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EMR H_2-Booster roadmap study

Current state of the hydrogen economy in the Euregio Meuse-Rhine (EMR)

STUDY REPORT

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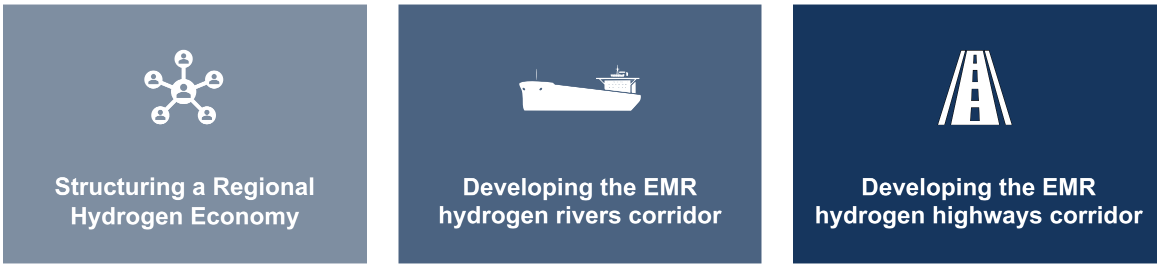
Executive Summary

This study was part of the EMR H_2 Booster programme, which to boost the hydrogen economy in the Euregio Meuse-Rhine (EMR). The objective was to provide a vision for the deployment of a hydrogen economy in the region and make a series of key recommendations.

The first conclusion is that there is no EMR H2 Booster without hydrogen, and it is therefore key to focus on the most efficient ways to bring rapidly large amounts of hydrogen in the region to make it a EU leader in this field, namely hydrogen pipelines. The region is indeed very energy-intensive but with limited renewable potential, thus largely dependent on imports for its energy supply. All North Sea ports are currently organizing themselves to be entry points for the import and supply of large amounts of hydrogen to the BeNeLux and Germany. These imports will come from productions in the North Sea, Norway, the UK, but also the arrival of hydrogen-derivatives produced in Africa, Middle East, North and South America. Hydrogen pipelines are already planned by European TSOs to transport large quantities of hydrogen from these import hubs towards the hinterland. The EMR is an interesting offtake point but between the coasts of Belgium, the Netherlands and Germany, and the triangle of the Meuse and Rhine River, industrial hubs around ports (Antwerp/ Rotterdam / Hamburg) and large industrial areas (ex the Ruhr Region) will certainly first be served unless the development and speed of deployment of new hydrogen pipeline will allow to have equal priority for offtakes in the hinterland.

During the study we talked to the major three players, Fluxys, Gasunie and OGE involved in this work, but we recommend that there is further political action at the top to make the deployment of these pipelines across regions and borders a top priority.

On the offtake site, the study highlighted **3 main pillars for the deployment of a hydrogen economy in the EMR: heavy-duty transport, inland waterway transport, and interactions between small and medium-sized enterprises (SMEs).**



1. *Heavy-Duty Transport:*

The study emphasizes the importance of deploying hydrogen infrastructure quickly, particularly H2 corridors of HRS (Hydrogen Refuelling Stations). Aligning decision-makers and homogenizing support for hydrogen supply infrastructure and hydrogen vehicles will facilitate the adoption of hydrogen heavy-duty transport.

2. *Inland Waterway Transport:*

Transporting hydrogen via waterways presents a limited option in terms of volumes, even though hydrogen can be transported pure and as derivative (like methanol). However, the geographic correlation between the rivers system and the planned H_2 gas network suggests pipelines will be the preferred solution to provide hydrogen for mobility, and even that the pipelines network will be able to support the adoption of hydrogen propulsion for inland vessels. The Meuse/Rhine ecosystem is the most active one in Europe, accounting for more traffic than the rest of Europe combined.

Hydrogen will be a key pillar for decarbonising the inland vessels, and the EMR has an opportunity for building an ecosystem of competences to become a leader in H_2 inland waterway transport, following three angles: developing projects, developing competencies, and tomorrow exporting them.

Both working on developing a hydrogen highway corridor and a hydrogen rivers corridor are essential tasks to build on the core strengths of the EMR territory.

3. *Interactions between SMEs:*

The study underscores the need for improved interactions between SMEs in the EMR of the hydrogen ecosystem and further interactions to be built also with competence centres. Bringing together members from different hydrogen associations and mapping the existing members along value chains can enhance visibility and facilitate subsequent collaborations. This will enable stakeholders to realize the richness of the regional ecosystem, discover new partners, and source closer to home. During the study we identified a successful collaboration model in North Rhine-Westphalia, where SMEs and R&D centres work together. We strongly encourage this model to be further developed at the EMR level.

It is essential that a real community gets developed and meets on a regular basis to work along these different axes, along with a political support to strengthen this community. The "Francorchamps Hydrogen Initiative" this April 2023 was the founding stone of this dynamic and should be continued.

Context

General Context

Policy makers across all borders of the EMR have recognized the importance of hydrogen for the sustainable development of their economies.

The Netherlands already mentioned the molecule in the "Climate Agreement" and the "Programmatic Approach to Hydrogen for the Energy Transition" of 2019, before publishing a national Hydrogen Vision in March 2020. The vision document indicates both the environmental benefits of hydrogen as well as the economic opportunities for the Netherlands to serve as a trading hub for this internationally traded commodity to be. In July 2021, the workplan of "Nationaal Waterstof Programma" (National Hydrogen Programme) was presented, to be further defined in a program plan later this year.

Germany presented its Hydrogen Strategy in June 2020, immediately accompanied by a budget of 9 billion euros. The German government expects a demand of between 90 to 110 TWh in 2030, a significant part of which will have to be imported from regions with more plentiful renewable resources to produce this amount of hydrogen. In November 2020 the national strategy was followed-up by a regional strategy from the State of North Rhine-Westphalia (NRW), the Hydrogen Roadmap. It puts an emphasis on employing hydrogen as a tool to make NRW a viable industry and business location for the future and names international co-operation with the neighbouring countries as a priority.

Also, the European Commission published a dedicated Hydrogen Strategy. The document outlined hydrogen as a key element of a cost-effectively decarbonized energy system which should primarily be used to decarbonise hard-to-abate sectors, such as industry, heavy duty transport or shipping.

In Belgium, hydrogen was mentioned in the coalition agreement of September 2020, indicating the ambition to be a forerunner on the topic. Several policy letters have also confirmed high ambition. A national hydrogen strategy was published in October 2022, with a five-step plan towards growing the role of a hydrogen in Belgium's economy. The Flemish Hydrogen vision dates from November 2020, and was reinforced by the creation of a "Hydrogen Taskforce". In Wallonia a number of roadmaps for various sectors were published in July, including the "Stratégie de Spécialisation Intelligente S3" dedicating a whole section to hydrogen. Also, a strategic hydrogen document is in the making and a call for projects is ongoing. During the course of this study (13/10/2022), WaterstofNet and Cluster TWEED also announced the creation of a Belgian Hydrogen Council gathering the major players in Belgium to facilitate cooperation at a national level which kick start event took place on March 17th of 2023.

The EMR H2-Booster project

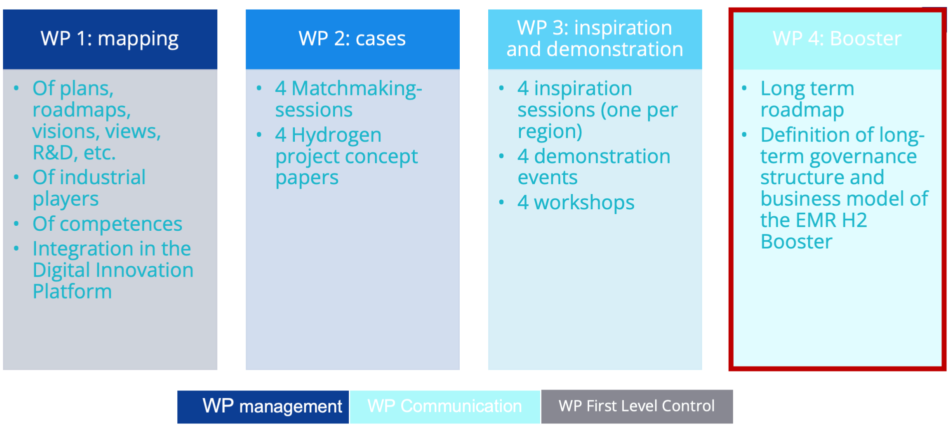
The EMR H2-Booster project contributes directly to all the forementioned visions and strategies as it aims to boost the development of a hydrogen economy in the EMR. By bringing together the regional expertise of the partners of this project, identifying cross-border opportunities in a wholistic manner, and communicating about the existence of both of these locally, the implementation of more tangible and valuable hydrogen projects in the region will be accelerated in line with the ambitions of the forementioned documents.

The EMR-H2 Booster project aims thus to boost the development of clean hydrogen innovation, demonstration and knowledge sharing in the Euregio Meuse-Rhine, as a first step towards the large-scale roll-out of a clean hydrogen economy in the region.

The project was initiated by 9 partners joining forces to achieve this ambition: Stadt Aachen, LIOF, POM Limburg, Cluster TWEED, SPI, IHK Aachen, Universiteit Hasselt, Waterstof Coalitie Limburg, and WaterstofNet who coordinates the project, and Regio Parkstad as an associated partner.

It is co-financed by the European Union through the EU Interreg programme, which aims to facilitate interregional and cross-border collaboration. The total budget of the project is 1.065.066,13€, of which half it is financed by the Interreg subsidy.

