programmes can be relevant to try and understand the dynamic behind this data of course focuses. Both categories have a high number of entries which makes the comparison possible. Furthermore, comparing Master and professional trainings can highlight some key findings as one aim at training students without necessarily a work experience for a job, whereas the other is about training people already in employment.

Table 2: Breakdown by focus for professional training courses and Master programmes

In blue you may see the focuses with less than 20 points of percentage between professional trainings and Master programmes and in orange the ones with more than 20 points of percentage.

Training Focus	Percentage of professional training courses indicating the focus category	Percentage of Master programmes indicating the focus category
Basic Electrochemistry	48%	71%
H2 Production	62%	71%
H2 Storage, Transport and Distribution	62%	73%
H2 End-uses: energy, power generation	55%	56%
H2 End-uses: industry	41%	28%
H2 End-uses: transports	68%	67%
H2 End-uses: buildings	40%	29%
Safety	55%	34%
Regulations, Codes, Standards	41%	18%
Life Cycle and Social Assessment, eco-design, recycling	12%	19%
Technical-economic evaluation	27%	24%

With this comparison, we may see that the certain topics are approximately equally tackled between Masters and professional trainings. This can be evaluated when looking at the different point of percentage between both training categories.

As an indicator, we may consider that a difference of 20 points of percentage or more between the two indicators shows a high discrepancy. With this reading, three focuses can fall into this category:

- Basic Electrochemistry (23 points of percentage of difference)
- Safety (21 points of percentage of difference)
- Regulations, Codes, Standards (23 points of percentage of difference)

It is an indicator that the relevance of a focus differs according to the training type.
In the case of basic electrochemistry, it may be explained by the fact that these courses are usually lengthier and take place over time. The public trained might either be familiar with electrochemistry or not be familiar at all in which case a professional training, often taking place on a few days only, might not be sufficient to get them up to speed with the knowledge of the field. In Master however this focus is more prevalent (71%). This finding shows that learning about this scientific basis is something less likely to be taught as an adult, to upskill or reskill workers if they are not familiar with this topic. It would be interesting to investigate whether this is something companies in need of trainings would expect this type of content for their employees or not. A more qualitative analysis of the data presented here would be beneficial to confirm these findings.

For the focuses of ‘Safety’ and ‘Regulations, Codes, Standards’, the situation is reversed. These topics tend to be more tackled in professional trainings than in Masters. This can be explained by the fact that the content has a clear application to a workspace. The question of safety is especially important for workers starting to work with hydrogen in their missions whereas they were not trained for it at the

time, for example first responders or automotive repair shops. These trainings are in demand and usually applied to a specific in-situ environment.

2.3. Areas for future consideration in the training section

The areas mentioned for consideration in the previous report are still valid and should be considered for future updates of the Observatory. For the 2021 update, no changes were implemented in terms of content displayed or information collected. With this additional year of experience and based on feedbacks received, other elements could be added to complement the list.

Methodology for data collection

To reach out to a maximum of training providers on a continuous basis, it would be a good approach to allow data submission via a form available on the website all year long. The data submitted would be validated on a monthly or a bi-monthly basis to confirm its validity.

In parallel, specific outreach campaigns could be organised during the year to address different audiences using specific momentum. This way, newly established trainings could be integrated as soon as they exist and would quickly be displayed on the website. The accuracy of the existing data would be checked yearly. This approach would also lead to less limiting the rework needed to transfer the data from a Google Form to the website.

Content displayed

1. Rating the level of "*hydrogen expertise*" of a training.

The level of expertise on hydrogen and fuel cells gained through a training or a degree might greatly vary depending on its content and weather it is the core content delivered or just one part tackled within a wider programme. A rating of the level of expertise delivered within a training was proposed by the FRH2 who ranked from 0 to 4 to the trainings they mapped. This proposal has similarities with the one of France Hydrogène who proposed in its Livre Blanc[5] to rank with a hydrogen colouring how much jobs are specialised on hydrogen. The levels should be clearly defined for trainers to be able to evaluate by themselves this aspect.

