

The hydrogen education and research landscape

Update of the October 2025 report

October 2026



Disclaimer

The aim of this report is to provide an overview of the training programmes and publicly accessible online educational materials available on the European Hydrogen Observatory, in addition to the trends and patterns in research and innovation activities within the hydrogen sector in Europe as of August 2026, unless stated otherwise. The authors believe that this information comes from reliable sources, but do not guarantee the accuracy or completeness of this information.

The data of the European Hydrogen Observatory will continuously be updated. These updates will take place annually for most datasets, while for some it 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 updated data that is presented on the European Hydrogen Observatory.

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Executive summary

This report aims to summarise the status of the European hydrogen education and research landscape. It is based on the information available at the [European Hydrogen Observatory \(EHO\) platform](#), the leading source of data and information on hydrogen in Europe (EU27, EFTA and the UK). Specifically for education, this report provides an overview of the European training programmes and education materials available in the EHO library. For research, this report gives insights in the trends and patterns of research and innovation activity in the hydrogen sector based on data of patent registrations and publications. The data is sourced from [Tools for Innovation Monitoring \(TIM\)](#) supplied by the Joint Research Center in August 2026. TIM tracks publications from Scopus and patents from PATSTAT based on keywords.

As of July 2026, a total of 327 European training programmes have been identified, up from 261 in 2025. Master's programmes and professional training courses continue to represent the largest share, accounting for 45% and 37% of the total, similar to the previous year. These programmes are offered in 14 languages, with English remaining the predominant language, used in 55% of cases (181 out of 327). The majority of programmes, 81%, are conducted in a single language, while 19% are multilingual. The European Hydrogen Observatory has mapped training programmes across 21 European countries. France continues to host the largest proportion of programmes at 31%, followed by

Spain with 14% and the United Kingdom with 11%. Interestingly, over half of the mapped training programmes focus exclusively on hydrogen and/or fuel cells. Hydrogen end-use applications in transport, hydrogen production and hydrogen storage, transport, and distribution are the predominant subjects featured in approximately 70% of programmes.

The EHO online library offers 198 reliable educational materials available in various formats, including slides, e-laboratories, experiments, games, case studies, lab protocols, and videos. These materials were created between 2006 and 2026, with a steep increase in the release of educational materials in 2024, when 51 new materials were added. The library provides resources in 16 different languages, with English being the predominant language, used in 81% of the materials. The primary focus of these educational materials is on general information on hydrogen, covered in 37% of the materials. Hydrogen end-use applications follows, included in 29% of the courses. Most materials are intended for audiences at higher education levels, specifically levels 5 and 6, corresponding to short-cycle tertiary education and bachelor's levels.

From 2006 to 2026, patent and publication activity in specific fields of fuel cells, clean hydrogen production, and hydrogen storage was analysed. In Europe, 24,456 publications and 1,317 patent registrations were identified,

representing 22% and 8% of the global totals, respectively. Overall, there is an increasing trend in the numbers of publications and patents in the most recent years. Fuel cells dominated the research landscape in the early years, shifting progressively toward hydrogen production more recently.

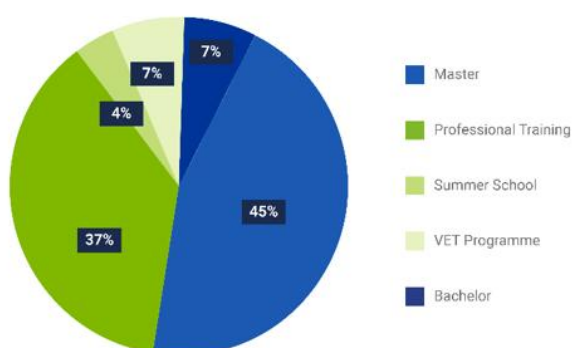
Key insights

Training Programmes & Education Materials

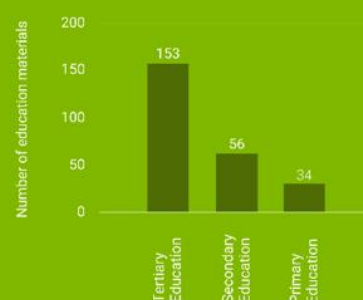
327 training programmes & 198 education materials available in the EHO online library.

Training programmes available in 14 languages and education materials in 16, with over 50% offered in English.

Training programmes by type



Education materials by level

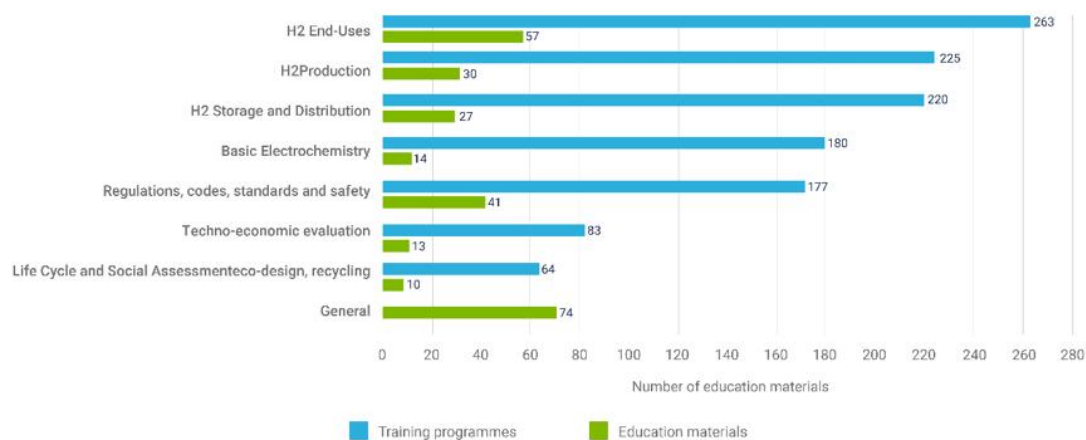


Primary Education: Primary school and middle school (ISCED 1–2).
Secondary Education: High school and post-secondary non-tertiary (ISCED 3–4).
Tertiary Education: Short-cycle programmes, bachelor's, master's, and doctoral degrees (ISCED 5–8).

The majority of the materials are intended for audiences with higher level of understanding, specifically short-cycle tertiary education and **Bachelor's levels**.

57% of the training programmes are taking place in **France, Spain and UK**.

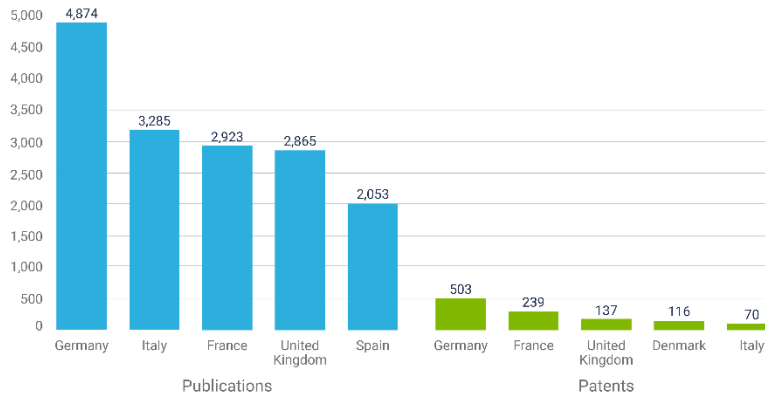
Training programmes and education materials by topic



Publications & Patents

The publication and patent data cover fuel cell (PEM, SO and alkaline), clean hydrogen production (PEM, SO, alkaline and non-electrolysis) and hydrogen storage (only onboard storage) sectors.

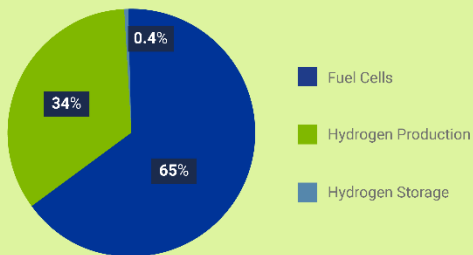
Top 5 European countries in publications and patents



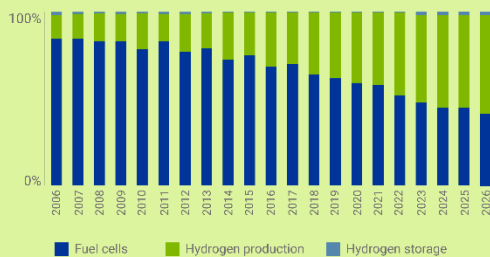
Hydrogen production has gained **increasing importance** in recent years in the research landscape **compared to fuel cells**.

A total of **24,456 publications** have been identified in Europe from 2006 to 2026.

Publications in Europe by topic

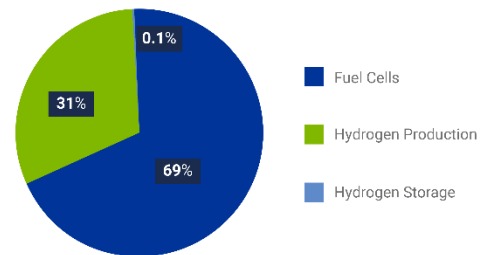


Historical data of publications in Europe by topic from 2006 to 2026

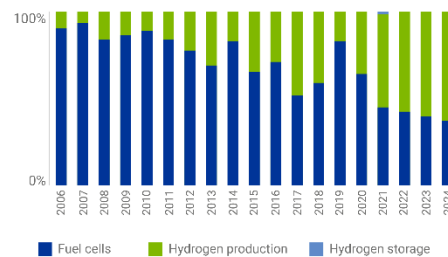


A total of **1,317 patents** have been identified in Europe from 2006 to 2025.

Patents in Europe by topic



Historical data of patents in Europe by topic from 2006 to 2024*



*Patents are only published starting 18 months after filing, so data from 2024 onwards may not yet be fully complete

Overview

In the rapidly evolving landscape of modern industries, education and research are crucial for fostering innovation, workforce readiness, and economic growth. As the global focus shifts towards sustainability and renewable energy, hydrogen technology demands robust educational frameworks, comprehensive training programmes, and cutting-edge research.

Education provides essential knowledge for advancing hydrogen technologies, with specialized programmes preparing individuals for hydrogen production, distribution, and end-use. Training programmes bridge theory and practice, equipping the workforce with practical skills and facilitating the re-skilling of workers from declining industries, thereby promoting job creation and economic resilience. Research drives continuous innovation in hydrogen technologies, leading to efficiency improvements, cost reductions, and solutions to technical challenges. Patents protect intellectual property and publications disseminate new knowledge, fostering further industry innovation.

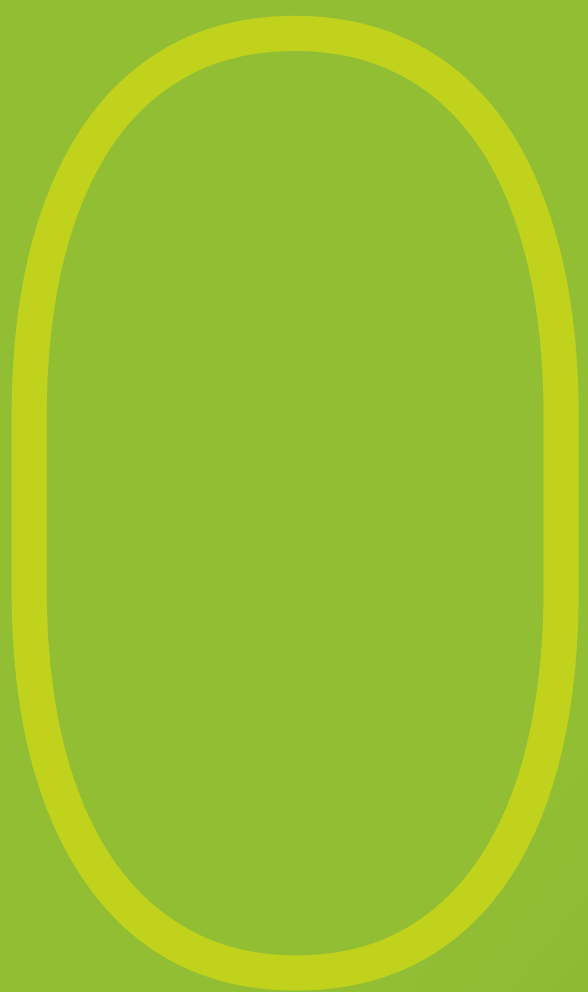
The synergy between education and research creates a robust ecosystem supporting the hydrogen sector's development. By investing in these areas, stakeholders can ensure the growth of the hydrogen economy and its contribution to global sustainability goals.

This report includes information on European training programmes, educational materials and the trends and patterns of research and innovation activity in the hydrogen sector with data of patent registrations and publications. It is based on the information available at the European Hydrogen Observatory (EHO) website (<https://observatory.clean-hydrogen.europa.eu>), the leading source of hydrogen data in Europe. The data presented in this report is based on research conducted until the end of August 2026.

The training programmes section provides insights into major European training initiatives, categorized by location. It allows filtering by type of training, focus area and language. It covers a wide range of opportunities such as vocational and professional trainings, summer schools, and Bachelor's or Master's programmes.

The education materials chapter summarizes the publicly accessible educational materials available online. Documents can be searched by educational level, by course subject, by language or by the year of release.

The section referring to research and innovation activity analyses trends and patterns in the hydrogen sector, using aggregated datasets of patent registrations and publications by country.

A large, stylized yellow number '01' is positioned on the left side of the image. The background is a solid green color with several large, semi-transparent, light green circular shapes that overlap each other and the edges of the frame. The number '0' is a simple outline, while the '1' has a short horizontal bar at the top.

01

Training
programmes

Introduction

This chapter provides an overview of the European training programmes that are registered in the EHO database and are relevant to the hydrogen sector. This chapter provides statistics of the training programmes based on location, the type of training, focus of the training and language.