This report summarizes the conclusions identified during this study, which constitutes the 4th Work Package of the EMR H2 Booster project, out of its 4 work packages:



Objectives of the study

The main objective of this mission is to produce a detailed report that clarifies the strategic axes of the hydrogen economy in the EMR territory, specifically focusing on H2 mobility corridors and collaboration between SME's. The target is to provide the 9 partners of the project with a vision on areas to work on to increase cross-border collaboration, and an action plan to boost synergies and kick-start the hydrogen economy in the region.

The objectives were divided into 6 phases:

1. Gather a global view of H2 production and use: in terms of quantities, origins, and destinations, as well as timeline of implementation
2. Focus on large projects
3. Focus on mobility applications
4. Focus on political context
5. Animate a workshop focused on mobility
6. Roadmap & action plan for the EMR consortium

Interviews and Methodology

Before the beginning of study, our consortium got familiarized with the knowledge acquired in the 1st Work Package, compiled in two deliverables:

- Deliverable 1A: Mapping of regional strengths in the field of green hydrogen
- Deliverable 1B: Mapping of industrial players in the field of green hydrogen

Interviews

After getting a grasp of the characteristics of the region, the first step was to conduct a series of interviews of all the key players to gather an understanding of the current state of play in the EMR.

The first objective of the interviews was to develop a global view of H2 production and uses, in terms of quantities, origins and destinations, as well as the timeline of their implementation. This global view, and first phase of the study, had two specific focus points: what to expect on the mobility side (1), and which hydrogen interactions of the EMR with the neighbouring regions in Belgium, the Netherlands and Germany (2).

Interviews were organized around four phases:

During a first series of interviews our consortium quickly came to the conclusion that while there is a strong potential for hydrogen consumption/demand in the region, there are in fact only a few options to get a supply of hydrogen at scale, the main one being via the development of hydrogen pipelines.

We then launched a series of three structured interviews of players ranked by type, as the following chart shows it:

Phase 2: Large projects focus	**Phase 3: Mobility focus**	**Phase 4: Politics focus**
• Energy companies • Industrial sites • Pipeline operators • Equipment suppliers • Ports / Airports	• Trucks • Buses • Barges • Users & Manufacturers	• Public authorities • Economic agencies • Partners to EMR H2 Booster
20 players max	*10 players max*	*4 players max*

The second phase of the project was thus emphasized on the identification of **large projects**, especially large-scale hydrogen production projects and import projects. Key actors were interviewed in the following areas of the hydrogen value-chain:

- Energy companies: Eoly, Engie
- Industrial sites: Chemelot (through WaterstofNet & Gasunie)
- Pipeline operators: Fluxys, OGE, Gasunie, Air Liquide
- Ports/Airports: Liège Airport (SPW), Port of Antwerp (as import hub)

While interviewing these key actors, a conclusion quickly arose that very few projects aimed to produce hydrogen in the region, and thus that **imports** would be a major element to deploy the molecules in the area. A strong emphasis was put during this phase to interview the key players in hydrogen imports (gas TSO's, maritime port, energy companies).

These interviews were followed by a focus on **mobility projects**, mainly targeting heavy mobility: trucks, buses, and inland waterway barges. Users and equipment manufacturers were consulted as well:

- Inland waterway key players: CCNR (Central Commission for the Navigation of the Rhine), Port Autonome de Liège, Port of Antwerp (as an inland waterway actor), De Vlaamse Waterweg
- Heavy duty trucks: HyTrucks (Waterstofnet)
- Equipment manufacturers: John Cockerill

Additionally, the partners of the consortium were interviewed as well to gather their vision on the deployment of hydrogen and their knowledge of the projects being carried on their territory.

- Belgium: Cluster TWEED, Service Public Wallonie (SPW), SPI, POM Limburg, Waterstofnet
- Netherlands: WaterstofCoalitie Limburg, Waterstofnet
- Germany: IHK Aachen (Industry and trades chamber)

Lastly, R&D players were interviewed as well:

- iGas (German R&D SME)

The following chart gives an overview of all the players interviewed.

Industrial actors & Hydrogen producers | Gas network operators | Waterways actors | Public entities & clusters | R&D players

Highway actors

Note: some interviews were conducted under an NDA. While the insights provided by confidential information helped sharpen the conclusions of the study, all the information shared in this study is public.

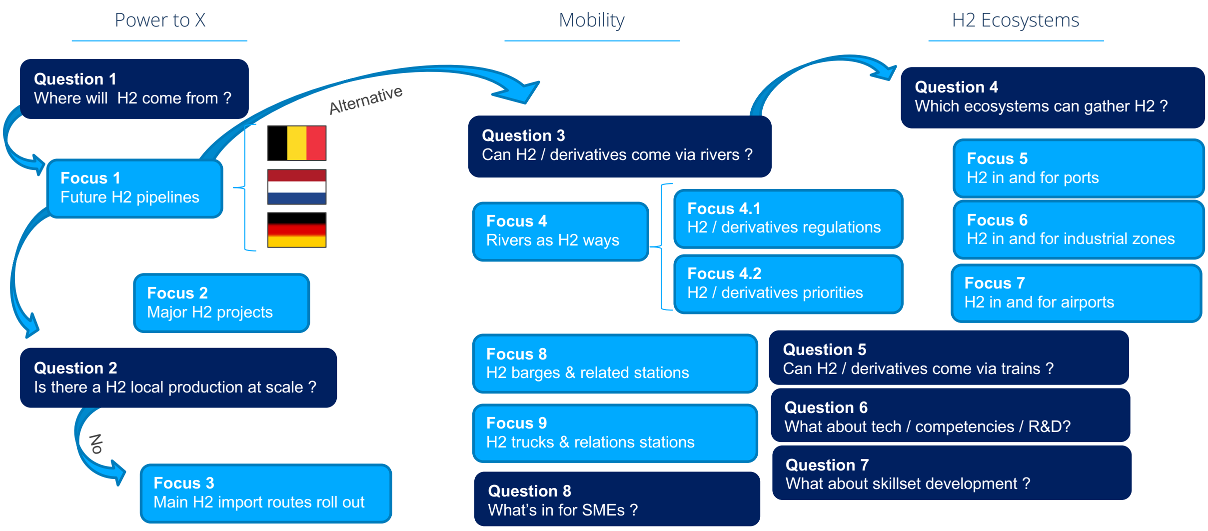
After all the interviews were conducted, a webinar was organized on March 16th of 2023, where the first conclusions of the study were shared, and a summary of the study was presented as well at the Spa Francorchamps event, hosting the "Francorchamps Hydrogen Initiative".

The main conclusions of the study and recommendations were then additionally shared at the final event of the EMR H2 Booster in Genk on 22 May 2023.

Methodology

The interviews we conducted with very precise ideas in mind and following a pre-set order.

The first question to ask was "where does the hydrogen come from?". This quickly led us to focus on the importance of imports and the main import routes. As a parallel question we wondered whether there could be a production at scale in the EMR that would come on top of the imports. Even if there are several projects of importance outside the region (on the coasts of Belgium and the Netherlands) that will deliver hydrogen to the EMR on the long run, we quickly noticed that besides in Germany where there are attractive schemes to support the development of green hydrogen production, there are actually very few projects in the region itself.



Next to transporting hydrogen via pipes we wondered whether it could be imported via rivers (question 3) and what would be the form of the imports (pure or derivatives) and the related regulations in place or to be developed.

Once production and import routes had been examined, we moved to analysing offtake with a specific focus on mobility, looking through all the possible options (mobility on rivers, road, and airports).

As additional questions we looked at the R&D centre, the development of competencies, and the interactions between SMES and the local ecosystem.

The following pages are coming back with more details on each and every aspect of the different topics as they got enriched via discussions with the different players.

Results

1. Where will the hydrogen come from?

The region is highly energy intensive

The Euregio-Meuse-Rhine lies at the core of the BeNeLux and North-Rhine Westphalia, and thus sits right in the centre of **the most energy intensive region in Europe.** These regions have a high concentration of industrial activities, high population densities (48 million inhabitants in the BeNeLux + NRW); and high logistics activities with Rotterdam (NL) and Antwerp (BE) being the biggest maritime ports of Europe, and Dusseldorf the biggest inland port of Europe.

As Figure 1 shows it, we have some of the most important industrial activities in central western Europe located in the Region.

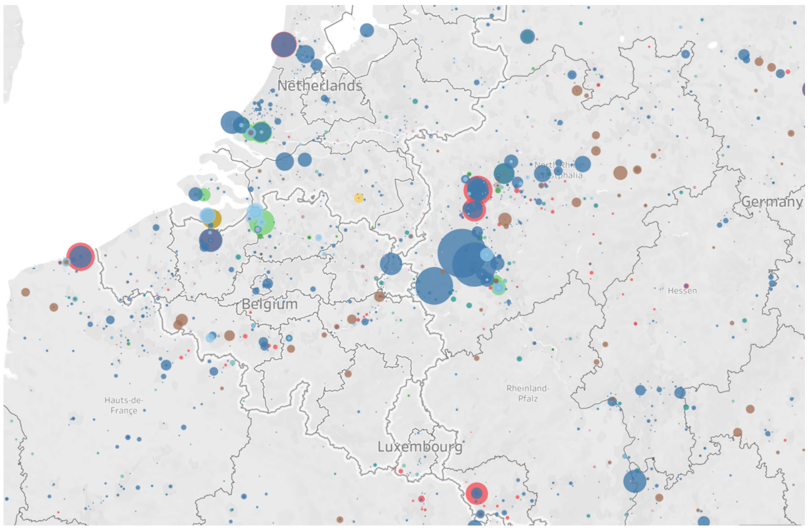


Figure 1 : Map of industrial emissions in Europe (source: EU ETS Transaction log 2022)

When one then looks at the balance between the demand and the production of energy in the region (seen figure 2), one notices that the EMR is the European Region with the greatest imbalance. It needs to import most of its energy.

