Final Value Chain & Stakeholder Analysis

Sam de Haas van Dorsser, Mark Meijer, Christian Ottesen | EGEN / PNO Innovation

10/12/2025

Credits

Disclaimer

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101091456.

Technical references

Grant Agreement N°	101091456	Acronym	HyInHeat
Full Title	Hydrogen technologies for decarbonization of industrial heating processes		
Work Package (WP)	Work Package 8		
Authors	Sam de Haas van Dorsser, Mark Meijer, Christian Ottesen		
Leading organisation	EGEN / PNO Innovation		
Date of publication	10/12/2025		
Quality control	Thomas Maidonis		
Document Type	R — Document, report		
Document Title	Value Chain & Stakeholder Analysis		
Dissemination Level	PU		

Document history

Version	Date	Partner	Authors
1	03/09/2025	EGEN / PNO Innovation	Sam de Haas van Dorsser, Mark Meijer, Christian Ottesen
2	07/11/2025	EGEN / PNO Innovation	Sam de Haas van Dorsser, Mark Meijer
Final	10/12/2025	EGEN / PNO Innovation	Sam de Haas van Dorsser, Mark Meijer

Table of contents

List of figures

List of tables

1 Introduction

This deliverable serves as the final Value Chain & Stakeholder Analysis. It provides an overview of the most relevant stakeholders related to the overall topic that HyInHeat focuses on, as well as some that are related to the specific HyInHeat value chain. While the stakeholder list in this deliverable is not exhaustive, we have used a methodological approach to assess and process relevant information for identifying high-relevance stakeholders. As such, this analysis provides valuable insights into HyInHeat's value chain and its stakeholders.

This deliverable consists of an analysis of European projects and outlines key stakeholders that can be approached to increase the impact generated through the project. In addition, a complementary analysis of a corpus of patents has been conducted. This analysis is closely related to the core activities of the project. Lastly, an assessment of network drivers, associations that drive business, has also been carried out, providing valuable insights into who to approach for greater exposure.

The aim of this deliverable is twofold. First, to guide the HyInHeat consortium partners to set up communication and dissemination actions targeted towards several different groups of stakeholders in the value chain. Second, the deliverable provides information to the wider public on any relevant industrial or academic stakeholders that could be partnered with during the HyInHeat project.

Together, this stakeholder analysis aims to help understand the potential roles of stakeholders in the metal processing industry, their interests and background, to be used for creating effective communication with them. All of these are crucial when developing and executing an effective communication, dissemination and exploitation strategy. This not only helps to identify groups of stakeholders but to also understand their motives and needs, which in turn can increase the overall impact of the project. This means that key innovations, challenges and outcomes will be shared and communicated with the identified stakeholders, and will entail tailoring to that specific stakeholder group.

2 Overview of the analysis

This stakeholder analysis has been performed using an established approach developed and deployed at PNO Innovation (formerly: EGEN). The aim is to identify the most relevant stakeholder categories by examining actors and the innovation landscape in general. This is done in a systematic and iterative way to ensure the analysis is done in high quality (Figure 1).