The data on training programmes presented on the European Hydrogen Observatory website are shared by training providers and processed by Hydrogen Europe Research and reflects the

situation as of June 2026. The information is provided by organizations and individuals through completion of our [questionnaire](#). For a training programme to be listed, it must include a minimum set of information and web references to facilitate posting.

Interactive data dashboards on [training programmes](#) can be accessed on the European Hydrogen Observatory website.

1.1. Overview

Currently, 327 training programmes are listed in the Observatory's online library, reflecting an increase of 66 programmes since 2025 (+25%).

Table 1, gives an overview of the different filters available in the training programmes dashboard, allowing users to refine their search according to specific needs. Users have the ability to filter their search results based on three criteria: type of training (5 options), course focus (11 subjects), and language availability (14 languages).

In addition to the three criteria mentioned above, organizations and individuals are able to provide additional information about their training programmes. Table 2 presents the extra information a training programme may provide in the EHO database, that can be seen by the user when navigating through the library, such as the name of the organization, target audience, training duration and many more.

Table 1. Categories of training programmes available on the EHO website.

Type of training	Course focus	Language
Bachelor	Basic electrochemistry	Danish
		Dutch
		English
		Finnish
		French
Master	H ₂ End-uses: industry	German
Professional training	H ₂ End-uses: transport	Greek
Summer school	H ₂ Production	Italian
Vocational Education and Training (VET) programmes	H ₂ Storage, Transport and Distribution	Norwegian
	Life Cycle and Social Assessment, eco-design, recycling	Polish
	Regulations, Codes, Standards	Portuguese
	Safety	Romanian
	Techno-economic evaluation	Spanish
		Swedish

Table 2. Additional information data providers may provide for training programmes.

Additional information on training programmes	
Question	Answer
Name of the organization providing the training	e.g. Université Grenoble Alpes
Location (address):	- For in-person training: address where the training takes place - For online training: location of the training provider
Is the programme entirely focused on hydrogen and/or fuel cells?	- Yes - No
Target audience for the training	E.g., Master students in engineering, electricians, trainers, etc.
How is the training taught?	- In person - Online - Hybrid / both options possible
Requirements from applicants	Minimum degree, prerequisite to attend the training, etc.
Materials / Infrastructures proposed	- Books / e-books - Demonstration platforms - E-Learning tools e.g. MOOCs - Handouts - Infrastructure visits - Labs (physical or virtual) - Serious games - Simulation environment - Slides
Duration of the training	- One day or less - Between a day and a week - Between one week and a month - Between one and six months - Between six months and a year - Between one and two years - More than two years
Recognition of the training	Issuance of a certificate by the organisation, obtention of a recognised degree, ECTS or ECVET granted, micro-credentials, other
Is the programme complimentary?	- Yes - No
If the programme is not complementary, how much does it cost?	e.g. cost in €
Capacity of the training	Maximum number of participants
Possibility to combine the training with employment	Description of the relevant scheme applying: apprenticeship, evening classes, study time arranged to combine the training with work etc.

1.2.

Training programmes by category

1.2.1.

Training programme type

Figure 1 shows the various training programme types and their respective shares of the total number of training programmes listed in the EHO database. These categories include bachelor's, master's, VET programmes, professional trainings, and summer schools.

Master's programmes represent the largest segment among the registered training programmes, totalling 146, which accounts for 45% of the total. Professional training programmes follow with 120 entries, comprising 37% of the total, while the remaining categories collectively make up approximately 18% of the programmes.

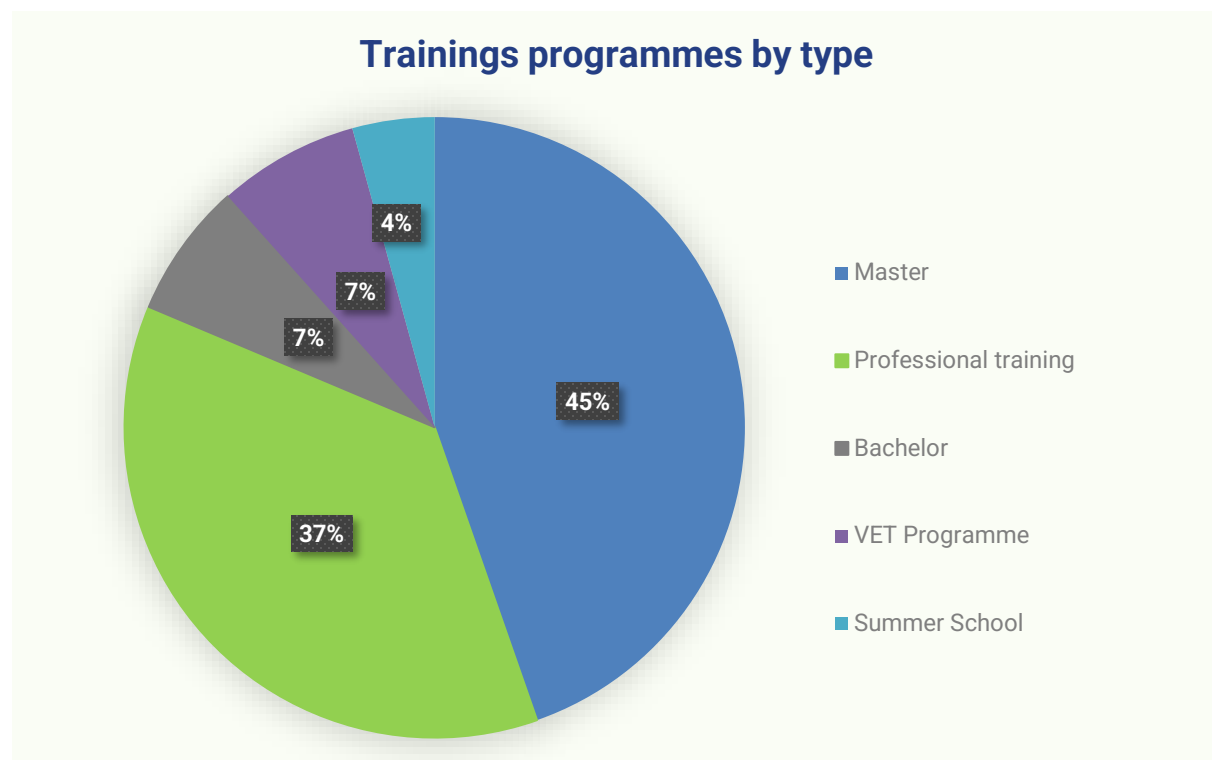


Figure 1. Share of training programmes in Europe by type, available in the EHO database.

Figure 2 illustrates the evolution of the training programmes registered in the EHO database from 2021 to 2026.

Overall, all categories of programmes have experienced sustained growth over the five-year period from 2021 to 2026, reflecting growing institutional commitment to diverse educational pathways.

Master's entries represent the largest segment and have shown the strongest expansion, rising from 54 in 2021 to 146 in 2026, a 170% increase. Growth was particularly pronounced between

2021 and 2022, when Master's more than doubled from 54 to 117 (117% increase). While growth moderated in subsequent years, the trajectory remained consistently upward, with acceleration in 2026 reaching 146 entries.

Professional training expanded from 47 in 2021 to 120 in 2026, representing a 155% increase. The most significant growth occurred in the 2021–2022 period, when entries increased from 47 to 73 (55% increase). Subsequent years saw continued but more gradual expansion, indicating a maturing segment within the portfolio.

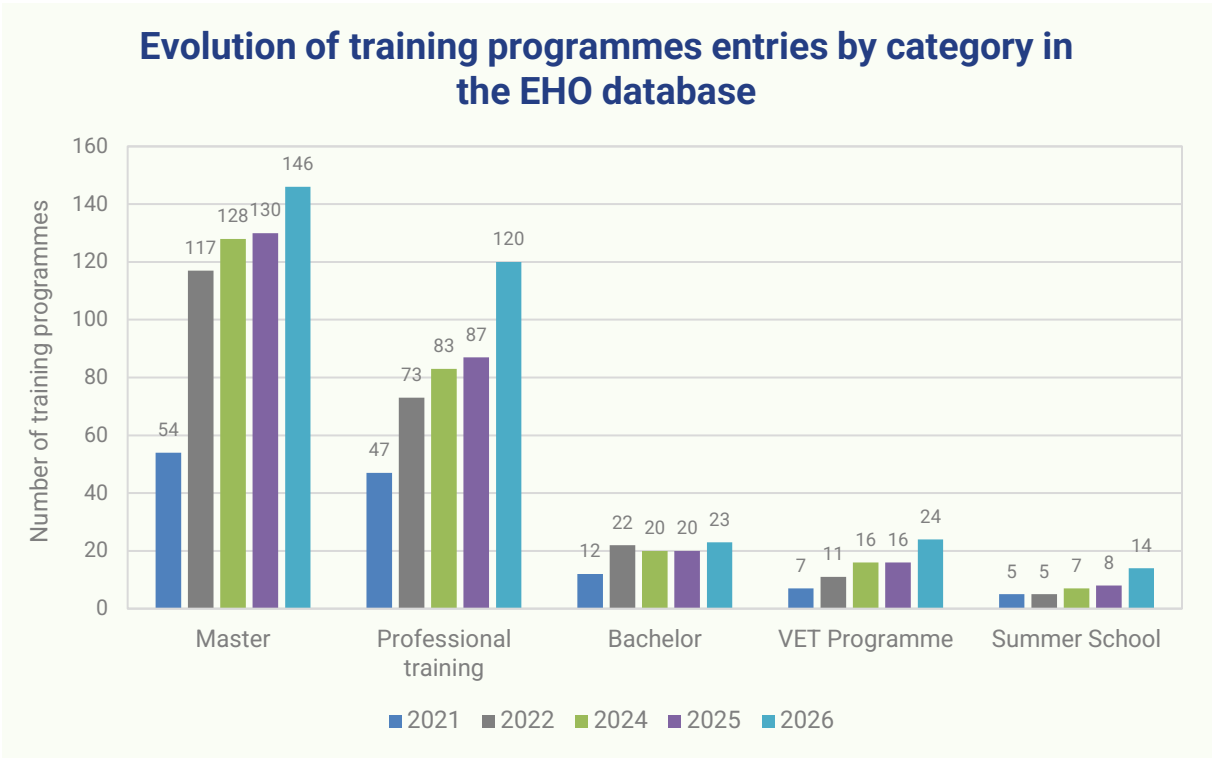


Figure 2. Evolution of training programmes offerings in Europe by category in the EHO database.

VET has emerged as the fastest growing category in recent years. Starting from 7 entries in 2021, it reached 24 by 2026, a 243% increase. Growth was modest from 2021 to 2024, but accelerated sharply between 2025 and 2026,

increasing from 16 to 24 entries (50% growth), reflecting increased institutional focus on vocational training pathways.

Bachelor's grew from 12 in 2021 to 23 in 2026, a 92% increase. Growth was most pronounced

between 2021 and 2022 (12 to 22, an 83% increase), after which expansion continued at a measured pace, suggesting stabilization within this segment.

Summer school entries, while remaining the smallest category, expanded from 5 in 2021 to 14 in 2026, representing a 180% increase. Growth was gradual and consistent throughout the period, with renewed momentum evident in 2024 to 2026.

Overall, the data reveals two distinct growth phases: an expansion period from 2021 to 2022 across most categories, followed by a consolidation and reacceleration phase from 2024 onwards. The expansion in Master's and VET entries reflects growing adoption of the EHO platform by programme owners, though current registrations do not capture the full spectrum of hydrogen training initiatives in Europe. Increased participation from training providers would strengthen the completeness and representativeness of the datasets.

1.2.2.

Language

The registered training programmes provide learning opportunities in 14 different languages. Figure 3 presents a summary of the languages in which the programmes are most abundantly available. Note that some programmes are available in multiple languages, so the counts reflect the availability in each language.

English is the predominant language, used in 55% of the programmes (181 out of 327). French is the second most common language, featured in 31% of programmes, followed by Spanish (12%) and German (9%). Italian is offered in 4% of programmes, while Dutch and Greek each account for 2%. Other languages such as Swedish, Danish, Polish, Portuguese, Norwegian, Finnish and Romanian, are offered less frequently, collectively accounting for less than 5% of total programmes.

It is also worth noting that not all countries with training programmes offer them in the local language. Some programmes are conducted in English, especially those under international schemes like Erasmus Mundus Masters. Additionally, certain programmes are available both in English and in the local language of the country where the training takes place.

As shown in Figure 4, the majority of the programmes mapped in 2026 (81%) are conducted in a single language, comprising 264 programmes, while multilingual programmes account for 19%, totalling 63 programmes. Multilingual programmes usually mean bilingual, typically offered in English and the language of the country where the training takes place.



Figure 3. Breakdown of training programmes in Europe available in the EHO library by language ¹.

Training programmes by language capability

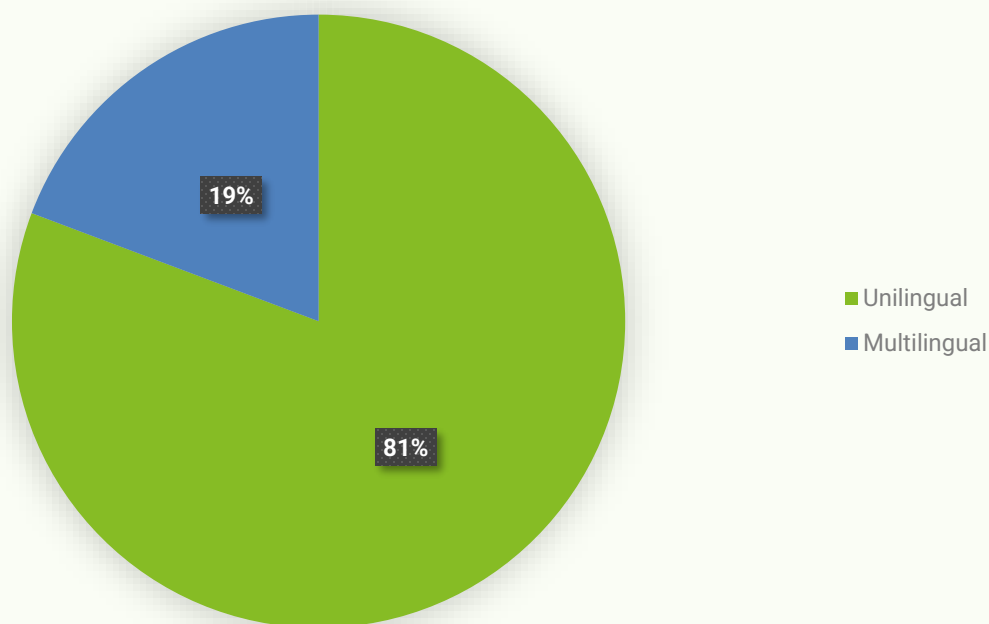


Figure 4. Share of training programmes in Europe by language capability.