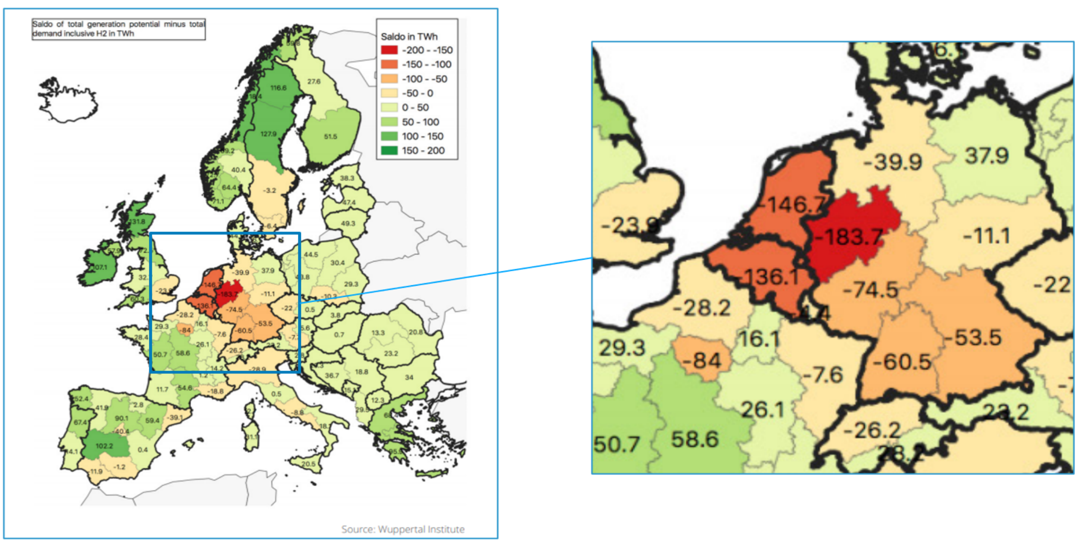


Figure 2: Map of the balance between energy production and us (Wuppertal Institute)

The next question is then naturally to wonder to which extend, with the development of the hydrogen economy, the EMR can develop additional energy production capacities that will feed into this new economy.

Renewables have limited potential in the region

— Solar resource is limited in the region, as solar panels will receive about half as much sun radiation as they would in Spain. The area is also mostly distributed between environmentally protected areas, urban areas, and agricultural areas. While solar energy still has a decent potential for distributed electricity production (such as rooftop solar), hydrogen projects typically connect directly to huge solar farms, which enables to by-pass the cost of using the grid and the associated balancing costs and taxes. As the potential for such large-scale solar farms is limited in the region because of the land constraints and limited solar exposure, the potential for hydrogen production from solar energy is also limited.

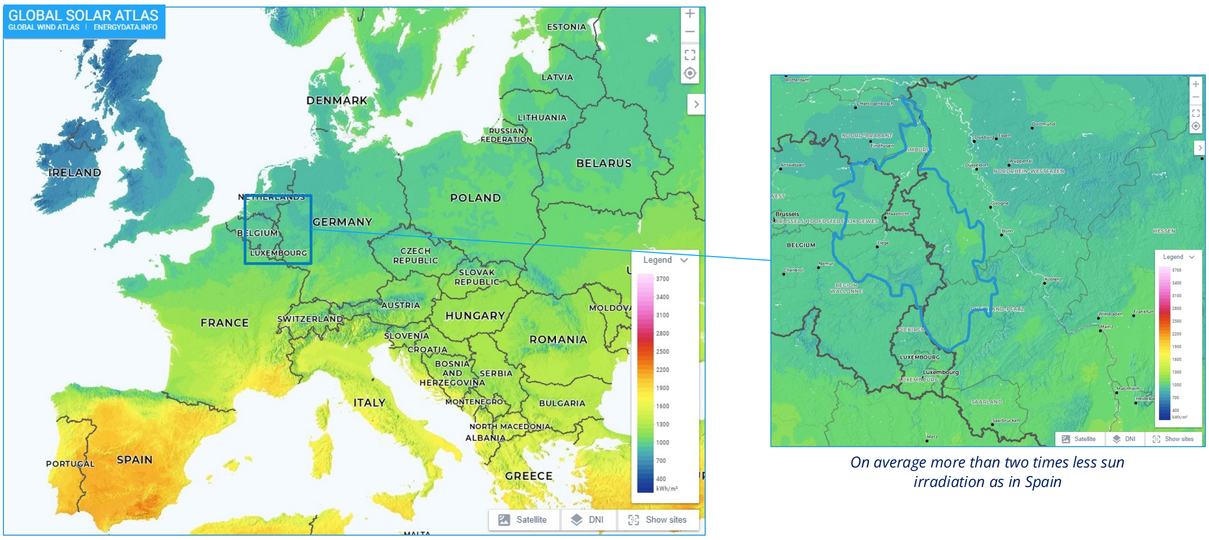


Figure 3: Map of solar exposure (Source: Global Solar Atlas)

During the interviews conducted for this study, several energy companies were consulted, all of them having activities in both solar energy production and hydrogen production, and still no project of H2 production from solar energy was identified.

— Wind energy potential is also limited. Wind exposure is quite favourable in the region, but the potential is limited by land constraints.

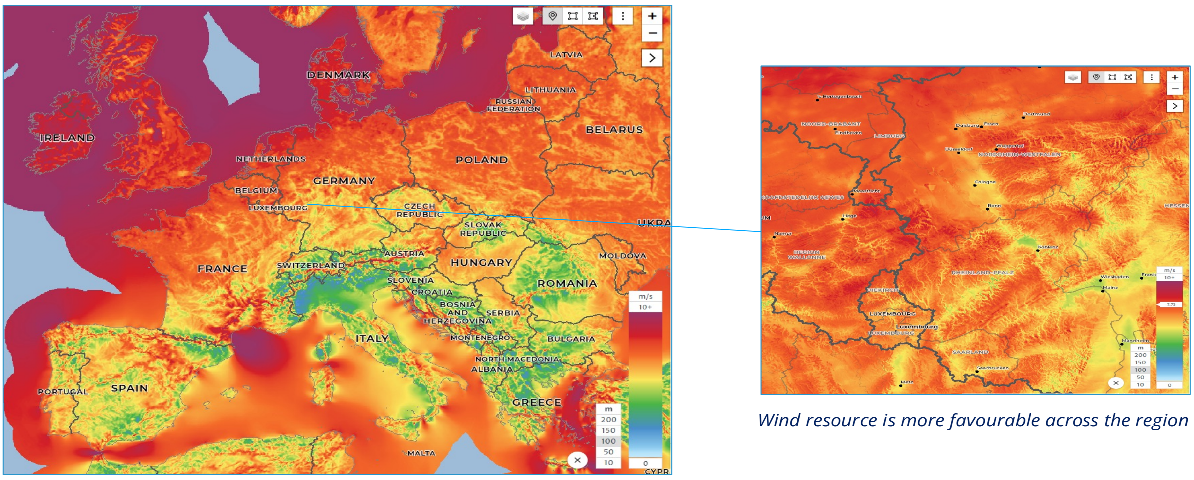


Figure 4: Map of wind exposure (Source: Global Wind Atlas)

As an additional characteristic, the EMR territory is heavily protected under Natura 2000 legislation, especially in Germany. The population density is also quite high, which limits the potential of large-scale wind projects because of minimum distance requirements between wind turbines and residential areas.

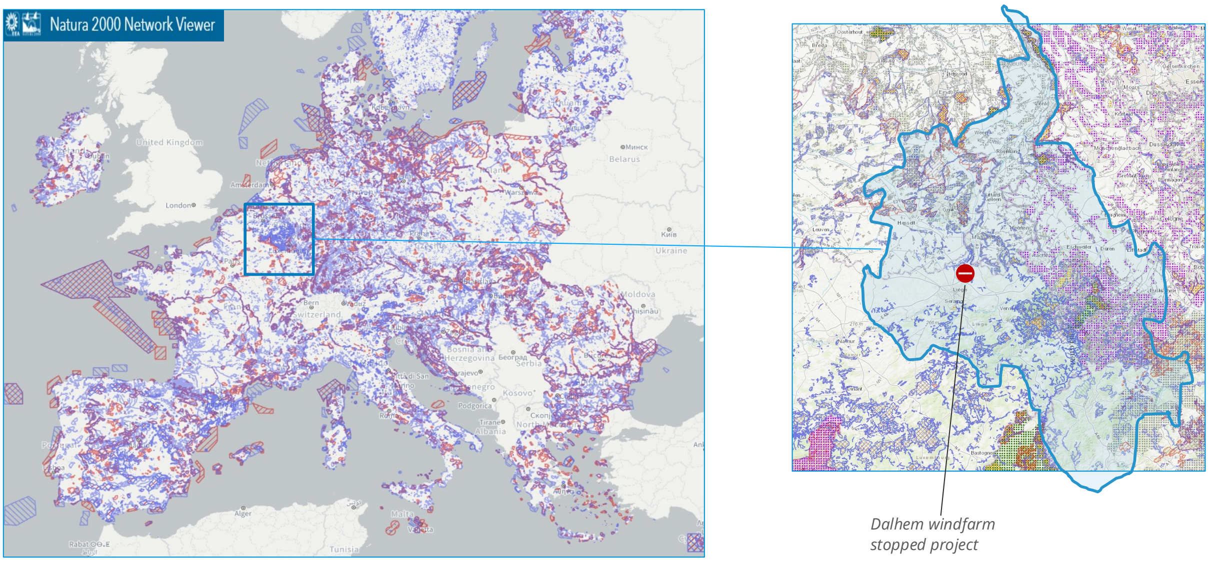


Figure 5: Map of the Natura 2000 Zones in the EMR (EU Commission)

As a last factor, the EMR territory also ambitions to host the international project of the Einstein Telescope, which aims to detect and measure gravitational waves. This telescope is very sensitive to vibrations, and nearby windmills would disturb the measurements of the telescope. In prevision of the construction of the telescope, a wind project in Dalhem was cancelled by the regional authorities in order to keep the area suited to host the telescope. If the location of the telescope is confirmed to be in the EM (2 locations are still in competition to host the project: Sardinia in Italy and the EMR) future projects will be limited as well.