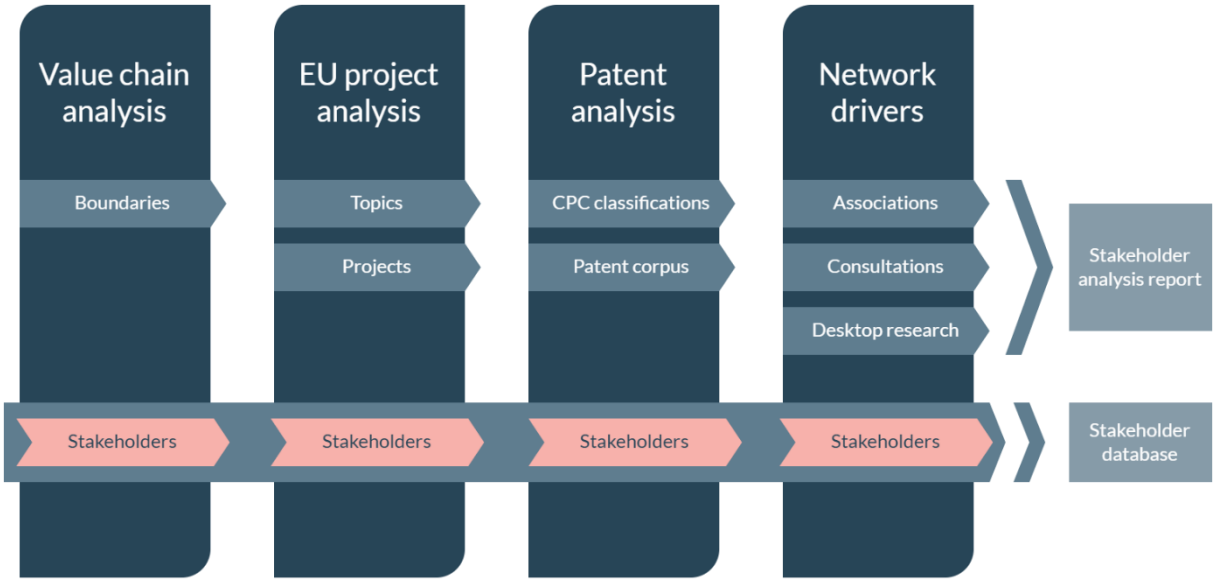

Figure 1: The stakeholder analysis approach used in this deliverable. Each stage entails different actions while simultaneously identifying stakeholders. The final results are this report, and a database containing relevant stakeholder information.

The process consists of four complementary phases comprising a good overview of the innovation, investment and business landscape. The approach followed in each individual part of the process is above, and the outcome of the analysis is presented in below.

Value chain analysis

The first step of the analysis focuses on understanding the project value chain. This was preliminary work that started at project launch and was validated through communication with consortium partners. The work in this phase has been categorized by setting boundaries for the analysis in order to identify relevant stakeholders effectively for the following phases.

EU project analysis

After the value chain analysis, the EU projects analysis aims to identify key relevant projects or innovators in Europe around related topics to HyInHeat. This was done using available databases of publicly funded projects, and information such as geographic distribution, project duration, stakeholders involved and relevance were all taken into account for the assessment. The EU project analysis was performed twice, in M12 and in M36 (i.e., this deliverable). This report integrates the result of both analyses.

Patent analysis

The third phase consists of an analysis of a corpus of patents using the Cooperative Patent Classification (CPC) system. Performing this allows for detailed insights into how a certain field of technology has evolved over time, as well as providing information about who has the most intellectual property in a given area of technology. The patent analysis was performed twice, in M12 and in M36 (i.e., this deliverable). This report integrates the result of both analyses.

Network drivers

Network drivers represent the final phase before the final outputs will be delivered. The key activity in this phase was a network drivers analysis aimed to identify the most relevant stakeholders involved from a sectorial or industry perspective. These might not be directly involved in the innovation process but can have high impact potential. In this stakeholder analysis the network driver analysis has been focused on associations due to their large outreach and powerful network capabilities.

Outputs

Using this methodological approach we have identified multiple stakeholders across multiple areas of the sector, directly or tangentially related to the HyInHeat project. The output deliverables are:

1. Stakeholder analysis report. This deliverable presents the analysis, how it was performed, the findings and our conclusions for which stakeholders are the most relevant.
2. Stakeholder tables. Each step of the methodological process has identified stakeholders, which has in turn been collected, categorized and processed into information that can be used to more easily facilitate communication and dissemination when necessary. The stakeholder tables are available throughout the document.

3 Methodology

3.1 Overall methodology

This chapter provides an overview of the methodology that was used in this value chain and stakeholder analysis. This stakeholder analysis is the final of two parts, integrating the results of the first part that was finalized in M12 of the project.

The value chain and stakeholder analysis is based on the most relevant stakeholder groups, both within the HyInHeat consortium as well as those surrounded to the project. These are groups that are likely to benefit from the HyInHeat project results, and their position towards the project has been assessed based on the EU CORDIS database, feedback from consortium members and their wider network as well as from desktop research. The overall analysis has been and will follow three stages:

1. An initial draft of the value chain for HyInHeat was made available for all consortium members in M2 of the project. The value chain was there validated by the partners and created a basis for communication and dissemination efforts.
2. The value chain was complemented by the result of the first stakeholder analysis, delivered in M12 of the project.
3. This document serves as the final value chain and stakeholder analysis, delivered in M36 of the project. This deliverable aims to enhance the implementation of the business and exploitation strategy and maximize the impact of the project results and final exploitation workshop.

The process has been a dynamic consultation process, having incorporated input, insights and feedback by multiple stakeholders into the final analysis.

3.1.1 Value chain analysis

Before performing a full stakeholder analysis the boundaries of the value chain of project activities needs to be in place. To do so, a confined description of the project activities was developed. A description encompassing both upstream and downstream stakeholder categories. A suitable bandwidth for the analysis has been chosen. A bandwidth appropriately encompass the most relevant stakeholders in the value chain. It has been a priority throughout this process to not create a too broad stakeholder scope, create biases or assumptions that unintentionally could have resulted in some stakeholders or channels to be overlooked for the following parts of the analysis.