¹ The abbreviations used in this figure refer to the language codes used by Eurostat and available here: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Language_codes

1.2.3.

Location

The Observatory's mapping of training programmes covers 21 European countries in 2026, maintaining the same geographical scope as the previous year. Figure 5 provides an overview of the geographical distribution of training programmes categorized by ranges of programme numbers, while Figure 6 details the number of programmes per country.

The training programmes are predominantly located in France, where 31% of the trainings are taking place, followed by Spain with 14%, and then the United Kingdom with 11%. Between 5% and 10% of the programmes are found in Germany (7%), Italy (7%), and the Netherlands (5%). The remaining European countries each account for less than 5% of the total trainings.

It should be noted that some training programmes are delivered across multiple

locations spanning more than one country. In addition to their geographical distribution, training programmes also vary in their mode of delivery. Programmes may be offered in person, online, or in a hybrid format combining both in-person and online participation. The choice of format may vary depending on the specific training programme and the institution providing it.

As a general tendency, trainings in the field of hydrogen seems to be more often provided in Western Europe. It is important to note that the EHO database may not capture all available training programmes. Training providers are encouraged to register their programmes by filling out the provided form.

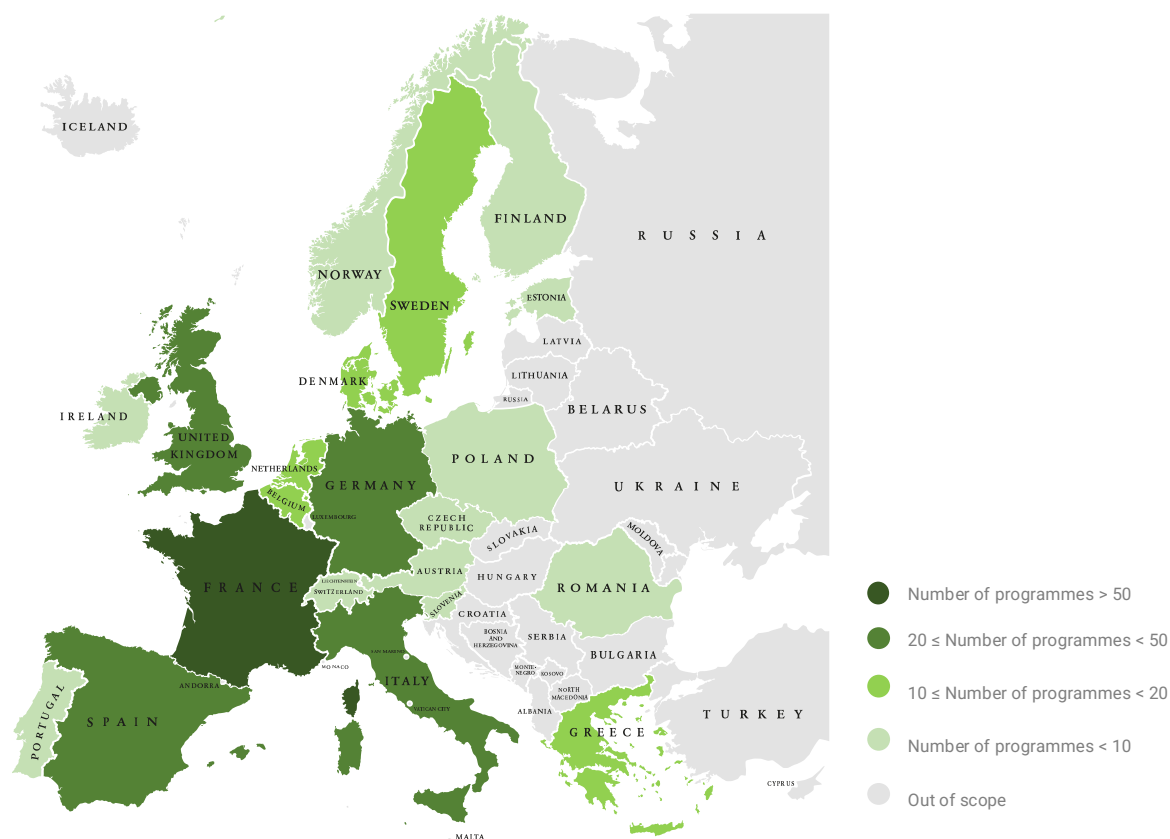


Figure 5. Geographical distribution of training programmes in Europe by ranges.



Figure 6. Number of training programmes in Europe by country available in the EHO library.

1.2.4.

Training focus

Most of the mapped training programmes are not entirely focused on hydrogen and/or fuel cells. As shown in Figure 7, just over half of the programmes (174 out of 327, or 53%) now concentrate solely on hydrogen and fuel cells, while the remaining 47% (152 out of 327) cover broader subjects where hydrogen and fuel cells are only part of the overall curriculum. This represents a shift from 2025, when 49% of programmes were not entirely focused on hydrogen and fuel cells, whereas this year 53% are now dedicated to hydrogen and fuel cells. This increase in dedicated programmes suggests

growing specialization in hydrogen and fuel cell trainings across Europe.

Table 3 provides an overview of the available subject categories related to the hydrogen topic, including detailed explanations for each item. Figure 8 illustrates the number of training programmes associated with each of these subject categories. It is important to note that most programmes address multiple topics, so the counts represent the extent to which each topic is included in the programmes.

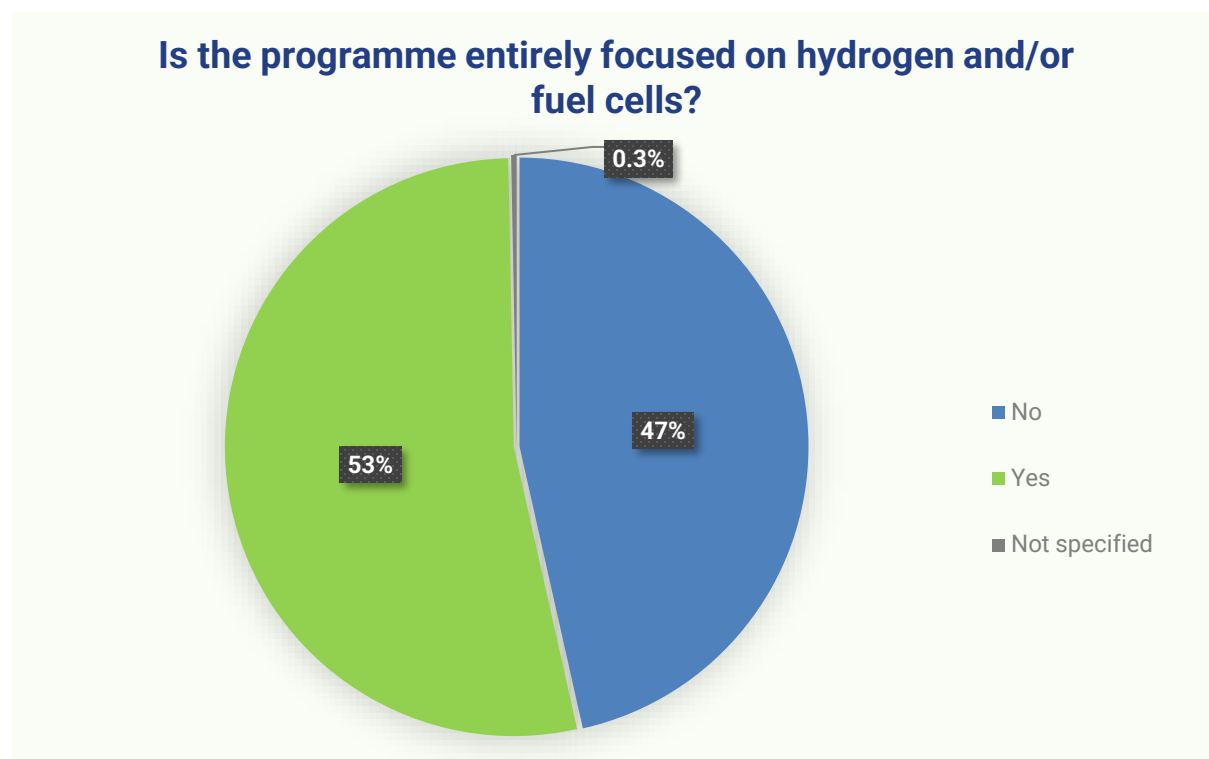


Figure 7. Share of programmes entirely focused on hydrogen and/or fuel cells.

Table 3. Overview of training programmes subject categories.

Training focus	Description
Basic Electrochemistry	Refers to the theory behind the electrochemical reactions that are taking place in electrolysis or fuel cell devices.
H ₂ Production	Refers to the different means to produce hydrogen (electrolysis, gasification of biomass, pyrolysis, etc.)
H ₂ 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.)
H ₂ End-uses: transport	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.
H ₂ End-uses: industry	Refers to hydrogen used in some industrial processes (e.g. steel manufacturing, chemicals, etc.)
H ₂ End-uses: buildings	Refers to electrical, heating and cooling applications including fuel cells, CHP, boilers, etc. using hydrogen or hydrogen derivative synthetic fuels.
H ₂ End-uses: energy, power generation	Refers to the production of electricity using hydrogen or hydrogen derivative synthetic fuels in turbines and/or fuel cells.
Regulations, Codes, Standards	Refers to the applicable regulations and the development and use of harmonized performance-based standards for hydrogen appliances and systems.
Safety	Refers to the safe production, handling and use of hydrogen or its derivatives.
Life Cycle and Social Assessment, eco-design, recycling	Refers to environmental and sustainability aspects of hydrogen.
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.

Hydrogen production, end-use applications in transport, and hydrogen storage, transport, and distribution remain the predominant subjects featured in approximately 67-69% of programmes. Basic electrochemistry and end-use applications in energy and power generation are covered by 55% and 56% of the programmes respectively.

Other subjects are covered less frequently: safety (49%), end-use applications in industry (44%),

end-use applications in buildings (32%), regulations, codes and standards (31%), technical-economic evaluation (25%), and life cycle and social assessment, eco-design and recycling (20%).

Compared to 2025, the coverage of core hydrogen topics remains stable, though there is a slight increase in the range of subjects being integrated into training programmes, particularly in safety and regulatory frameworks.

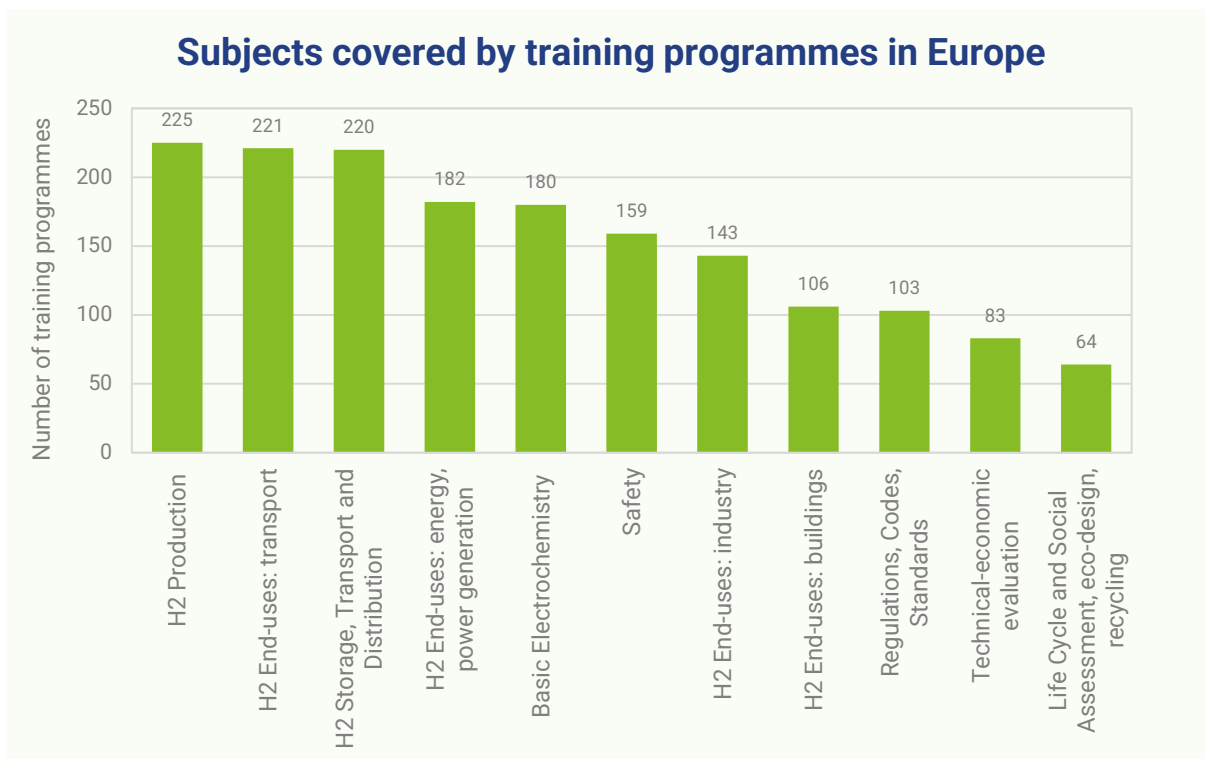


Figure 8. Number of training programmes in Europe by subject.