Note: Production from offshore wind has a strong potential but will be considered in this report as imports from the EMR point of view.

— Other options are limited as well. Other options exist do produce hydrogen in the region, but all of them are either limited, too expensive, or not mature enough to enable quick large-scale hydrogen offtakes:

- Waste & biomass: Hydrogen can be produced by electrolysis using electricity from a *waste recovery unit* (waste-to-power), but the electricity output of these units is not considered as fully renewable. The supply of wastes is limited in volume as well. *Direct production* of hydrogen from wastes/biomass can also be considered, through process of pyrolysis, plasma, or digestion. Demonstrators are planned in Dutch Limburg (based on a plasma technology), and NRW (RWE's "Furec" project). Such technologies promising but not mature enough to produce hydrogen at scale in the short term, and not scalable enough to address the consumption potential of this energy intensive region in the long term. We recommend to keep monitoring them though.
- Nuclear power: The Tihange 3 reactor (1038MW) in Belgium is now officially extended for at least 10y, and the extension of Tihange 1 (962MW) is under negotiation. It is unlikely however that their electrical output will be dedicated to hydrogen production, as the Belgian electricity grid operator ELIA stated that the electricity supply of Belgium is already under tension.

In Dutch Limburg, 3 Small Modular Reactors (SMR) are planned, but again there is no indication that their electricity supply will be used for hydrogen production.
One must however keep in mind that producing low carbon hydrogen from nuclear plants at night is an option to optimize their production rate, and that electrolysing steam is more efficient than electrolysing water (-20% of energy savings).
While the regulatory context concerning hydrogen produced from nuclear power is still unclear, the benefits of high efficiency and enhanced utilisation of nuclear assets make this topic worth mentioning.

- Grid power: Electrolysers can still connect to the grid and sign Power Purchase Agreements (PPA) to guarantee a production from renewable energy. A large-scale production (>20 MW) can claim a direct connexion to the high-voltage grid which enables to by-pass the distribution grid and reduce the grid taxes. There are some sites across the region equipped with such connexions that would be free to welcome a hydrogen production site. However, at this stage, there is still uncertainty around the exact whereabouts of the EU delegated act concerning the production of green hydrogen (which gives further precision when it comes to hydrogen produced from the grid). And we have not been able to identify concrete projects.

NB: we did not look at during the study the production of hydrogen from natural gas either via steam methane reformers or other technologies that would allow to break natural gas into hydrogen and carbon black. We do not believe that the hydrogen economy in the EMR will be driven by the development of steam reformed hydrogen beyond the actual quantities. As regards the development of blue hydrogen (from fossil energies with carbon capture) it is an interesting track but still with non-fully mature and at scale (production of carbon black), and so are to be kept in the radar but not considered as mainstream.

There are little to no hydrogen production projects inside the EMR

These limitations of the local hydrogen production can be easily illustrated by the following map. Almost all the big projects are located at coastal areas where the offshore wind potential is stronger and maritime ports can serve as both production and import hubs.

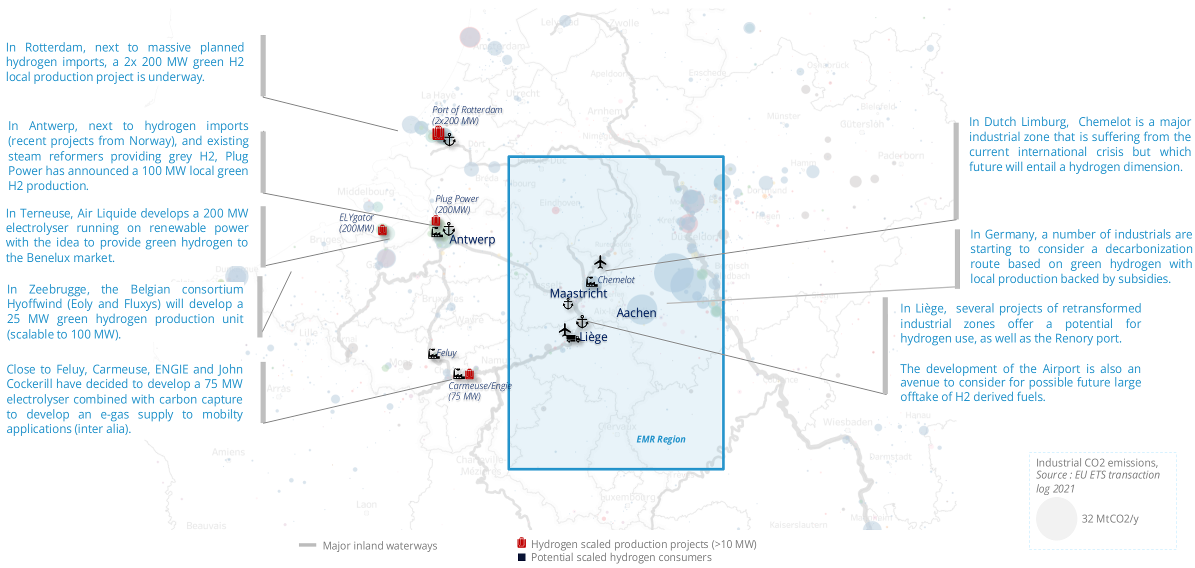


Figure 6: Identified projects of large-scale hydrogen production (>20MW), in and around the EMR

Note: There is no existing database of key hydrogen projects that are relevant to the EMR (projects located either in the region or at the gates of the region) that will have an impact on the hydrogen supply. It would be good to develop such a mapping or dataset in a simple and structured way to help share the global *view of productions and consumptions, and also be able to aggregate consumptions data for the deployment of infrastructures.*

Conclusion: the hydrogen equation in the EMR will be mainly driven by imports

— Hydrogen pipelines will likely be the main driver of delivering hydrogen to the region.

The location of the EMR is double-edged. On one hand, as shown in the previous paragraphs, the potential for hydrogen production—and more generally for energy production— is limited. On the other hand, the territory lies between the strong import hubs (Zeebrugge, Antwerp, Rotterdam), and the heavily industrialised Ruhr area.

The Russian aggression against Ukraine changed the picture in terms of gas and energy imports/exports in Europe. Germany was particularly affected as it had to cut away from its first source of natural gas, which led to a paradigm shift where Germany now imports more gas from its western flank than its from eastern flank. According to Fluxys, Belgium now transfers 4 times as much gas to Germany than its own consumption (mostly from Norway and LNG).

On the 14th of February 2023 Prime Minister Alexander De Croo and German Chancellor Olaf Scholz have met in Zeebrugge (near Fluxys' LNG terminal) for a Belgian-German energy summit, emphasising the importance of the Zeebrugge-to-Germany energy corridor.

As gas pipelines already play a strategic role in the energy equation of the region today, hydrogen pipelines will also likely be backbone of the energy supply of the energy intensive region to the east.

All three gas TSO's from the EMR (Fluxys, Gasunie, OGE) have published plans for deploying retrofitted and new hydrogen pipelines, most of these pipelines being scheduled to be put into service by 2030, forming the so-called Hydrogen Backbone.

As pipelines seem to be the main option to bring large quantities of hydrogen to the EMR, the speed of deployment of the said pipelines will drive the pace of the development of the hydrogen economy in the region.

The following chart (Figure 7) shows the anticipated pipelines in the EMR territory in the 10 and 20 years to come:

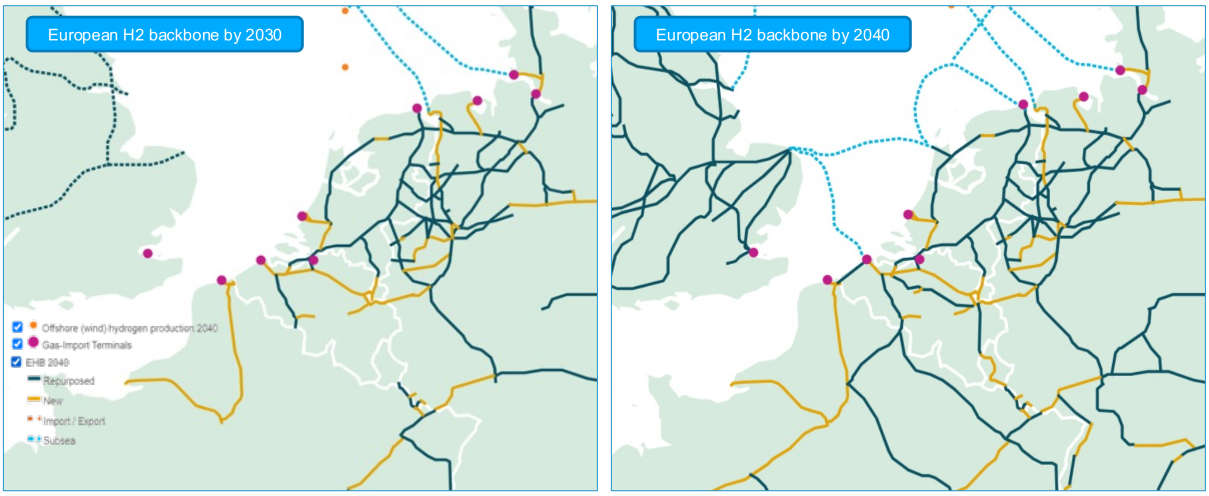


Figure 7: Hydrogen transport network by 2030 and 2040 (Source: European Hydrogen Backbone 2021)

— The pipelines will provide access to the North-Sea ports and in turn to large volumes of hydrogen from the North-sea, Norway, and the world market of shipped H2-derivatives.