It was suggested in the past report to give percentage of the different topics proposed. In order to keep the tool simple to use it might be easier to propose responders to highlight the topic the most emphasised in the training, if relevant.

2. Providing an indicator to describe the activities 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.

4. Providing training titles in the teaching language and in English to facilitate analysis.

[5] Livre blanc des compétences et métiers de la filière hydrogène, 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 as an online library focused on FCH learning materials. 341 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.

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 1 to 8), the course focus, the language, or the source. The materials listed were created between 2006 and 2021. In order to preserve the internal logic defined by those who developed the course, it was decided in this update to revolve to the website of a project listing different materials from one course (e.g. a course, an exercise and a case-study). Once having landed on the page the user can look their entirety of the lesson with all relevant files.

Observing trends in the materials listed with this update, compared to the previous one would have a limited interest as most materials added are not new materials, and have been developed several years back.

3.1. Focus on sources

The approach chosen for the materials section of the Observatory 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.

With the 2022 update of the Observatory, the first step was to check whether ongoing projects had developed new materials, or if existing materials had been updated. Two projects were concerned by this.

First, in the continuity of the HyResponse project (2013-2016), the HyResponder project updated the existing materials and developed further platforms to train responders throughout Europe, and to train responders' trainers. At this stage, only materials in English were available on the website, but they should be translated in 8 languages via an e-Platform. This should be monitored in the future. Then, the FCH Go project that ended in 2021 has developed materials in new languages that could be added in this update.

As no new projects in the field of education had started in 2021 within the Fuel Cells and Hydrogen Joint Undertaking, other relevant database for projects were explored. The Erasmus + programme appeared as a good choice for this. If not dedicated to fuel cells and hydrogen topics, the programme focuses on education and training, and projects within it might be dedicated to hydrogen. Furthermore, an Erasmus + project (Hyschool) was already included in the previous mapping of materials.

The Erasmus + search tool of project results is well designed and allows to retrieve projects using key words which was particularly useful in this case. Using the key words "hydrogen" and "fuel cells", respectively 36 and 15 projects were listed. Some of the results were listed in both categories. From this pool, only four additional projects had developed materials that could be added from this research. What led to such a low number in comparison to the high number of results is that many projects have developed content on a website that is not maintained once the project ends. Therefore, a lot of work has been done in past projects but cannot be retrieved if the website is not kept alive. This issue is known, and for some projects, all content developed is hosted on the Erasmus + platform which appears to be a good solution to make sure that content developed is not lost.

This issue also underlines the limitation of the Observatory approach; due to copyright reasons, it can only point to other websites hosting the materials. When these websites stop being maintained, the materials will need to be removed from the Observatory, unless an alternative solution is found.