Education
materials

Introduction

This chapter provides an overview of the current education materials in the EHO database for learners and students interested in the field of hydrogen.

The EHO database provides an online library relevant for all different levels of education, as described by the International Standard Classification of Education (ISCED) and covers many different course subjects and languages. Only materials intended for public use are shared in the library.

The data on educational materials presented on the European Hydrogen Observatory website are

collected by Hydrogen Europe Research from European projects' deliverables (Clean Hydrogen Partnership and other EU programmes) as well as other reliable sources identified through desk research and reflects the situation as of July 2026. Individuals and organizations wishing to contribute to this open-access library are encouraged to contact the EHO team.

Interactive data dashboards on [education materials](#) can be accessed on the [European Hydrogen Observatory website](#).

2.1. Overview

198 reliable materials are available on the online library of the EHO, reflecting a decrease of 47 materials since 2025 (-19%). Some materials were no longer available from their original sources and were consequently removed from the library. It is the go-to-resource for finding hydrogen related materials developed in the framework of European projects.

Table 4 provides an overview of the filters that are available to refine the search of users according to their needs. The filters include the education

level (ranging from 0 to 8 ISCED level), the course focus, and the language.

The International Standard Classification of Education (ISCED) levels, developed by UNESCO, is an internationally recognized system that categorizes education programmes and qualifications by level and field, enabling consistent comparison across different education systems globally. By aligning the materials with each ISCED level, a clear and structured understanding of the various stages of education is provided.

Table 4. Categories on educational materials available on the EHO website.

Level of education	Course focus	Language
ISCED 0: Early childhood education	Basic electrochemistry	Czech
ISCED 1: Primary education (primary school)	General	Danish
ISCED 2: Lower secondary education (middle school)	H ₂ Production	Dutch
	H ₂ Storage and Distribution	English
ISCED 3: Upper secondary education (high school)	H ₂ End-uses	French
	Life Cycle and Social Assessment, eco-design, recycling	German
ISCED 4: Post-secondary non-tertiary education	Regulations, Codes, Standards & Safety	Greek
ISCED 5: Short-cycle tertiary education		Hungarian
ISCED 6: Bachelor's or equivalent level	Techno-economic evaluation	Italian
ISCED 7: Master's or equivalent level		Norwegian
ISCED 8: Doctoral or equivalent level		Polish
		Portuguese
		Romanian
		Serbian
		Spanish
		Turkish

Additionally, users can search for relevant materials based on their release year. The educational materials available were created between 2006 and 2026. Figure 9 illustrates the number of educational materials released within this period.

The highest number of materials were released in 2024 (54 materials), 2006 (43 materials), 2019

(32 materials), and 2021 (20 materials). The fewest materials were released between 2015 and 2018, with fewer than five materials released each year. In 2025, only three materials were published, and in 2026, 13 materials have been added so far, reflecting increased output as recent projects progress toward completion of their educational deliverables.

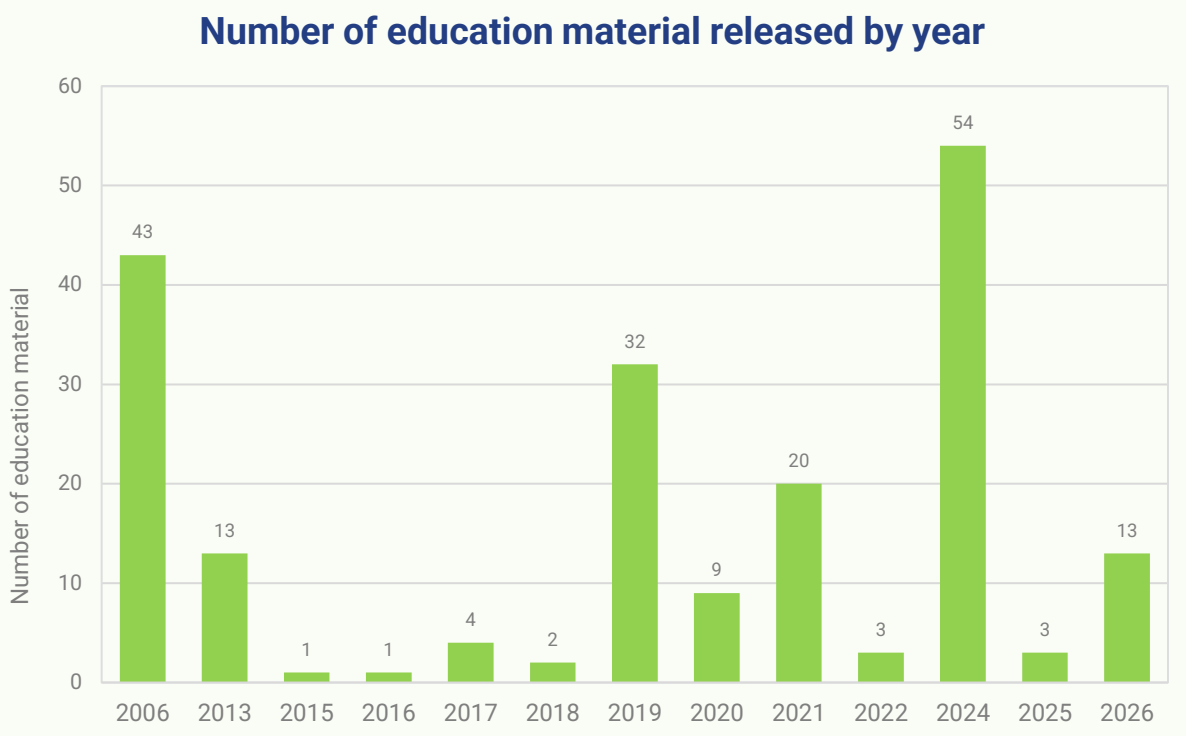


Figure 9. Number of education materials released by year.

The educational materials are available in various formats, mainly slides, but also e-laboratories, experiments or games, case studies, lab protocols, videos and more.

The sources include CertifHy, CLEAN-kWAT, College of the Desert and SunLine Transit

Agency, ene.field, FCH Train, FCHGO, GreenSkillsforHydrogen, H₂ Training, HyFacts, HyResponder, HySchools, Jess Summer School 2011 and 2012, JUST GREEN AFRH2ICA, NET-Tools, PACE, SkillSea, Sustainability by Biotechnology, UpHyMob and US Department of Energy.

2.2.

Education materials by category

2.2.1.

Language

Education materials spanning 16 different languages are currently listed in the EHO library.

Those languages include Czech, Danish, Dutch, English, French, German, Greek, Hungarian,

Italian, Norwegian, Polish, Portuguese, Romanian, Serbian, Spanish and Turkish.

Figure 10 displays the languages in which educational materials are available in the EHO library. Note that some materials are available in multiple languages, so the counts reflect the availability in each language.

English is the predominant language, available in 81% of the materials (160 out of 198). Italian follows with 25% (50 materials), German with 20% (39 materials), French with 18% (36 materials), and Spanish with 17% (34 materials).

Romanian accounts for 11% (22 materials), while Czech, Dutch, Turkish, Greek, and Norwegian each represent 7% of the collection. The least represented languages include Portuguese (6%), Polish (5%), Danish (4%), Hungarian (2%), and Serbian (1%).

Compared to 2025, English remains dominant but decreased slightly from 84% to 81%. Italian and German have increased, reflecting growing demand for materials in these languages.

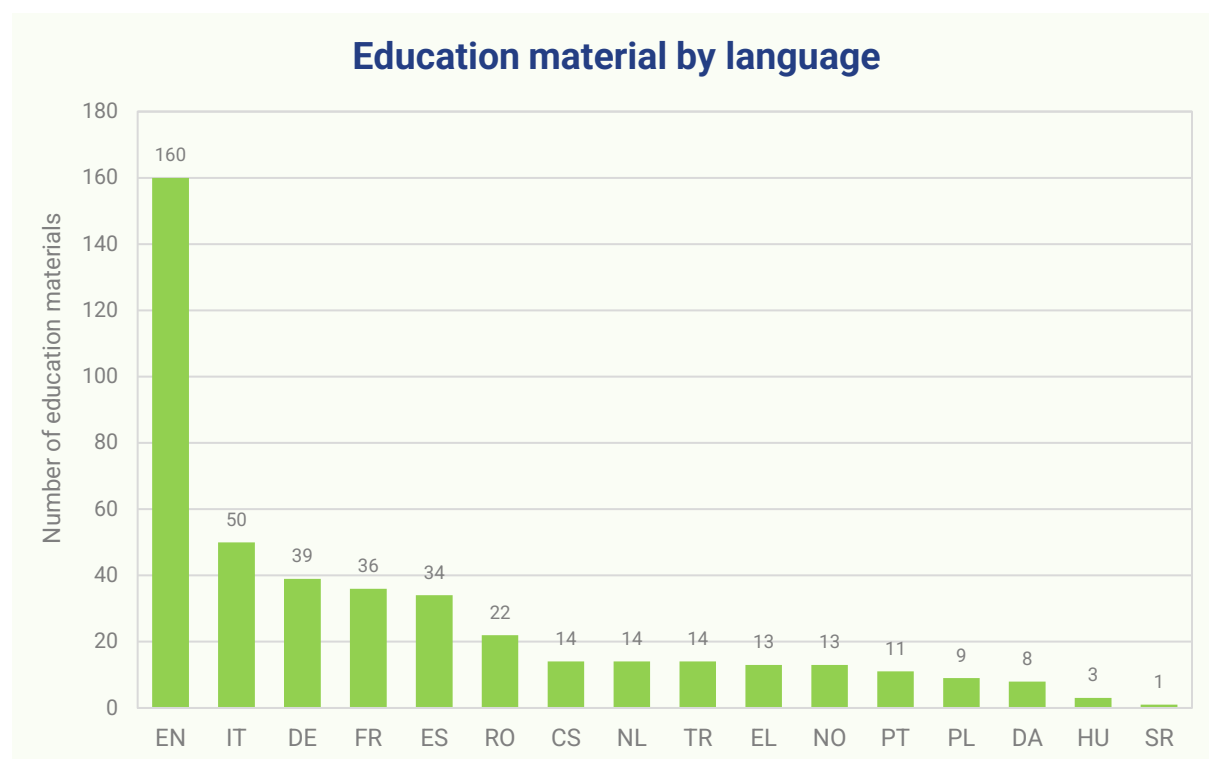


Figure 10. Breakdown of education materials available in the EHO library by language².

² The abbreviations used in this figure refer to the language codes used by Eurostat and available here: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Language_codes

2.2.2.

Course topic

Like the training programmes, the education materials are categorized according to their course topics. Table 5 provides a comprehensive overview of these topics, including detailed explanations for each.

Figure 11 illustrates the number of courses that each topic is applicable to. It is important to note that most courses address multiple topics, so the counts represent the extent to which each topic is included in the courses.

Table 5. Overview of available education material topics.

Course topic	Description
General	Refers to information remaining at a broad level of understanding, not going into technical details.
Basic Electrochemistry	Refers to the theory behind the electrochemical reactions that are taking place in electrolysis or fuel cell devices.
H ₂ Production	Refers to the different means to produce hydrogen (electrolysis, biomass gasification, pyrolysis, etc.)
H ₂ Storage and Distribution	Refers to the methods used to store, transport and distribute hydrogen (e.g. storage in salt cavern, transport via pipelines, etc.)
H ₂ End-Uses	Refers to hydrogen usages in transport, industry, buildings or to generate power.
Regulations, codes, standards and safety	Refers to the applicable regulations and the harmonized performance-based standards for hydrogen appliances and systems, as well as the safe production, handling and use of hydrogen, particularly hydrogen gas fuel and liquid hydrogen.
Life Cycle and Social Assessment, eco-design, recycling	Refers to environmental and sustainability aspects of hydrogen.
Techno-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.

General information on hydrogen is the predominant topic, covered in 37% of courses (74 materials). Hydrogen end-use applications follow with 29% (57 materials). Regulations, codes, standards, and safety are addressed in 21% (41 materials), while hydrogen production is covered in 15% (30 materials). Hydrogen storage and

distribution accounts for 14% (27 materials). Other topics include basic electrochemistry (7%), techno-economic evaluation (7%), and life cycle and social assessment, eco-design, and recycling (5%).

Compared to 2025, the distribution of topics has remained relatively stable. General information on hydrogen and hydrogen end-use applications continue to be the leading topics, with their rankings reversed. General now at 37% compared

to 29% previously, while end-use applications decreased from 36% to 29%. Hydrogen production has increased from 11% to 15%, showing growing emphasis on production technologies.