Last April 19th was announced the North Sea gas TSO's declaration[1], a joint declaration signed by the 9 TSOs surrounding the North Sea (*Energinet, Fluxys, Gascade, Gas Networks Ireland, Gassco, Gasunie, GRTGaz, National Gas Transmission and OGE*) setting ambitious targets for both offshore wind energy production and associated green hydrogen production capacity. The offshore wind production in the North Sea could rise to up to 300 GW by 2050.

Norway also has plans to produce green hydrogen (from offshore wind but also hydro-electric power) and blue hydrogen (steam-reformed natural gas with carbon capture). Pipelines connecting Norway and the European continent are also planned, and agreements have been signed between Germany and Norway[2].

A connexion to the North-sea Ports will also provide access to shipped hydrogen and hydrogen-carriers produced in energy abundant regions of the world. Whether in the form of liquid hydrogen (proven but not yet scaled technology) or hydrogen carriers such as ammonia, methanol, or LOHC's. The major European ports will likely import large volumes of decarbonised molecules and feed the needs of the region.

On a longer term, further import routes from the Iberian Peninsula, as well as Africa and Eastern Europe, may channel additional quantities to the EMR.

— Import routes other than hydrogen pipelines do not seem suited for large scale hydrogen transport.

Hydrogen imports through other means like waterways or railways that have also been investigated during this study do not seem to be able to offer the same quantities, while they could play their part.

It is worth noticing that:

Compressed-hydrogen transport is being developed by the Rhine consortium in the RH2INE project, which aims to develop a common standard for swapped hydrogen containers for propulsion of hydrogen vessels. The project's target is to supply vessels with hydrogen for their propulsion however, not (at least at this stage) to transport hydrogen to supply other uses.

Transport of methanol through the river systems might have potential, but there still is a question mark on the supply and take off. The CCNR (regulatory body for the navigation on the Rhine) stated that while methanol is still a dangerous substance, leakages in a river already happened in the past and can be handled. Transport of ammonia is a no-go as it is much more toxic than methanol and the impact of a leakage of ammonia linear environment of a river would be unacceptable.

No projects for liquid hydrogen tankers were identified, as costs are still too high. Considering the time-to-market of such technologies, and the geographic match between the river system and planned H2 network, it is unlikely that this type of transport will be competitive with pipeline transportation. But one should not keep an eye away from the current development of LH2 as a vector to transport hydrogen as there are several consortia working on it.

[1] https://www.fluxys.com/en/press-releases/fluxysbelgium/2023/230419_press_north_sea_summit_declaration
[2] https://www.euractiv.com/section/energy/news/germany-norway-want-to-tie-the-knot-with-new-hydrogen-pipeline/

No projects for hydrogen transport by railways have been identified either. Transport of dangerous goods such as ammonia is already done by railway but limited in capacity because of safety precautions.

Our analysis can be summarized as follows when it comes to the hydrogen supply equation:

Summary of the hydrogen supply equation for the EMR

Where to get the hydrogen ?

Local production

Production from solar and wind

Wind potential is limited because of moderate wind exposure and the Einstein Telescope project requiring a low vibrations environment.
Scaled solar potential is limited too by natura 2000 protected areas.
→ Wind and solar can't be scaled enough for local hydrogen production .

Production from grid power

Sites with strong electrical connexions are available where hydrogen could be produced using grid power, but the question of carbon content and renewable character of the produced hydrogen remains

Production from Nuclear power

The Tihange 3 reactor (1038MW) is officially extended for at least 10y, extension of Tihange 1 (962MW) is under negotiation.
3 Small Modular Reactors are planned in NL Limburg
→ Low carbon hydrogen could be produced from nuclear power, but costs, low carbon principle, and political framework still remain unclear

Production from waste and biomass

Hydrogen can also be produced directly from waste or biomass pyrolysis (promising but still immature), or by electrolysis with waste-to-power electricity.

Imports

H2 potential suppliers

Connected through pipeline connexions :
- Norway
- United Kingdom
- North Sea (production from offshore wind power)

Shipping routes : global H2 markets

H2 import nodes

- Port of Antwerp
- Port of Zeebrugge
- Port of Dunkirk
- Port of Rotterdam
- Port of Wilhelmshaven
- Port of Hamburg

How to bring the H2 in the EMR Regio ?

H2 pipeline network

Existing :
Air Liquide has 600+km of piping in the region, but not passing through the EMR.
Repurposed natural gas pipelines (case by case study).

New :
Fluxys, OGE, Gasunie have plans to develop a backbone of H2 pipelines through the region by 2030, starting some lines as early as 2026.

Highways

Suitable for limited volumes or short ranges supplies (such as production site to station deliveries), but not suited for large scale or industrial uses supplies.

Railways

Probably suited for H2 derivatives (ammonia, methanol, e-kerosene…), but limited in volume for safety reasons

Waterways

Probably suited for H2 derivatives (ammonia, methanol, e-kerosene…), but limited in volume for safety reasons and ammonia can not cross cities on rivers.

Local production potential is limited, imports will be necessary to address the demand. Pipelines seem to be the main option to deliver quantities in the future

Beyond the analysis we suggest the following recommendations:

Conclusions and our recommendations

- While some local hydrogen projects get developed, the fundamental development of a hydrogen economy in the EMR territory versus on the coast of Belgium, Germany and the Netherlands will be directly related to the speed of deployment of H2 backbones.
  - ⇒ **Align decision makers on the importance of doing everything to deploy quickly new hydrogen pipes, especially at the interconnection points (make things easy at administrative level / handle the societal acceptance dimension)**
  - ⇒ **Speed up actions to favour the visibility of the aggregate offtake on the heavy-duty transport side (rivers & roads).**

- There is no existing database of key hydrogen projects that are relevant to the EMR = either in the region or at the gates of the region that will have an impact on the hydrogen supply
  - ⇒ **It would be good to develop such mapping / dataset in a simple and structured way to help share the global view of productions and consumptions, and also be able to aggregate consumptions data for the deployment of infrastructures.**

- Next to hydrogen imports and some green hydrogen production from wind (on the different countries coastal regions), there might be an equation for the production of hydrogen from waste in the inner land.
  - ⇒ **Beyond the existing pilot projects, a more structured assessment of the potential global resources and production, as well as the widening of the number of players / start up invited to play in the region, would be beneficial.**

- Transporting hydrogen and hydrogen derivates on the water ways is a limited option is terms of volumes. It would however be good to deepen the vision to develop partial alternatives routes to the transport of hydrogen per pipe and road by using rivers.
  - ⇒ **The partners should launch a group focused on the development of hydrogen transport on waterways across the EMR as the development of hydrogen barges will be an increasing topic; and as there will be a need to supply Liege airport with increasing volumes of green fuels which cannot be supplied by road. Such discussions have started in different places, we recommend bringing them now to the next level.**

After having analyzed the production and transport of hydrogen, let's now move our focus to the use of hydrogen, and more specifically in the transport sector, which is one of the main focus points of the demanded study.

2. What can be said about hydrogen use in the transport sector?

The region is very logistics intense and sits at the core of 3 TEN-T corridors

The Trans-European Transport Network (TEN-T) is a planned network of roads, railways, airports, and rivers spanning across the entire EU territory. It consists of a 'core' network with the busiest axes, and a 'comprehensive' network which is more expanded. 9 axes of the core network were defined as "corridors", and consist of the most important and strategic axes, mostly connecting Europe from North to South and from West to East.

The EMR lies in between three of these strategic corridors: the Rhine-Alpine, North Sea–Mediterranean, and the North Sea-Baltic corridors, of which the last one passes right through the EMR as showed in figure 8 hereafter.