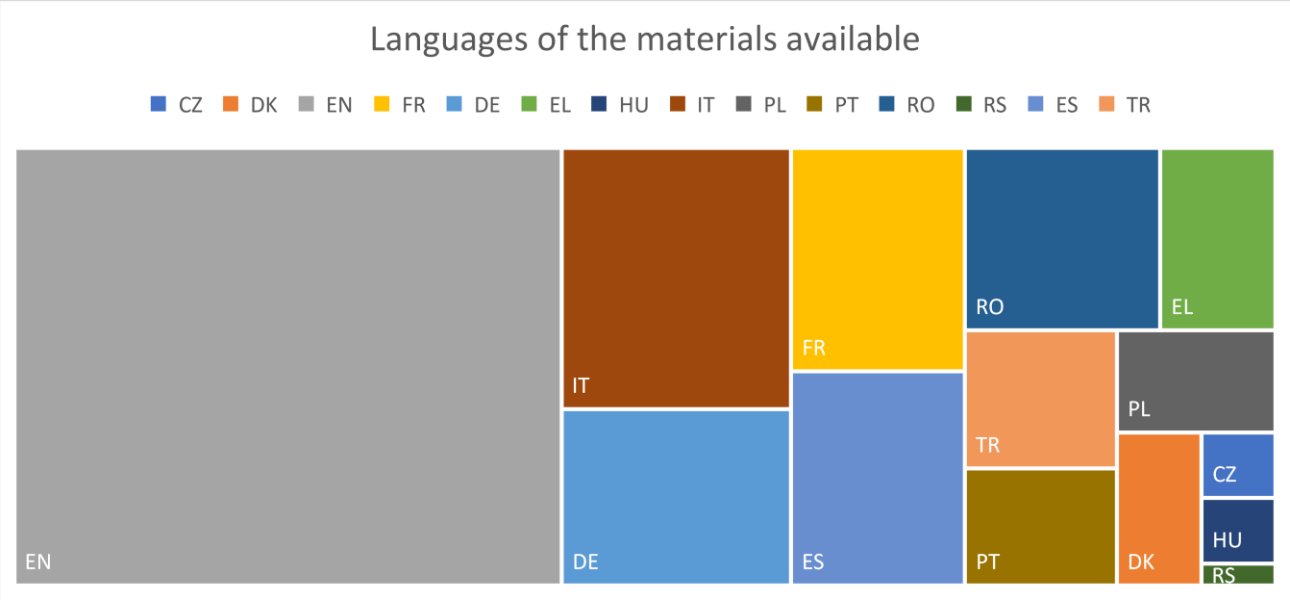
The materials listed were collected through pre-identified European projects. 14 different sources are currently included:

- AlterDrive
- CertifHy
- CLEAN kWAT
- Ene.field
- FCHGO
- H2 Training
- HyFacts
- HySchools
- HyResponder updating HyResponse
- JESS 2011
- JESS 2012
- NET-Tools
- PACE
- Sustainability by biotechnology

3.2. Focus on languages

Materials in 14 different languages are currently listed in the library. It is 5 more than in the 2020 update of the library. Those languages are Czech, Hungarian, Portuguese, Serbian and Turkish. A majority of the materials are in English language (43%). Materials in Italian language are then the most common ones (11%), followed by German (7%) French (7%), Romanian (5%), Spanish (5%), and Romanian (6%).

Figure 6: Breakdown of the materials by languages[6]



[6] The abbreviations used in this figure refer to the country codes used by Eurostat and available here: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Country_codes