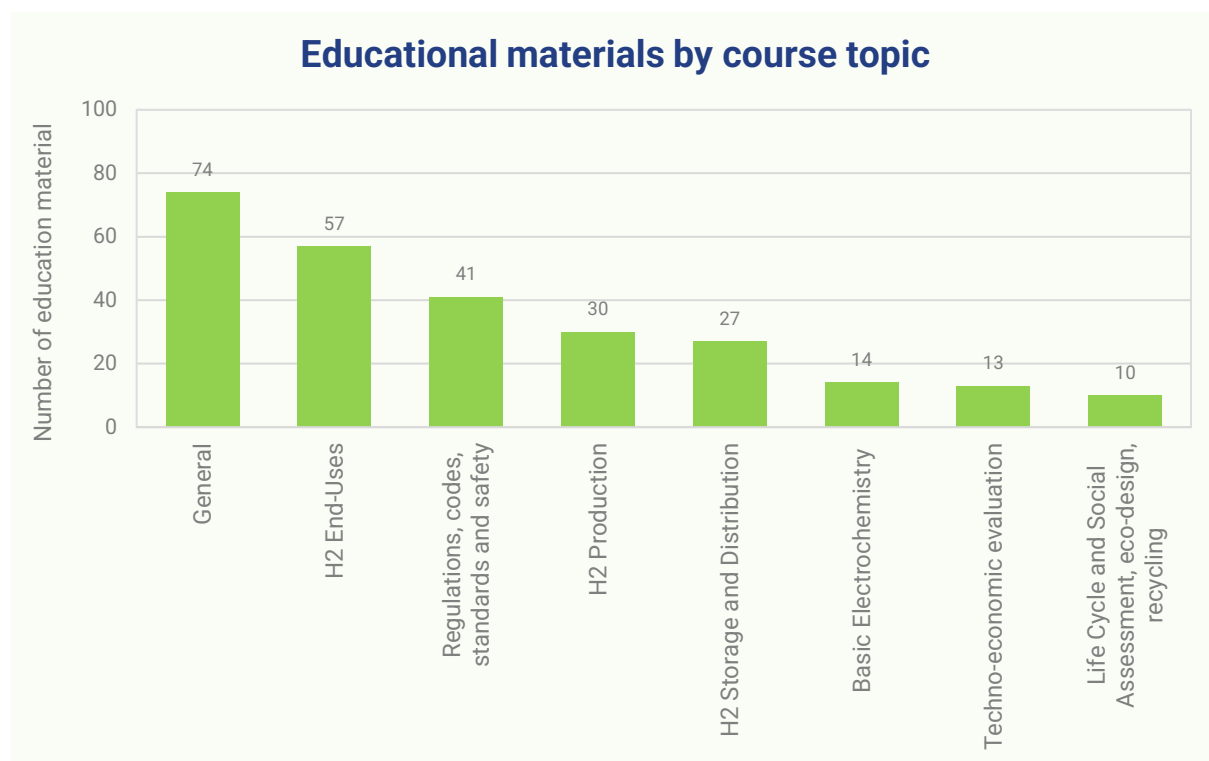


Figure 11. Educational materials available in the EHO library by topic.

2.2.3.

Education level

This section provides a comprehensive overview of educational materials, organized by the ISCED framework.

Figure 12 displays the number of educational materials categorized by ISCED level, ranging from level 1 to 8. The descriptions of each ISCED level are provided in the introduction of this chapter. It is important to note that many materials cover multiple ISCED levels, so the

counts reflect the total inclusion across these levels.

As illustrated in Figure 12, most of the materials are intended for audiences with higher levels of understanding. ISCED 5 is the predominant education level, targeted by 64% of the courses (126 materials). This is followed by ISCED 6, associated with 55% of the educational materials

(109 materials). Additionally, ISCED 7 is targeted by 37% of the materials (74 materials).

It is also worth noting that lower-level education is targeted in several courses. ISCED 2 and ISCED 3 each account for 17% (33 and 34 materials respectively), ISCED 4 for 13% (25 materials), and ISCED 1 and ISCED 8 for 2% and 10% respectively. These courses are often translated into different languages to ensure accessibility for various national audiences.

However, the educational materials available in the EHO library do not target early childhood

education (ISCED 0), as hydrogen-related topics are relatively complex and not yet suited for this age group.

Compared to 2025, there has been a notable shift in the distribution of education levels. ISCED 5 has become the predominant level, increasing from 49% to 64%, while ISCED 6 decreased from 66% to 55%. ISCED 7 also decreased from 53% to 37%, indicating a strategic reorientation toward mid-to-higher education levels rather than the most advanced levels.

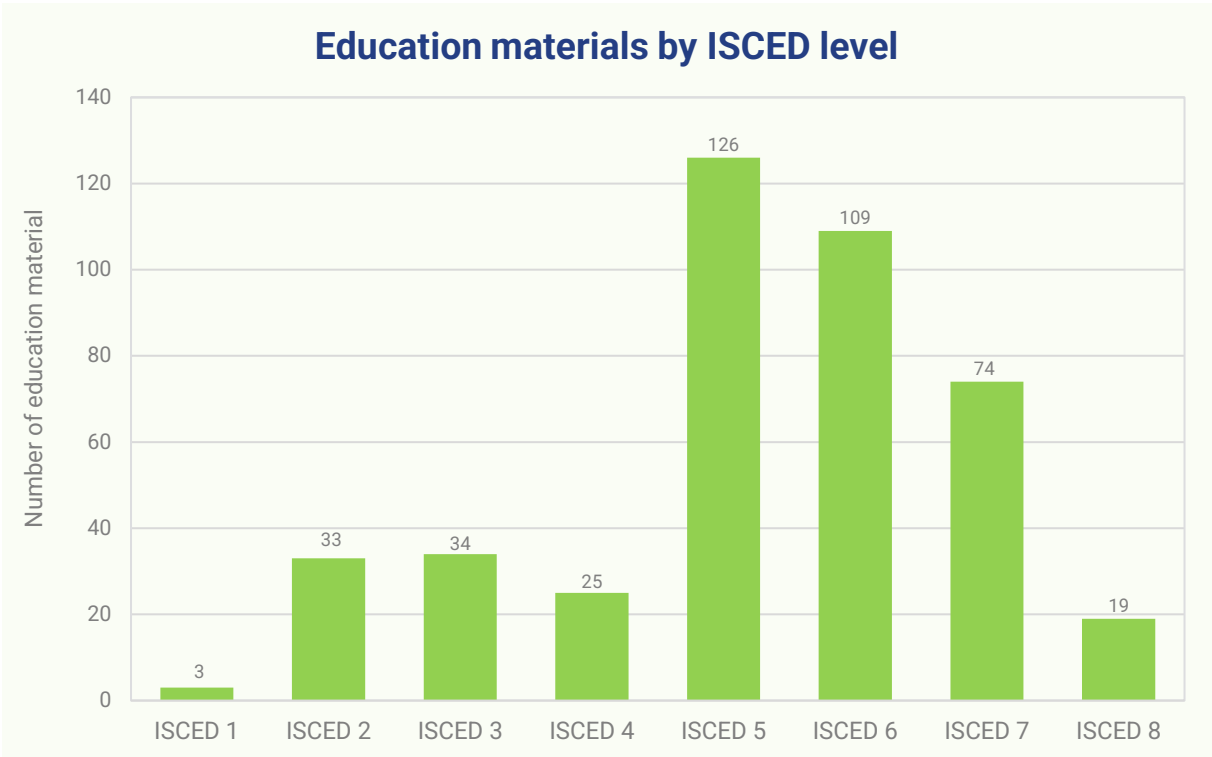


Figure 12. Number of education materials by ISCED level.

A large, stylized logo consisting of the letters 'O' and 'R' in a thick, yellow-green outline font. The 'O' is on the left and the 'R' is on the right, partially overlapping. The background is a solid green color with faint, larger-scale circular patterns in a lighter shade of green.

Research and
innovation activity

Introduction

This chapter provides an overview of trends and patterns in research and innovation activity in the hydrogen sector, using aggregated datasets of patent registrations and publications by country.

Data for patents and publications is sourced from [Tools for Innovation Monitoring \(TIM\)](#) supplied by the Joint Research Center in August 2026. TIM tracks publications from Scopus and patents from PATSTAT based on keywords. The data summarized from the TIM datasets encompasses patents and publications as of 2006 and will be updated annually. The data are categorized into three main topics: (1) fuel cells, which include Solid Oxide (SO), Proton Exchange Membrane (PEM), and alkaline technologies; (2) hydrogen production, encompassing SO, PEM, and alkaline electrolysis as well as other clean production methods; and (3) hydrogen storage, focusing specifically on onboard storage solutions. The TIM database covered only these hydrogen technologies, so for this reason no statistics are presented for e.g. other end-use technologies.

It is acknowledged that when conducting searches, duplicates may exist between the different TIM 'spaces' (categories) as for example, one patent or publication might cover both SO and PEM fuel cell technologies. Nevertheless, duplicates cannot exist within the same dataset and therefore we believe that the TIM data is an accurate way to portray trends in patents and publications within the hydrogen topic. Fractional counting is used to determine the number of patents and publications per country for patents filed and publications written by institutions from multiple countries.

For more information on hydrogen patent activity, we recommend the [‘Hydrogen patents for a clean energy future’](#) report of the IEA and EPO, which provides the most comprehensive and up-to-date global review of patenting trends in a broad range of technologies.

Interactive data dashboards on [patents](#) and [publications](#) can be accessed on the European Hydrogen Observatory website.

3.1.

Publications

3.1.1.

Overview

The scientific and technical literature on hydrogen spans a wide range of topics, reflecting the multidisciplinary efforts to harness its potential. Publications in this field highlight significant advancements in technologies such as electrolysis, fuel cells, and hydrogen storage materials. They also address the challenges and opportunities in scaling up hydrogen production, improving efficiency, and integrating hydrogen into existing energy infrastructures.

This dataset seeks to identify emerging research trends in the hydrogen sector.

A total of 113,162 publications worldwide have been identified from 2006 to 2026 in the fields of fuel cells, clean hydrogen production, and

hydrogen storage. This represents a 9.4% increase in just one year compared to the previous report covering publications up to 2025. Figure 13 illustrates the geographical distribution of these publications, focusing on Europe (EU27, EFTA, and UK) and the rest of the world, as well as the distribution of publications by topic.

Publications in Europe account for a smaller share of the global total, comprising 24,456 (22%). Within Europe, the predominant topic is fuel cells, which represent 65% of the publications, totalling 15,929. The remaining publications primarily focus on hydrogen production and in a small extent on storage.

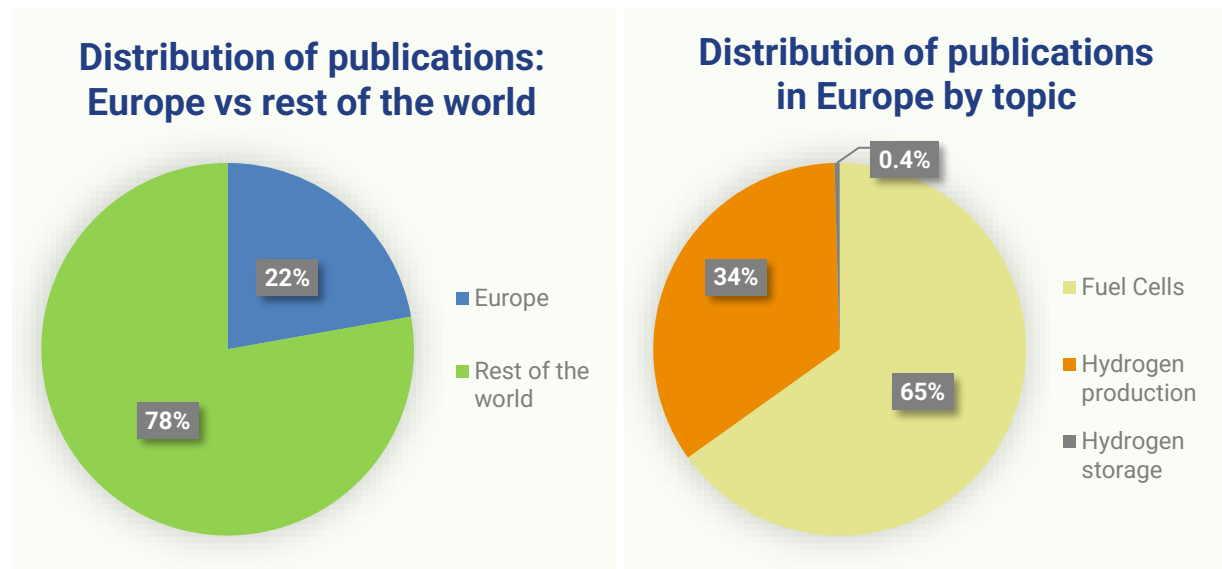


Figure 13. Geographical and topic distribution of publications from 2006 to 2026.

3.1.2.

Publications by topic and technology

Figure 14 presents the distribution of European publications since 2006 by selected topics and technologies. In fuel cells, PEM and SO technologies account for 31% and 29% of total publications, respectively, representing 47% and 44% within the fuel cell category. Alkaline technologies represent 5% of total publications. For hydrogen production, other clean methods

lead with 14% of total publications (39% within the hydrogen production category), while PEM and alkaline electrolysis account for 9% and 8% of total publications respectively. Regarding hydrogen storage, only publications related to onboard storage are included, accounting for 0.4% of total publications.