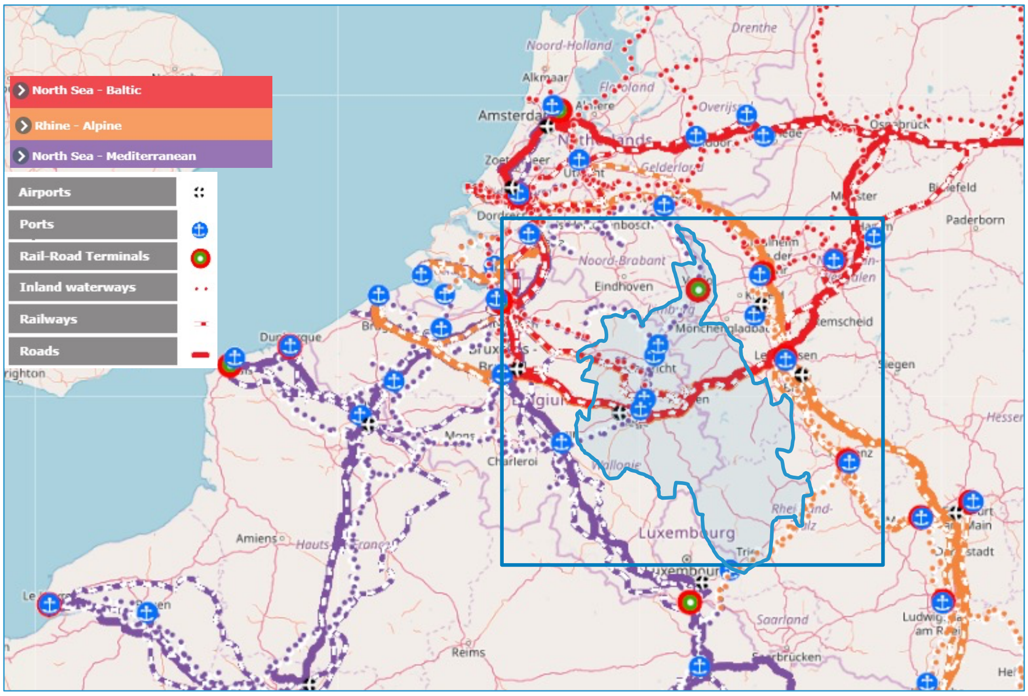


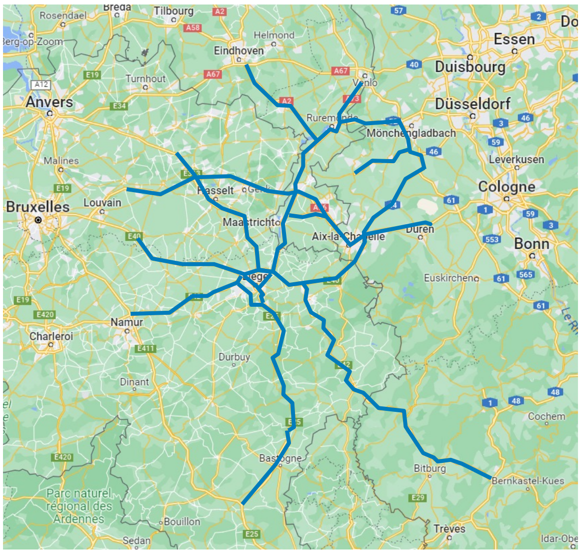
Figure 8: Ten-T corridors passing through the EMR (EU Commission)

On the 28th of March 2023 an agreement was announced by the EU on the Regulation for the deployment of alternative fuels infrastructure (AFIR). The regulation will impose a quota of at least one hydrogen refuelling station (HRS) every 200km along the core network and at least one per urban node, with a capacity of at least 1t/day, equivalent to the refuelling of about ~200 cars or ~25 trucks per day.

The EMR will be an essential node at the cross-section of future H2 highways in Europe and must prepare to have a proper network of H2 stations.

Considering the intensity of logistics transport in Europe and the position of the EMR at the cross section of major roads, acting as a big round about (see figure 9), the HRS capacity to address the demand will likely exceed the minimum requirements of the EU[3] but it is essential that the EMR gets ready to deploy stations in an orderly manner.

[3] 1 ton of hydrogen enables a truck to drive ~12 000km, or 60 trucks to drive 200km/day.



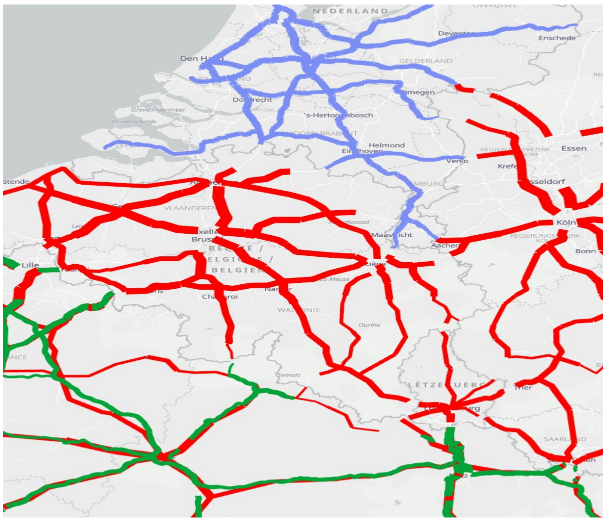


Figure 9: on the left–network of highways connecting the EMR, on the right–the traffic density of the highways (traffic proportional to the width of the lines)
— Source: Google Maps & Hydrogen Advisors/Seiya Consulting retreatment / UNECE Road Census (2005-2020)

There is a risk that uneven support schemes across countries and regions part of EMR may hamper an orderly development of H2 stations across the entire territory

Schemes for the support of Hydrogen Refuelling Stations (HRS) and hydrogen trucks (FCEC or H2ICE) differ indeed widely from country to country.

Germany leads the pack with strong subsidies of 80% of HRS Capex and 80% of the delta cost between FCEV and diesel trucks, whereas Belgium's and the Netherlands' incentives are much weaker. The Netherlands launched a 30M€ support scheme "AanZET" for zero-emissions trucks, but the amount of subsidy per truck was capped (131 900€) making the scheme much more attractive to battery electric trucks than for hydrogen trucks. This scheme is part of a wider envelope of up to 250M€, so future schemes more adapted to hydrogen mobility should come in a near future. Belgium on the other hand grants little support for the construction of HRS (13,5 of CAPEX) and H2 vehicles (24% of the cost delta). Despite being part of one of the 4 key pillars of the national strategy stating published in 2022, no support scheme (coming close to Germany's one at least) seems to be planned in the foreseeable future. This discrepancy in support schemes across the borders will inevitably lead to imbalances between the deployment of hydrogen mobility between the regions of the EMR. As the region is full of borders and international traffic is high, these imbalances might slow down the adoption of H2 mobility in the whole region.

H2	State subsidizes 80% of stations (on a station of 6MEuros, 4,8 MEuros paid)	No financing of H2 refuelling stations nor hydrogen trucks but upcoming 250 MEuros fsupport to help transition of vehicles	Call for projects and permanent subsidy of 13,5% of stations = limited	ADEME calls subsidies usually 25% of Capex. South Region - 35% ADEME and 5% region	CEF-T-AFIT, last call in 2023, 30% of infra Clean Hydrogen Partnership allocated 30 MEuros subsidy in 2022. It went to a project led by Shell in Germany.
H2	State subsidizes 80% of the delta between diesel truck and FCEV truck (on 500 kEuros, 100 kEuros left to finance)		Call for projects and permanent subsidy o 23/24% of trucks delta	Occitanie Region - EIB and CEF helped finance 58 out of 75 MEuros of infra and Region subsidy of up to 60% of truck delta. New ADEME call in March (275MEuros)	
	Toll road on diesel No toll road on ZEV.	No toll road but in planning. Its introduction will be compensated by upcoming 250 MEuros support to transitioning vehicles	Toll road on diesel No discount yet on ZEV	Toll road on diesel Accelerated amortization mechanism on ZEV trucks	

Challenge for the Belgian regions of the EMR Region to finance stations at the same pace – topic for EMR funding ?

River systems: the BeNeLux and West-Germany have the busiest waterways in Europe.

The rivers system is also a part of the TEN-T network, and inland waterways play a major role in merchandise transport in Belgium, the Netherlands and Germany, transporting over 60 billion tonnes-km of cargo in the North-South axis. Inland waterway transportation is also likely to play a key role in the energy transition, as transporting cargo with inland vessels consumes 6 times less energy than with trucks, and 2 times less than with trains. Based on the sector emissions and emission rates provided by the Flemish Institute of Research, we estimated that if all the inland vessels were to be converted to hydrogen, the consumption would reach about 150ktH2/year[4], equivalent to 1GW of electrolysis.

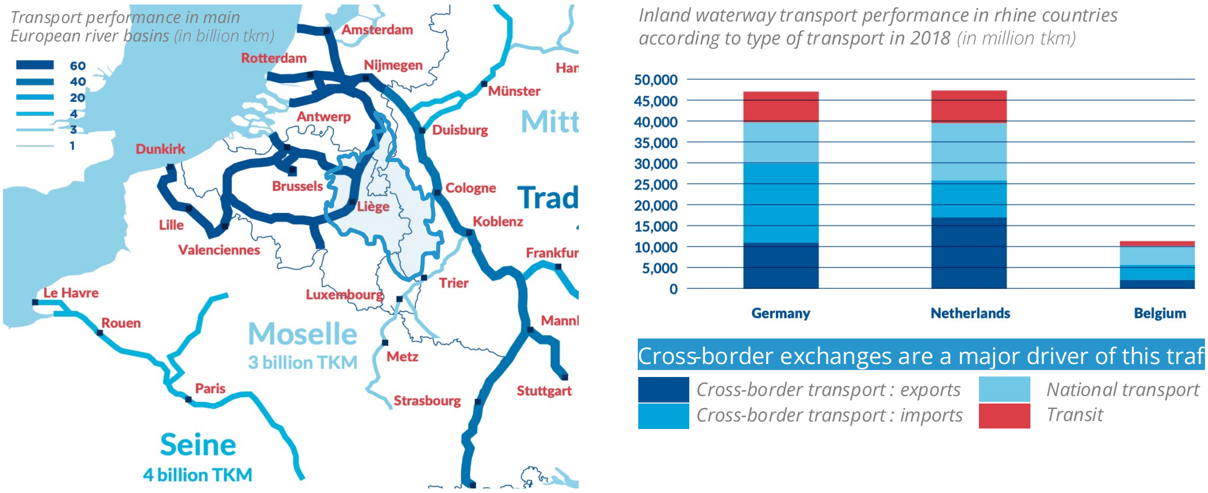


Figure 10: left–map of waterway traffic intensity, right–type of traffic (source: CCNR annual report 2019)

The Rhine Transport Authority also produced a study (see figure 11) showing that up to 45 per cent of the fuel used by inland transport vessels by 2050 could come from hydrogen or its derivatives!