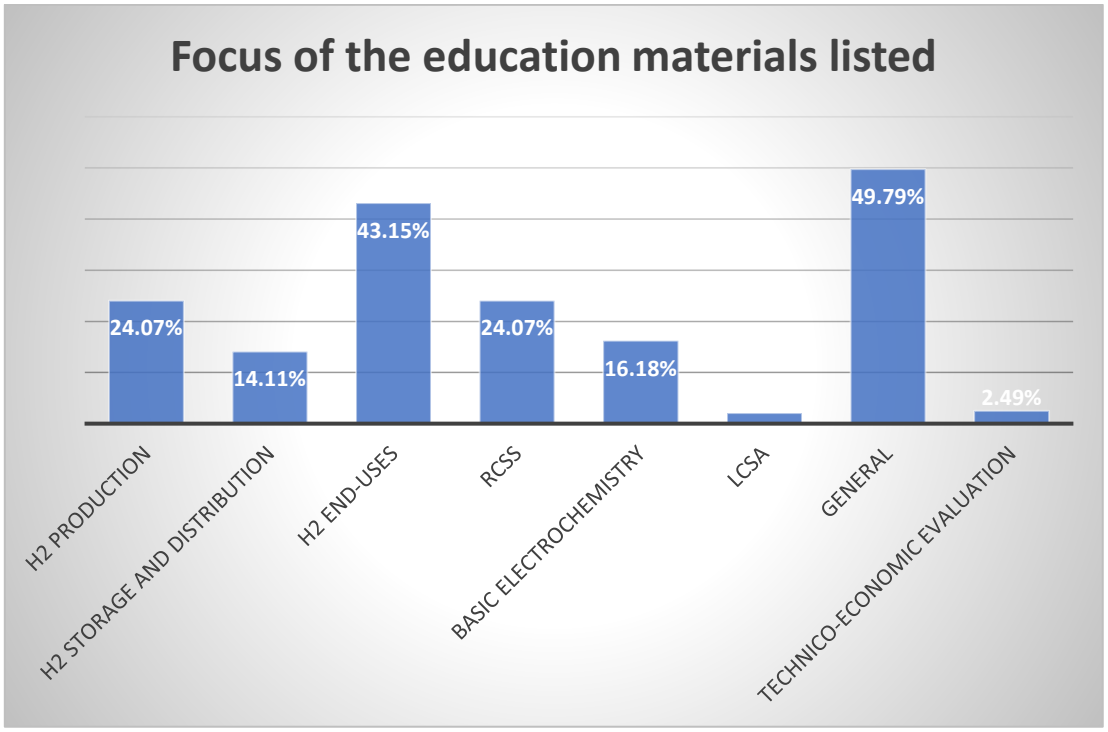
3.3. Focus on the course topic

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 7) 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 7) *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 and Technico-economic evaluation were the least tackled focus categories in comparison with only one material focusing on this specific issue.

Figure 7: Focus of the education materials listed



3.4. Formats and target audiences of the materials developed

Table 3: Focus on the ISCED level of materials listed

ISCED level	Percentage of materials in the corresponding ISCED level
1	6%
2	6%
3	6%
4	4%
5	24%
6	40%
7	45%
8	22%

A majority of the materials listed address a public on a higher level of understanding, as shown in table 3. However, several projects also target lower-level education. They are usually translated in different languages to be accessible to different national audiences.

Regarding the format, the use of virtual reality or e-lab for some of the higher ISCED materials is to be noted. This has been the case in projects like HyResponder and Net Tools. At lower ISCED levels, the content often includes games and interactive lessons with experiments and are aimed for teachers to use with their students. The core of the materials listed remain slides or texts. How materials can be used by self-learners in the absence of a teacher should be further investigated.

3.5. 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/or 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 a project could automatically be added to the website. The responsible project partners could download from the website a template to list and classify their materials as they are the best placed to do this exercise. This would help overcoming the language barrier when listing 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 in case this change is pursued.

4. Conclusion

The annual update of the FCH Observatory's Education and Training section allowed to further expand the database of both education materials and programmes or trainings available in the field of fuel cells and hydrogen. Whilst the data listed might not be comprehensive, relevant trends can be observed or confirmed, in comparison to the first year of mapping (2021).

Master programmes and professional training courses remain the categories with the most entries in 2022. The geographic coverage of the trainings available is slowly expanding (20 countries in 2022, compared to 18 in 2021), but the prevalence of Western European countries is still noticeable. "Hydrogen Production" and "Hydrogen end-uses: transports" remain the most selected focus of courses among the 11 categories proposed.

In the case of Master programmes, FCH tends to be more often an element integrated in a programme than its core focus. The diversity of programmes listed shows the cross-sectoral nature of hydrogen. It is interesting that again in 2022, the categories of professional trainings and Master programmes diverge in terms of content covered. This is especially noticeable for the focuses on Basic Electrochemistry; Safety; Regulations, Codes and Standards that are given a different weight in the different category.

Regarding education materials, most of the ones listed in the library are available in English and focus on higher ISCED levels, especially the levels 6 and 7 which correspond to Bachelor and Master levels. They tend to have a "general" focus. The category "Hydrogen End Uses" is then the most common focus in the materials listed. Virtual reality and e-labs are taking some importance in the materials listed, and it would be interesting to see how this will develop in the coming years. The library should keep on growing with the starting of new projects aiming at developing materials for the general public and specialists in the field of fuel cells and hydrogen, under the Clean Hydrogen Joint Undertaking as well as perhaps through other programmes.

Future updates of the Observatory should be put in perspective with the trends already observed.