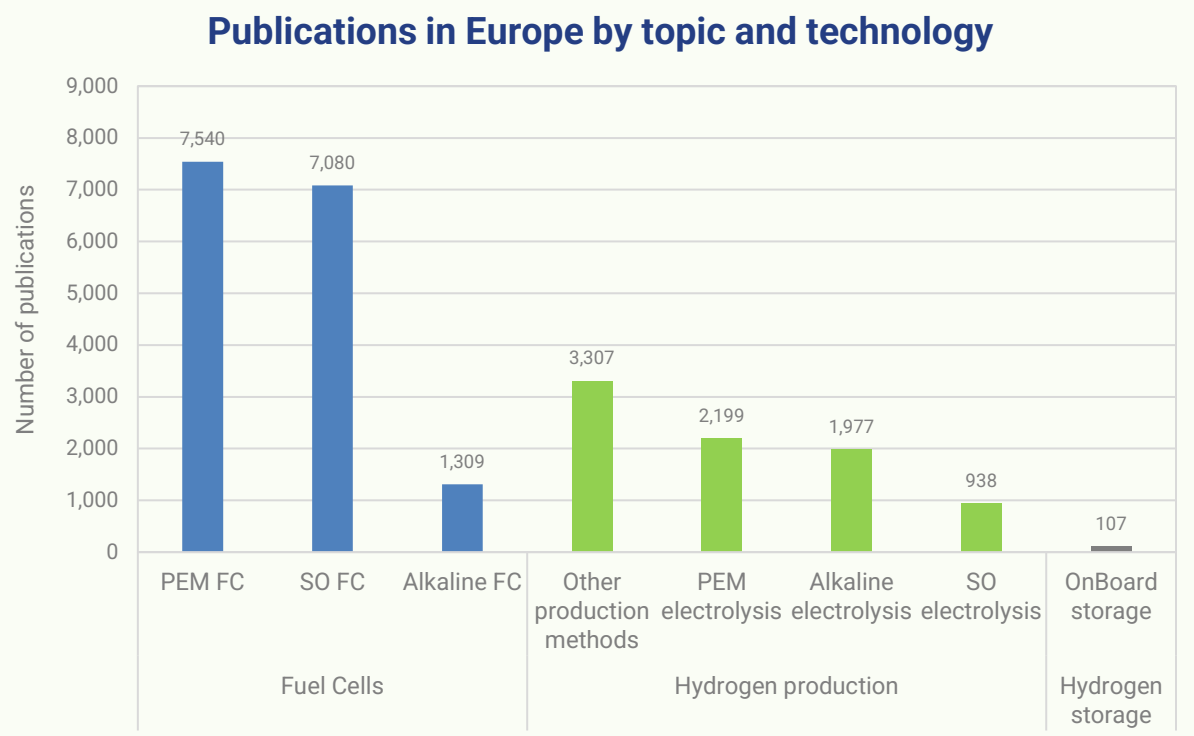


Figure 14. Breakdown of publications in Europe by topic and technology from 2006 to 2026.

Figure 15 presents the historical data on the number of publications for selected topics and technologies in European countries (EU27, EFTA, and the UK) from 2006 to 2025.

The data reveals a fluctuating pattern, with periods of growth followed by declines. However, an overall upward trend in publications can be seen, particularly from 2019 onwards, where significant growth is observed. Notably, from 2024 to 2025, the overall growth trajectory has stabilized, with total publications remaining relatively flat, suggesting a potential plateau in research expansion after years of sustained increase. When looking at the individual

technologies, especially a strong increase is observed in publications related to hydrogen production (alkaline and PEM electrolysis combined), while for fuel cells it remained more constant.

Fluctuations in hydrogen-related publications can stem from varying research funding cycles, technological advancements, policy changes, market dynamics, international collaboration, and media coverage. These factors collectively influence the level of research activity and publication outputs, shaping the observed trends over time.

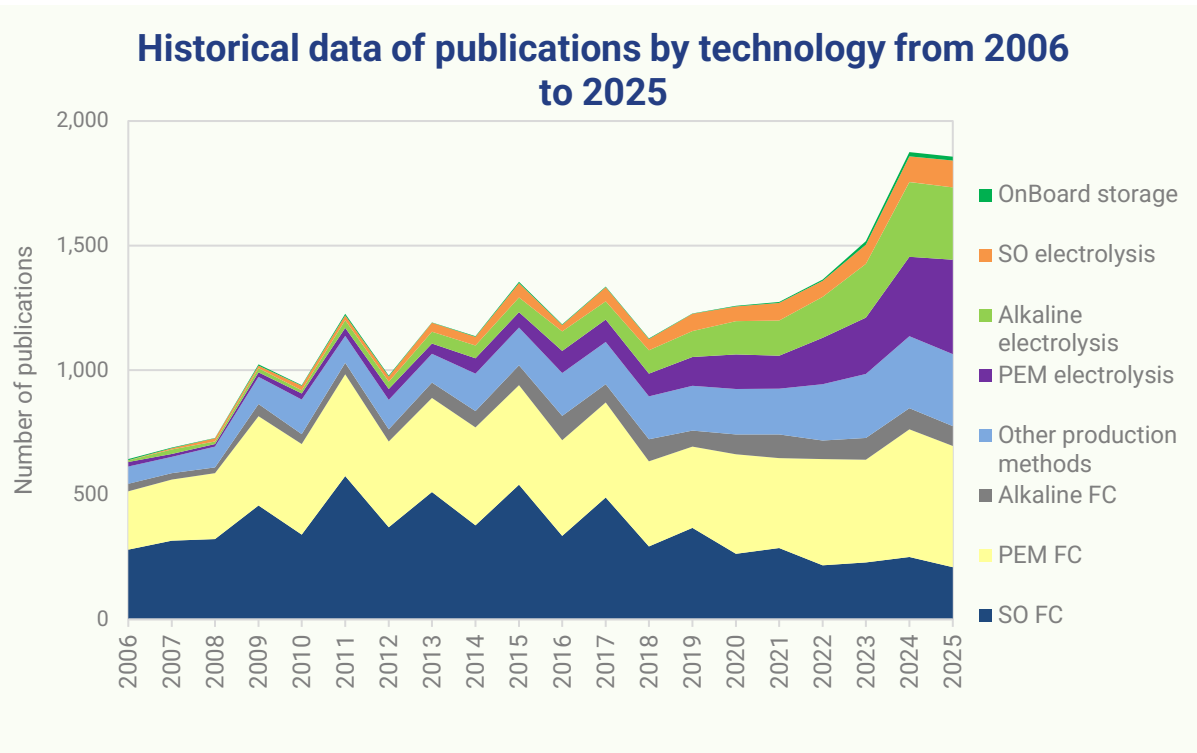


Figure 15. Historical data of publications in Europe by technology from 2006 to 2025.

3.1.3.

Geographical distribution

Figure 16 provides an overview of the geographical distribution of publications in Europe categorized by ranges of publication numbers, while Figure 17 details the number of publications per country and technology, covering the period from 2006 to 2026.

Germany stands out as the leading country with the highest number of publications (4,874), comprising 20% of the total mapped publications. Among the top ten countries with

the highest publication numbers are Italy (13%), France (12%), United Kingdom (12%), Spain (8%), Denmark (5%), Poland (4%), Switzerland (3%), Sweden (3%), and the Netherlands (3%).

The remaining countries collectively contribute less than 17% of the total publications. In most countries, Solid Oxide (SO) and Proton Exchange Membrane (PEM) technologies in fuel cells dominate the historic publication landscape.

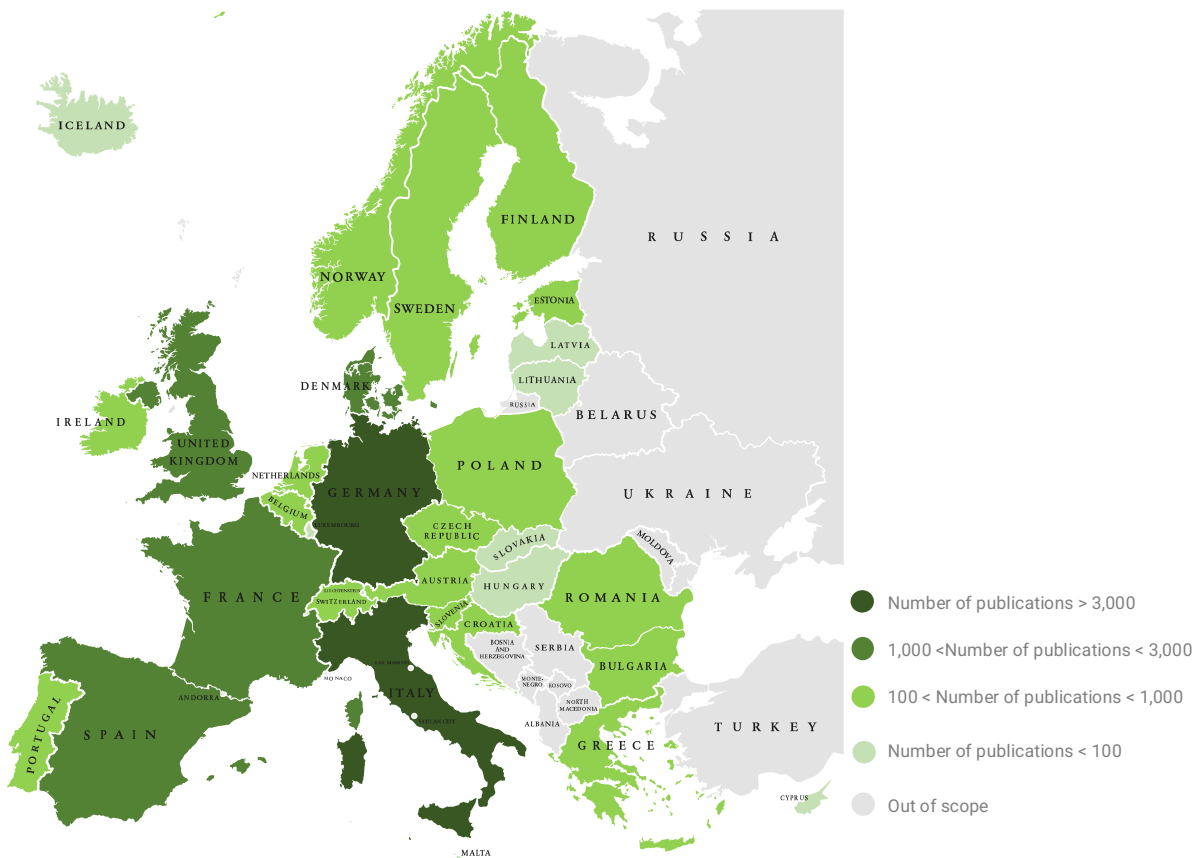


Figure 16. Geographical distribution of publications in Europe by ranges in the period 2006 - 2026.

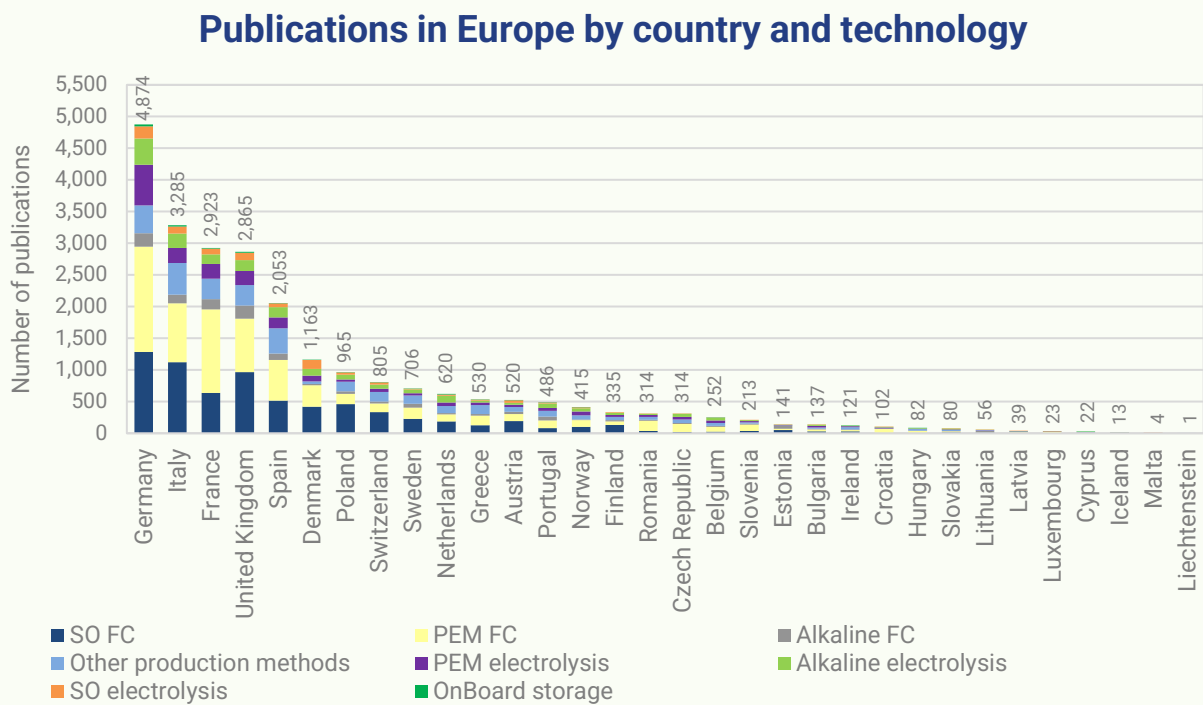


Figure 17. Number of publications by country and technology in Europe in the period 2006 - 2026.

Figure 18 illustrates the publication trends by examining the evolution in the top 10 countries with the highest number of publications over three consecutive five-year periods (2011-2015, 2016-2020, 2021-2025) by topic.

Out of the ten countries analysed, seven demonstrated an overall increase in the number of publications when comparing the periods 2011-2015 to 2021-2025. The Netherlands experienced the most significant rise with a 91% increase, followed by Germany with a 53% increase. Spain and Poland also recorded notable growth of 43% each, while Italy, Sweden, and the United Kingdom saw increases of 36%, 25%, and 22%, respectively. In contrast, Denmark, France, and Switzerland showed declines of 16%, 4%, and 1%, respectively, over the same period.

Distinct patterns emerged across the three time periods. Most countries that demonstrated consistent growth throughout the three periods showed acceleration in the final period, with the Netherlands, Spain, and Italy recording

particularly strong increases of 63%, 40%, and 30% respectively from 2016-2020 to 2021-2025. In contrast, the United Kingdom, France, and Switzerland experienced initial declines before recovering in the final interval. Denmark remained on a declining trajectory throughout both periods, while Sweden showed minimal change initially before achieving substantial growth of 25% in the final period.

A significant shift in research focus is evident across all countries. Fuel cells, which dominated publications in 2011-2015, have declined or stagnated in most countries. Conversely, hydrogen production publications have surged, particularly from 2016-2020 onwards, with countries like Spain, Germany, Italy, and the United Kingdom now publishing more on hydrogen production than fuel cells. This transition reflects a fundamental reorientation of research priorities toward hydrogen production technologies.