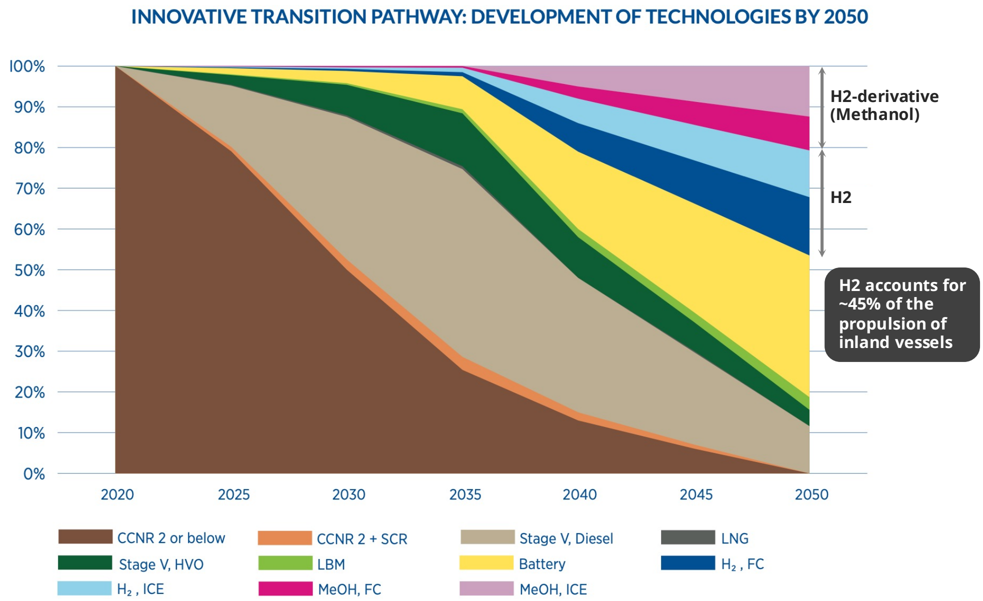


Figure 11: CCNR's 'innovative pathway' roadmap for decarbonization of the inland vessels on the Rhine

[4] *Hypotheses: 21gCO_2/tkm (for a 1 350t rated vessel, Flemish Institute of Research); 2,65 kgCO2/L and 10kWh/L for diesel; Efficiency ICE 30%, Efficiency fuel cell power train: 50% based on LHV (33,3 kWh/kg H_2)*

The previous calculation is only an intellectual exercise, as other means of propulsion exist and not all inland vessels will be converted to hydrogen fuel cells propulsion.

The EMR territory concentrates a very large part of the high-volume transport by barges in Europe on inner rivers, as such it represents a very interesting play for decarbonisation with impact. We are not talking here about new projects and decarbonisation, but realty the emergence of a new clean vessels on rivers industry which competencies and products could then be exported.

It was not requested as part of the study that we provide detailed information on the current projects of hydrogen-based vessels for inland transport on rivers. We provide however in the annex such overview in order to further strengthen our recommendations (see figure 12).

Conclusions and recommendations

- The EMR-Region concentrates a very large part of the high-volume transport by barges in Europe on inner rivers, as such it represents a very interesting play for decarbonisation with impact.
  - ⇒ **The EMR should build on the high decarbonization vision of the CCNR to make this scenario the reference also for the Meuse ecosystem and bring all parties to work to implement it all over the region.**
- There are an increasing number of hydrogen-based barges being developed in Europe.
  - ⇒ **The EMR should develop as a priority to foster the supply of hydrogen on its water ways and favour the development of a chain of SMEs at the forefront of hydrogen-based vessels development and maintenance that could serve client's fleet beyond the region (being centrally located).**
- The EMR is a major a central note / like a roundabout for the distribution of heavy-duty vehicles at the corner of Germany, the Netherlands and Belgium, and at the corner if 3 major Ten-T Corridors
  - ⇒ **The EMR must have H2 refuelling stations on its network and articulate them with a wider vision of the developing networks of stations in the Netherlands and Germany to ensure continuity of supply on the main crossing highways.**
  - ⇒ **Further work should be done on the harmonization of stations for trucks and barges across all countries.**
- There are however wide differences in the funding of refuelling stations and H2 vehicles that could jeopardize the development of proper H2 refuelling corridors across the entire Region.
  - ⇒ **European funding, via the EMR hydrogen dynamic could eventually fill the financing gap in the regions where the support of hydrogen stations and vehicles is lower than in neighbouring regions, in the interest of Europe.**

3. What can we do to increase cross-border collaboration?

Interactions between actors of different member state are mostly limited

While hydrogen associations exist throughout the EMR (as displayed on the map below) connecting their members across the region, the conducted interviews revealed that interactions among the individual members are currently limited. There are no associations connecting actors between: Belgium—Germany; Germany—Netherlands; Netherlands—Wallonia, and across all borders.

One notable exception is the connection between WaterstofNet and H2 Hub Wallonia in Belgium, where some members are involved in both associations. The upcoming launch of the Belgian Hydrogen Council, a joint initiative, is expected to further strengthen collaboration between these associations.

But there is clearly, and this is the essence of the EMR H2 Booster objective, an opportunity to go beyond. Large groups have better opportunities to connect with other players across borders than SMEs, and so it is essential to allow, via joint action to help SMEs connect across borders with all possible resources (including competencies centres) to develop an EMR based hydrogen economy.

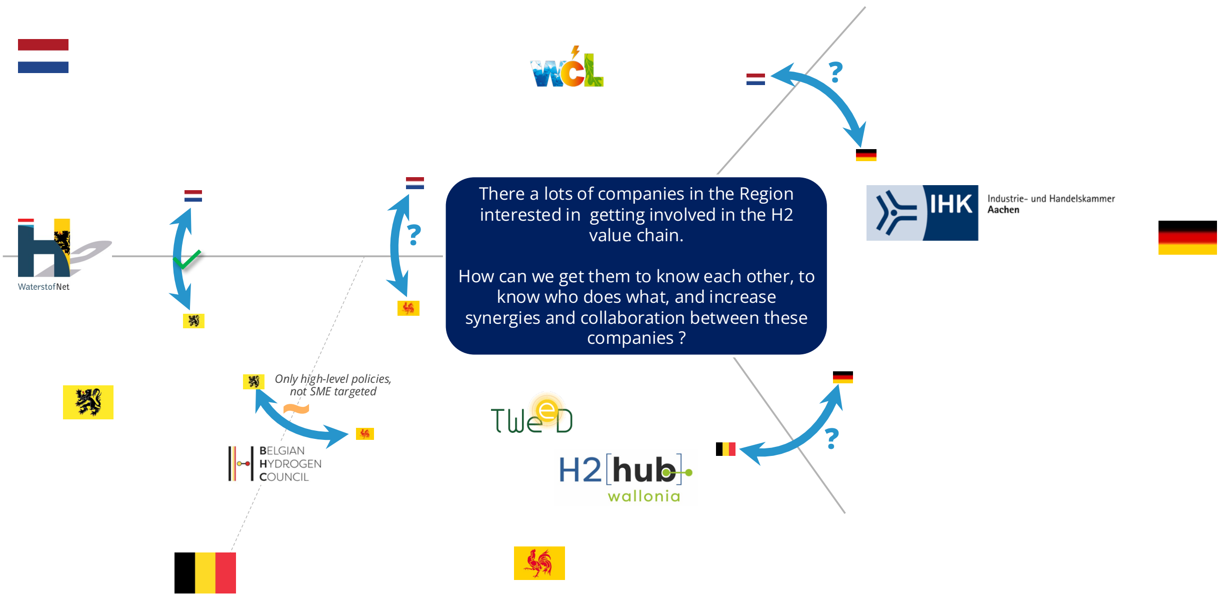


Figure 12: map of associations with cross-border collaborations

The region lacks a map of projects, actors, and initiatives

There is no census that brings together the identified projects in the EMR, providing an overview of what's being done where and who does what. Such a mapping could help bring together deeper understanding of the richness and diversity of the EMR's hydrogen ecosystem, and boost synergies between actors. For example, by discovering new potential partners, local players may be encouraged to source materials and expertise closer to home, creating mutually beneficial relationships within the region.

During the course of the study it became clear that there was a need to develop a hydrogen community across borders. Francorchamps had been identified as a place to host an event. Via an active work with the stakeholders of the EMR H2 Booster, we recommended to launch a Francorchamps Hydrogen Initiative, similar to what was done in the early days of the hydrogen policies in Europe via the Linz Initiative. It invites, on a non-binding basis, all voluntary actors to be part of a transnational community of players and actions. As such it creates the cement for future deepened action binding politicians and economic players. This initiative is therefore a clear outcome of the study.

The Francorchamps Hydrogen Initiative and Event was a great tool to raise awareness of regional activities and bring people together—it should now become a recurring event

The event was an opportunity for stakeholders to realize the breadth of ongoing activities. By fostering cross-border awareness and bringing people together, the region can unlock the potential for collaboration and maximize the benefits of shared knowledge and resources. We believe the event was a success—with notably the initial signing of the Francorchamps Hydrogen Initiative by the Walloon Minister of Energy - and then numerous other players, and should be renewed as a recurring event to regularly bring together local actors.