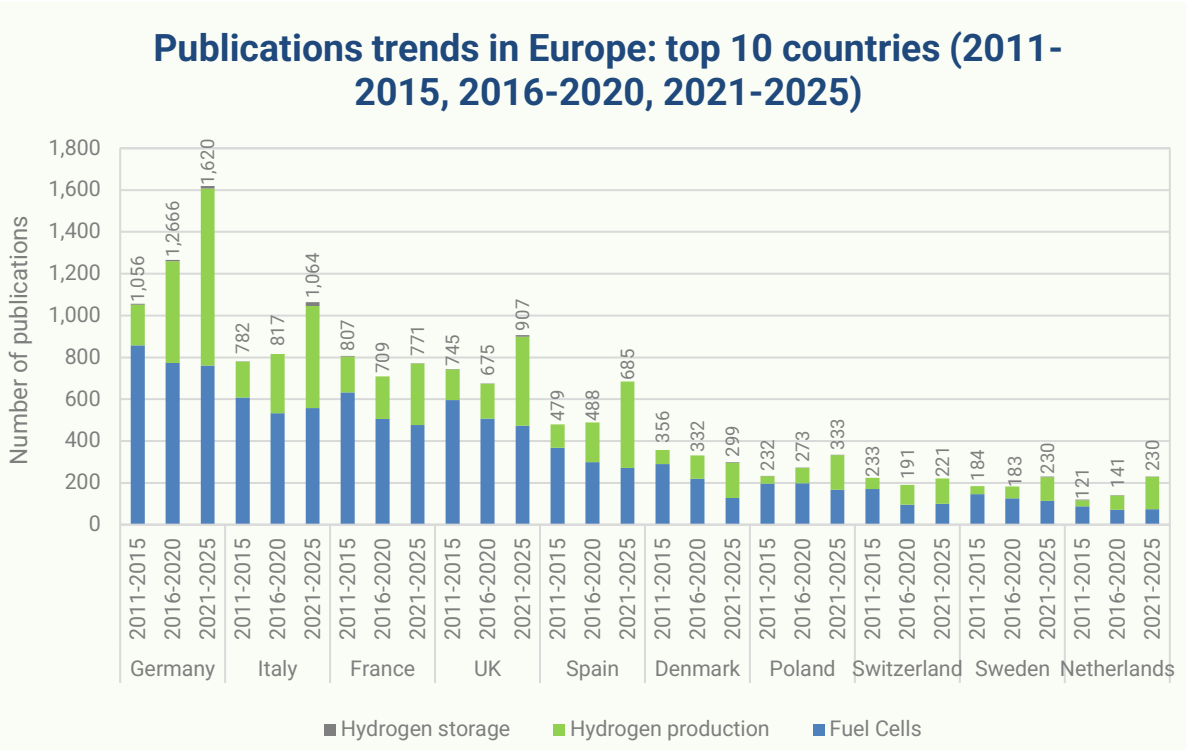


Figure 18. Publications trends in the top 10 countries over three consecutive five-year periods (2011-2025).

3.2.

Patents

3.2.1.

Overview

Patents are monopoly rights granted by Patent Offices in respect of inventions which are new, inventive, and industrially applicable. Patents are territorial and are granted by individual national or regional patent offices in respect of those territories. As such, the geographical extent of filing of a patent application is an indicator of the perceived value an inventor has for the underlying invention.

Almost all countries around the world have adopted a 'first-to-file' system which awards the first inventor to file a patent application at a Patent Office. This means that inventors are encouraged to file patent applications early in the research and development process and, because of this, patent filing statistics are a significant marker of research and development activity. For many inventions patents are the only source of

published technical information relating to the underlying principles upon which an invention is founded.

Patent applications are published approximately eighteen months after filing. In many cases this is the first time the public can see information relating to the invention.

The mapped patent data show the number of inventions in the fuel cell, clean hydrogen production, and hydrogen storage sectors. These numbers are broken down by technology type and year of application, offering a detailed view of innovation trends. By focusing on these specific sectors, the data illustrate the areas where patent registrations are concentrated, revealing the global priorities in developing sustainable energy technologies. This analysis highlights the progress and research efforts in different

countries to advance cleaner energy solutions over time.

A total of 17,116 patents worldwide have been identified from 2006 to 2025 in the fields of fuel cells, clean hydrogen production, and hydrogen storage. This represents a 14% increase in just one year compared to the previous report covering patents up to 2024. Figure 19 illustrates the geographical distribution of the patent registrations related to the hydrogen topic, focusing on Europe (EU27, EFTA, and UK) and the rest of the world, as well as the distribution of patents by topic.

Patent registrations in Europe account for a small share, comprising 1,317 registrations (8%) from 2006-2025. Within Europe, the predominant topic is fuel cells, which represent 69% of the patents, totalling 908 registrations. The remaining patents are primarily related to hydrogen production.

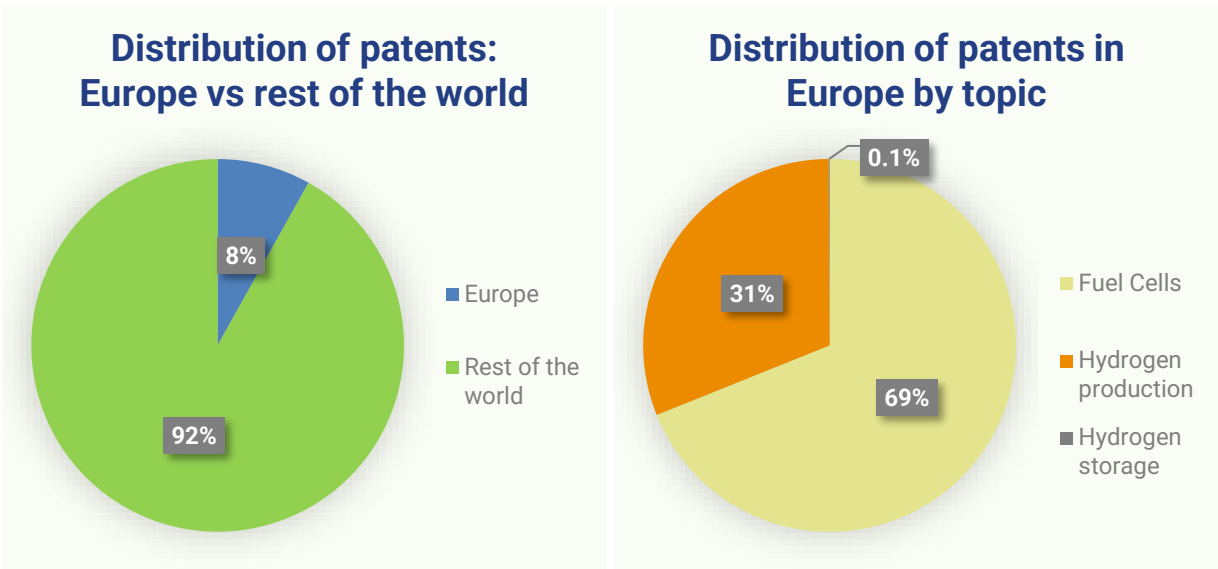


Figure 19. Geographical and topic distribution of patents from 2006 to 2025.

3.2.2.

Patents by topic and technology

Figure 20 presents the distribution of European patents registered since 2006, categorized by selected topics and technologies. In the field of fuel cells, the majority of patents are related to PEM technology, which represents 37% of the total patents and 54% of the patents specifically on fuel cells. The remaining patents in this category are mainly related to SO and in a lower extent to alkaline technologies, totalling 373 and 49 patents, respectively.

In the area of hydrogen production, most patents focus on alkaline electrolysis technology, which accounts for 11% of the total patents and 36% of the patents specifically on hydrogen production. The remaining patents in this category are related to PEM electrolysis, SO electrolysis, and other production methods, totalling 136, 70, and 56 patents, respectively.

Regarding hydrogen storage, only patents related to onboard storage are included, accounting for <0.1% of total patents.

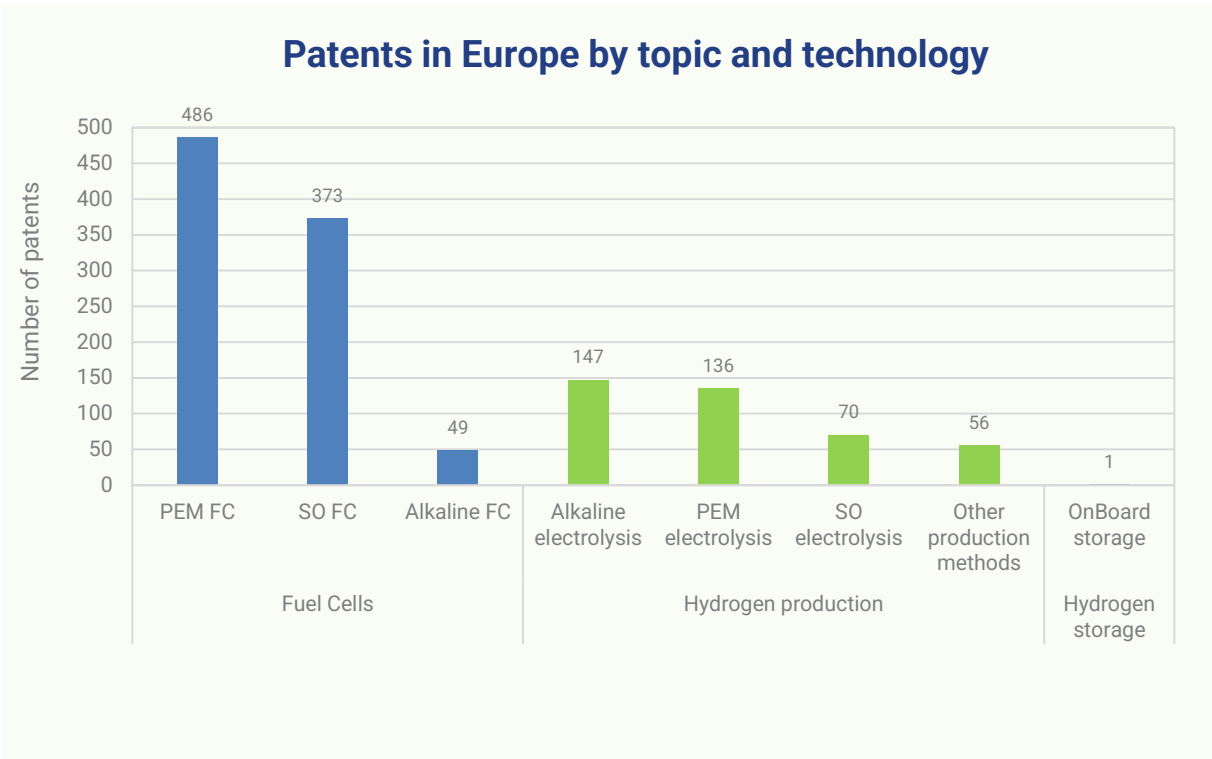


Figure 20. Breakdown of patents by topic and technology in the period 2006-2024.

Figure 21 presents the historical data on the number of patents for selected topics and

technologies in European countries (EU27, EFTA, and the UK) from 2006 to 2024.

Overall, there was a declining trend in patent activity, especially for fuel cell technologies, up to 2018, after which again an increasing trend is observed in the most recent years. Notably, there are four peaks in 2007, 2012, 2017, and 2023, with 93, 93, 56, and 136 patents respectively.

The sharp drop in the number of patents in 2024 can be attributed to the delay in the patent publication process. Patent applications are published at the earliest eighteen months after filing, resulting in a delay in their appearance in the database. Consequently, data for 2024 is not yet complete.

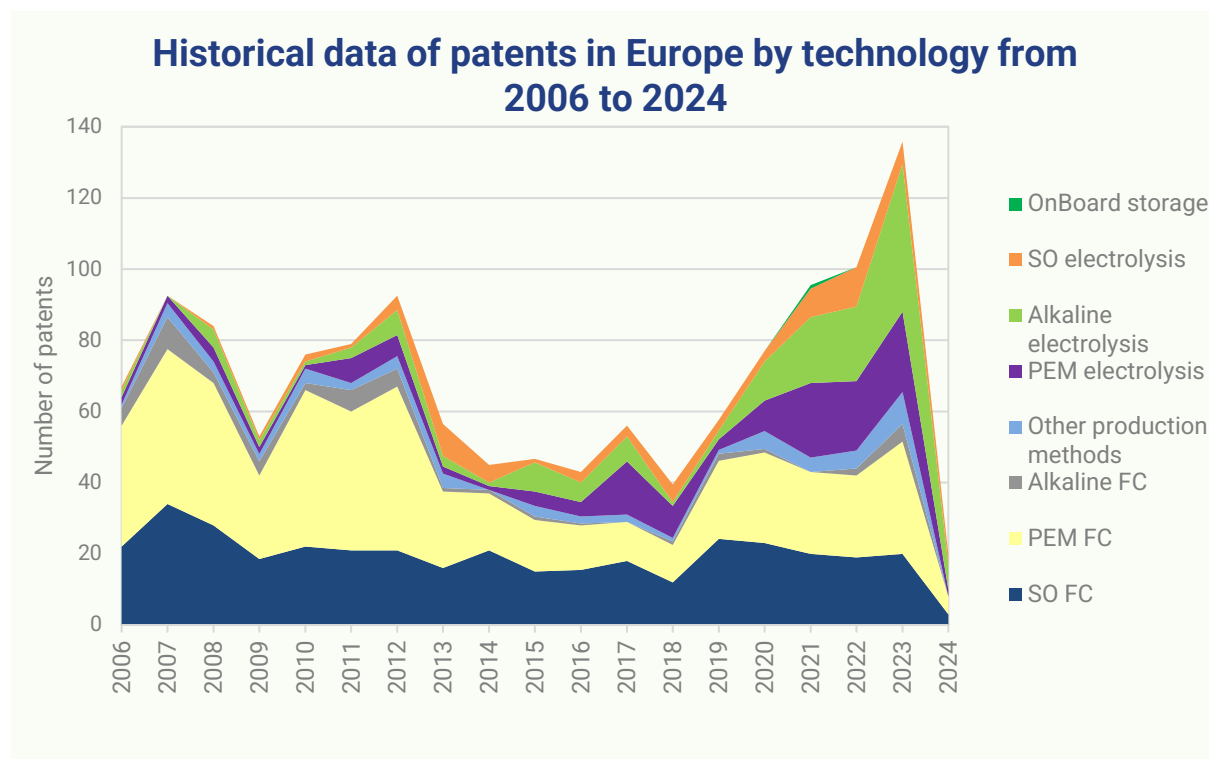


Figure 21. Historical data of patents in Europe by technology from 2006 to 2024.