The collaboration model of the Jülich H_2 ecosystem could be widened at EMR level

The study identified a strong ecosystem of small and medium-sized enterprises (SMEs) and research and development (R&D) centres in North Rhine-Westphalia, actively collaborating to develop practical solutions and expand knowledge in the hydrogen sector. This successful collaboration model could be expanded to the entire EMR as we could notice that there are embryos of similar joint actions, for instance in Wallonia and Limburg. By fostering similar partnerships and knowledge exchange initiatives, stakeholders across the region can accelerate the development of concrete hydrogen solutions and further establish the EMR as a hub of hydrogen innovation.

Building a long-term vision of the hydrogen economy at the Euro Region Level

To gain a broader perspective and to align efforts towards a common vision, we recommend that public stakeholders organize a prospective exercise at the Euro Region level of the deployment of hydrogen solutions. This exercise would involve key stakeholders, including associations, SMEs, R&D centres, and governmental bodies, with the aim of identifying future trends, challenges, and opportunities in the hydrogen sector. By engaging in proactive strategic planning, the EMR can position itself as a leader in the European hydrogen landscape. It is key to develop a vision for the 10 to 20 years to come.

The dense river system offers the opportunity to the region to become/stay a leader in hydrogen solutions for rivers

The region accounts for the densest inland river traffic in Europe, and the Netherlands, Belgium, and North-Rhine Westphalia have more waterway transport than the rest of Europe combined. The competences available in this industry, combined with the competences in the hydrogen sector, can position the region as a spearhead in hydrogen-propelled inland transport. This dynamic has already started to a certain degree: all the hydrogen vessels projects identified during this study are European projects, and 3 of them are partially located inside of the EMR (ZELLIE, H2Ships, RH2INE). There are however levers left to catalyse this potential and make the EMR a leader in this industry, such as the setting of standards for hydrogen refuelling infrastructures and supporting projects financially. This topic should be put at the core of transnational actions under the umbrella of the EMR.

Conclusions and our recommendations

- In all parts of the EMR there are hydrogen associations but besides connection at the top there does not seem to be interactions at the level of members (besides in Belgium between WaterstofNet and H2 Hub Wallonia - as some members are in both, and now will be reinforced by the upcoming launch of the Belgian Hydrogen Council, their joint initiative).
  - ⇒ **It would be good to bring all members together for once to make them realize there is a lot happening (ex: Liège) and get them to know what happens being borders that they honestly ignore.**
  - ⇒ **It would be good to map existing members in all three clusters along value chains to 1) increase the visibility of the richness of the EMR ecosystem 2) facilitate afterwards interactions between members of the different clusters 3) lead some players to source closer to home as they discover new possible partners. This has been done in some organizations but not across organizations at the EMR Level.**

- There is a very strong ecosystem of SMEs and R&D centres trying to work together in North Rhine-Westphalia to develop concrete solutions and knowledge (while we noticed in some other place collaborations between local companies and R&D centre on specific projects)
  - ⇒ **Such approach could be widened at EMR level.**

- There is not yet a common work done on human resources, whereas skillsets and resources are being organized in the field of hydrogen as a must be for the development of this new economy.
  - ⇒ **Public stakeholders should consider organizing a prospective exercise at the level of the Euro Region.**

General conclusion

The study emphasizes three key pillars for the development of a hydrogen economy: heavy-duty transport, inland waterway transport, and interactions between SMEs. The successful deployment of hydrogen at scale is contingent upon the rapid deployment of pipelines, as it remains the most scalable solution for hydrogen supply.

The EMR is very energy intensive and has a limited potential renewable. Surrounding regions (BeNeLux and North-Rhine Westphalia) are in the same situation and the whole area will rely on hydrogen imports, likely by pipeline from the North Sea (including the UK and Norway) and shipments of hydrogen derivatives. The EMR can ride on the wave of this import dynamic, and quickly become a scaled importer of hydrogen. The study emphasizes the **critical role of pipelines infrastructure** in enabling the importation of hydrogen to the EMR. Importing hydrogen through pipelines offers a scalable and efficient solution for meeting the region's hydrogen demand. As such we recommend aligning decision-makers and streamlining administrative processes to enable the rapid deployment of hydrogen pipelines.

On the offtake side, **heavy duty road transport** was identified as a key pillar for the hydrogen economy. The region has a very dense road network and strong logistics activities, the ports of Antwerp and Rotterdam being the biggest ports of Europe and delivering goods all across the region. Hydrogen solutions still require financial support to be viable however, and support across the 3 countries of the EMR widely differ, leading to a very unbalanced deployment of hydrogen stations and trucks. This heterogeneous deployment can slow down the whole region, including in Germany where financial support is strong, as international transport constitutes a significant portion of the traffic.

Inland waterway transport was identified as the second pillar. The Meuse/Rhine ecosystem is the most active one in Europe, accounting for more traffic than the rest of Europe combined. Hydrogen will be a key pillar for decarbonising the inland vessels. If all the inland vessels were to be converted to hydrogen FCEV, we estimated the consumption would reach 150kt/y, equivalent to 1GW of electrolyser power. The CCNR estimates that hydrogen should be responsible of 45% of the propulsion (through liquid H_2, compressed H_2, or derivatives) by 2050. The EMR also has an opportunity for building an ecosystem of competences to become a leader in H_2 inland waterway transport and later export these competencies.

Interactions between SMEs and other stakeholders (large groups, R&D hubs, competence centres, ...) play a vital role in unlocking the full potential of the EMR's hydrogen ecosystem. By fostering collaboration and mapping existing members along value chains, stakeholders can improve visibility, foster innovation, and establish fruitful partnerships. Drawing inspiration from the successful collaboration model observed in North Rhine-Westphalia, expanding this approach throughout the EMR will strengthen the collective efforts and accelerate hydrogen-related developments.

Next steps: Considering the differences in policies, support, and vision, we believe public stakeholders should consider organizing a **prospective exercise** at the Euro Region level to **provide all players with a coordinated vision of the deployment of hydrogen solutions and potential in the region**. Additionally, **now that a new and really engaged cross borders hydrogen community has been built around the Francorchamps Hydrogen Initiative, we strongly advise to keep this ecosystem alive both via virtual and physical meetings.**

Annex

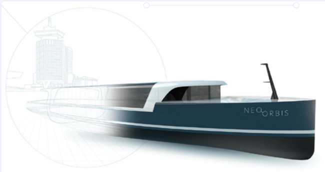
1. List of abbreviations

FCEV	(Hydrogen) Fuel Cell Electric Vehicle
H2ICE	Hydrogen Internal Combustion Engine
HRS	Hydrogen Refuelling Station
TEN-T	Trans-European Network – Transport

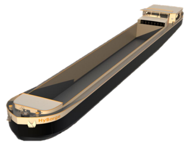
2. H_2 propelled vessels projects

H2- propelled barges projects

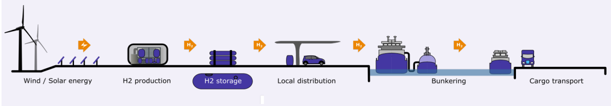
H2Ships
European barges project in Belgium and the Netherlands to demonstrate the technical and economic feasibility of hydrogen bunkering and propulsion for shipping. Backed by Interreg (6,3M€ project).



Hybarge
project led by the SAS Crew for the Occitanie region; capacity: 300 tons of goods.
Start of production in 2023; Expected launch in 2024. This barge can sail on all the canals of Europe.



RH2INE
EU backed project funded through the CEF, first comprehensive corridor approach which aims to develop hydrogen for heavy mobility (rail, road, & waterways) along the Rhine.
The joint initiative aims to put 280 hydrogen-powered barges into operation by 2030



Zulu 06
EU-backed "Flagships" project (through the CHP).
Electric propulsion with 2x200kW fuel cells, 350kg H2 tank, commissioning scheduled for September 2022 along the Seine (first hydrogen-powered barge in Europe)

ZELLIE
led by Eoly Energy and Novandi, they plan to build a hydrogen production unit on the Renory site in Liège and to decarbonize logistics flows by commissioning 2 hydrogen barges and a refueling station intended for mobility on the road.

Future Proof Shipping (FPS)
EU-backed "Flagships" project (CHP).
First H2 retrofitted barge is already complete (200 TEU capacity), the new two are in the design phase. FPS plans to offer zero-emission shipping along the Rhine by 2023.

H2-derivatives propelled barges projects

Methanol powered barge

OCI, Unibarge:
A dual-fuel bunker barge powered by green methanol. It will be the first green inland waterway craft in Europe to also serve as a methanol bunker delivery vessel, both delivering and operating on green methanol. It will be deployed at the Port of Rotterdam, Europe's largest port, in 2024.

Ammonia powered barge

No projects identified. Ammonia is a dangerous and toxic chemical and leaks are difficult to manage, especially in rivers which are a flowing but enclosed environment.

Cold ironing

ELEMANTA H2 – H2 bunkering & cold ironing
Améthyste, ArianeGroup, Cetim, HDF Energy, Rubis Terminal and Sofresid engineering have teamed up to develop a hydrogen-powered fuel cell barge to deliver green electricity and hydrogen to large

Green HARBOUR
Nexeya project for a cold ironing H2 barge in the Port of Sète (Occitanie, France). The barge will provide up to 2 MW of electric power to other ships at berth.

Figure 12: identified projects of hydrogen inland vessels. Blue background means the project is located in the EMR.