3.2.3.

Geographical distribution

Figure 22 provides an overview of the geographical distribution of patents categorized by ranges of patents numbers, while Figure 23 details the number of patents per country and technology, covering the period from 2006 to 2024. Germany leads with 503 patents, representing 38% of the total. Among the top ten

countries, France holds 18%, the UK 10%, Denmark 9%, Italy 5%, the Netherlands and Spain each contribute 3%, while Austria, Belgium and Switzerland each contribute 2%. The remaining countries collectively contribute less than 8% of the total registrations of patents. In most countries, Solid Oxide (SO) and Proton Exchange

Membrane (PEM) technologies in fuel cells dominate the patent landscape.

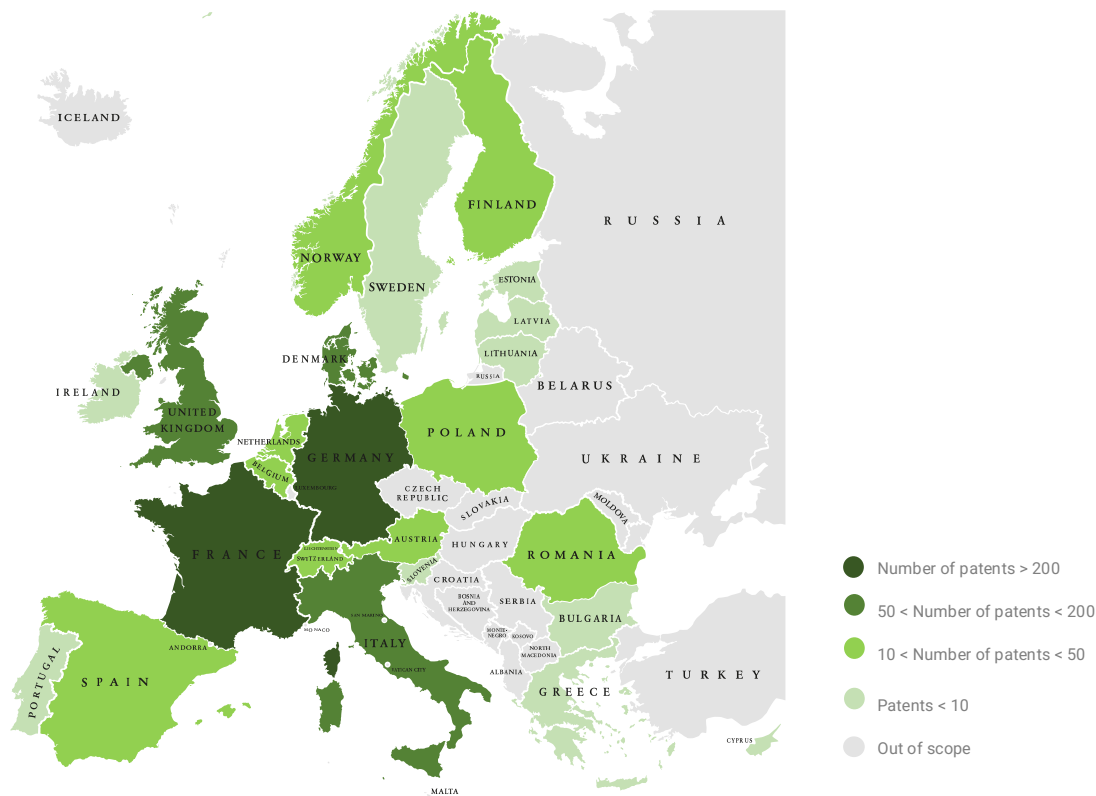


Figure 22. Geographical distribution of patents by ranges.

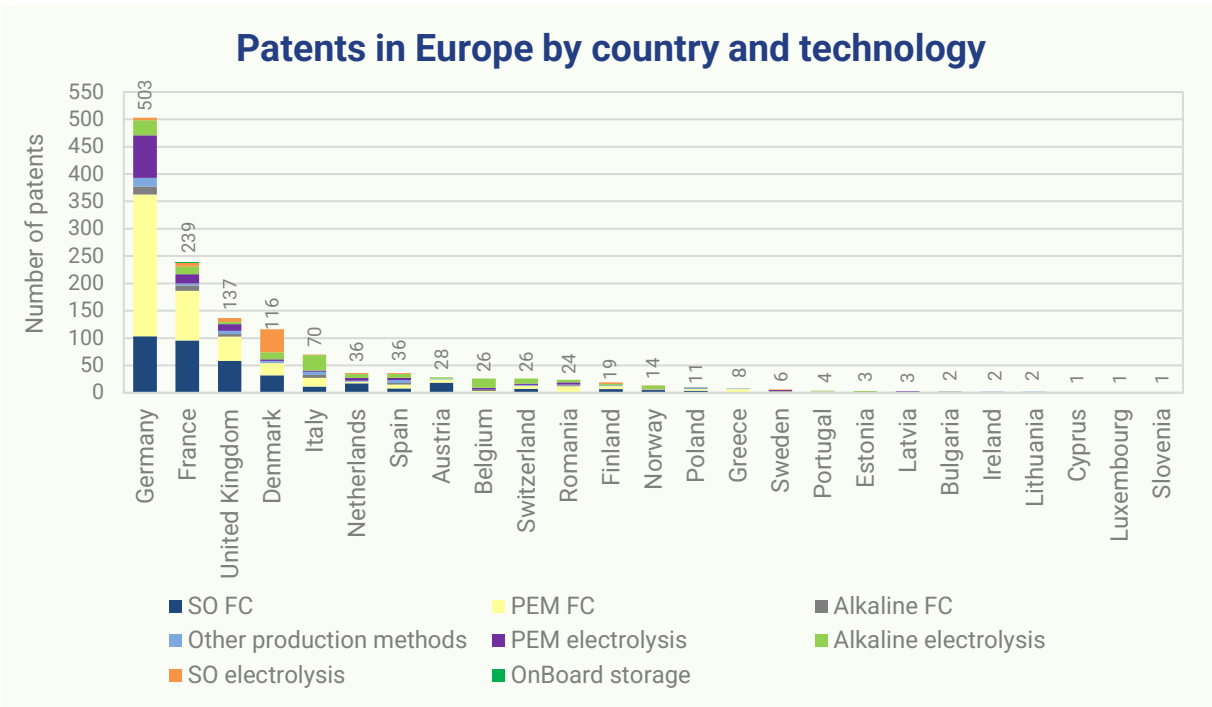


Figure 23. Number of patents by country and technology in Europe.

Figure 24 illustrates the patents trends by examining the evolution of their numbers in the top 10 countries with the highest number of registrations over three consecutive five-year periods (2009-2013, 2014-2018, 2019-2023).

Out of the ten countries analysed, nine demonstrated an overall increase in the number of registrations when comparing the periods 2009-2013 to 2019-2023. The most significant growth was observed in the Netherlands, Belgium, and Italy, each recording increases of over 100%. In contrast, Germany saw a decline in patent registrations, with a 6% decrease over the same period.

However, distinct patterns emerged across the three time periods analysed.

Half of the countries under examination experienced a decline in patent registrations between the first and second periods. Belgium showed the largest decrease at 83%, followed by Spain (78%), Germany (65%), the United Kingdom

(15%), and France (14%). In contrast, Italy, the Netherlands, and Austria reported increases during the same period, with growth rates of 70%, 200%, and notable new activity respectively. Denmark remained relatively stable across the two periods, with a marginal increase of 3%, while Switzerland recorded no significant change.

From the second to the third period, all countries demonstrated growth in patent registrations. Belgium showed the most substantial increase at 1800%, followed by Spain at 450%. The United Kingdom, Germany, and the Netherlands each achieved growth exceeding 100%, with increases of 183%, 172%, and 150% respectively. Austria recorded growth of 78%, while Italy, Switzerland, and France showed more modest increases of 47%, 29%, and 22% respectively. Denmark experienced the smallest growth rate at 9%

Similar to publications, recent years have also seen growing interest in hydrogen production in patent activities.

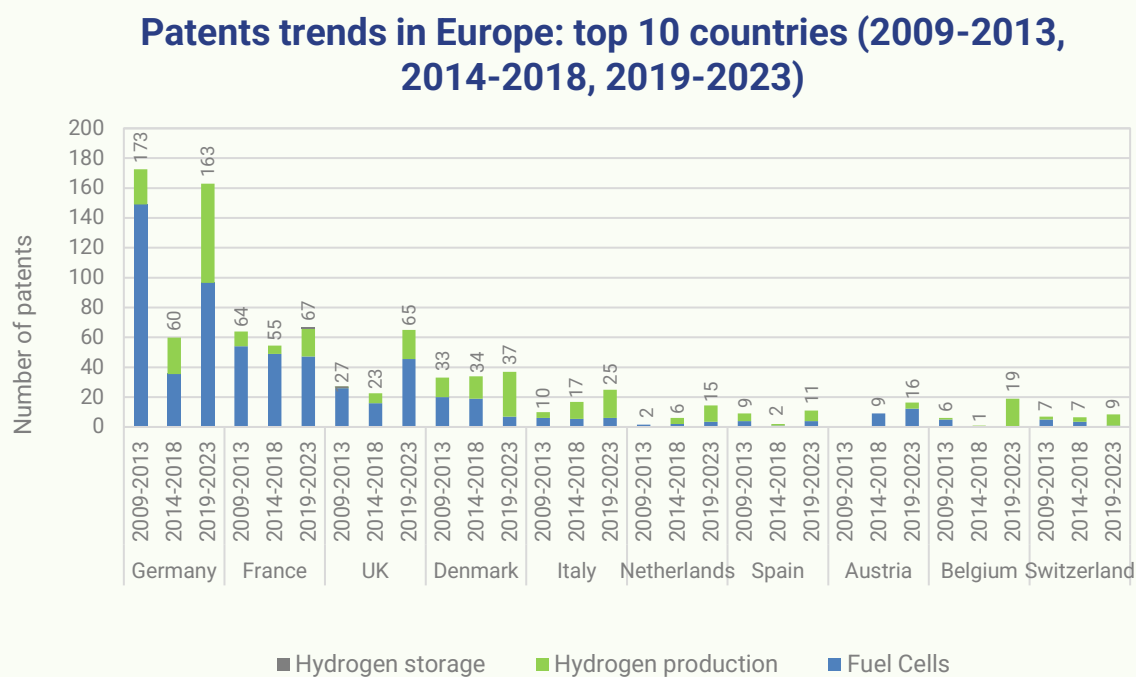


Figure 24. Patents trends in the top 10 countries over three consecutive five-year periods (2009-2023)³.

³ Data from 2024 were limited and therefore excluded.

Conclusions

The purpose of this report is to provide a comprehensive overview of the latest statistics covering the hydrogen education and research landscape, encompassing training programmes, educational materials, publications, and patents in the hydrogen sector. This is the third report released following the relaunch of the European Hydrogen Observatory, which introduced a more focused scope by narrowing its attention exclusively to developments within the EU. By focusing on the EU, the Observatory enables a more detailed and targeted analysis of regional progress in hydrogen research and education, thereby supporting more effective policy-making and strategic planning to advance the hydrogen economy across the region.

Training programmes

A total of 327 training programmes are listed in the Observatory's online library, reflecting an increase of 66 programmes since 2025 (+25%). On the programme level, master's and professional training programmes, represent the largest segments among the registered training programmes, accounting for 45% and 37% of the total.

The registered training programmes are offered in 14 different languages, with English being the primary language in most programmes. The European Hydrogen Observatory maps 21 European countries, with France leading in the number of training programmes offered.

"Hydrogen End-Uses: Transport", "Hydrogen Production" and "Hydrogen Storage, Transport and Distribution" remain the predominant subjects among the 11 categories, each being covered in approximately 70% of the training programmes.

Education materials

The EHO online library contains 198 reliable materials reflecting a decrease of 47 materials since 2025 (-19%) as some materials were no longer available from their original sources and were consequently removed from the library. The highest number of materials were released in 2024, totalling 54, while the fewest materials were released between 2015 and 2018, with fewer than five materials released each year. Educational materials in 16 different languages are currently listed in the EHO library. English is the predominant language, available for 81% of the materials.

General information on hydrogen is now the predominant topic, covered in 37% of the materials. Hydrogen end-use applications is the second most common topic, included in 29% of the materials. The majority of the materials are intended for audiences with higher levels of understanding, specifically levels 5 and 6, which correspond to short-cycle tertiary education and bachelor's levels.

Research and innovation activity

Publications and patents registrations in Europe (EU27, EFTA and UK) account for 22% and 8% of those identified worldwide respectively, in the fields of fuel cells (PEM, SO and alkaline), clean hydrogen production (PEM, SO, alkaline and other production methods) and hydrogen storage (onboard storage) from 2006 to 2026. Overall, there is an increasing trend in publications, while patent activity declined until 2018, particularly in fuel cell technologies, and has been increasing again in recent years.

In Europe, fuel cells dominate the research landscape, accounting for 65% of publications and 69% of patents. However, this prominence was more pronounced in earlier years. Recently, there has been a notable shift towards increased activity and a growing emphasis on publications and patents related to hydrogen production. This trend indicates a broadening of the research focus, highlighting the rising recognition of hydrogen production alongside fuel cell technologies.