3.1.2 EU projects analysis

Since its start in 2021 the Horizon Europe program has signed more than 7.000 grants with more than 15.000 unique participants all across Europe. This includes research institutes, large and small industries, RTOs and associations participating in developing innovation from an early stage to advanced prototypes. The Community Research and Development Information Service (CORDIS) is the European Commission's primary public repository of information regarding all EU-funded projects and their results. However, other funded projects from other national databases are excluded.

To ensure a solid project coverage, this analysis has been based in large parts on the proprietary search engine tool WheesBee (www.wheesbee.eu). As such, the analysis provides insights into previously funded projects (see Figure 2). This tool integrates the information available through the CORDIS database with other European national databases.

In order to narrow down the amount of projects to only those of relevance to HyInHeat, we performed a refined search based on relevant keywords and terms. The selection of keywords was a structured approach. The approach relied on identifying key terms from the HyInHeat project proposal, but also combining them with terms used by other projects in the same sector. This ensured that practically all of the most relevant terms got included in the final search. This meant avoiding using a singular generic term such as "hydrogen"; 10.770 results, nor a too specific term: "green hydrogen as fuel in steel and aluminium industries"; 0 results.

To ensure that the most relevant terms were included, a scan of the project descriptions was done to capture professional terms or abbreviations that might be used such as H2 instead of "hydrogen". Certain words also

have a different spelling such as “decarbonization” and “decarbonisation", which was also accounted for. Furthermore, only projects that were currently active either in full or in part for the duration of HyInHeat were included in the search. Consequently, the final search created a combination of keywords based not only on the terms used in the HyInHeat project description, but also on terms used by other projects in the same sectoral field.

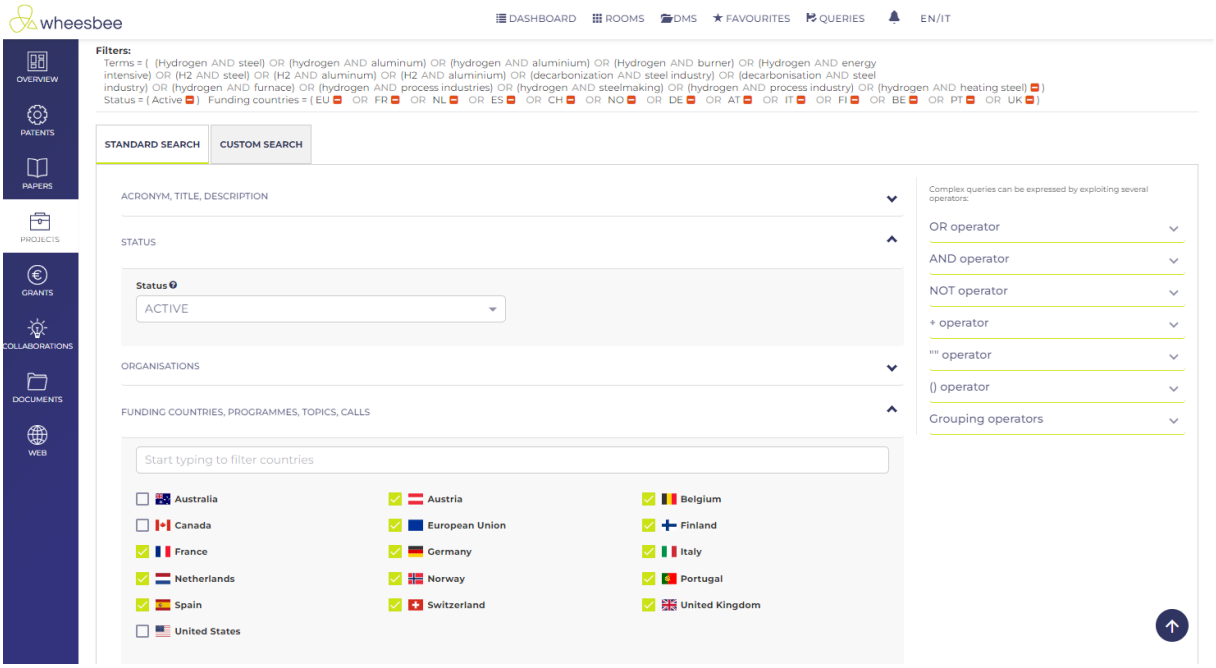

Figure 2: WheesBee was used to perform the projects search, which allows for several filtering options. The platform has access to several international and national databases accross Europe.

The list of projects was thereafter exported into an Excel which allowed for analyzing the raw data, as well as providing a visualization basis. The analysis entailed ranking the list of projects based on its similarity and/or relevance to HyInHeat. This ranking was based on the project description, goals and aims, project title, project origin, as well as an evaluation of potential synergies with HyInHeat. The outcome of the final project search can be found in Chapter 5.

3.1.3 Patent analysis

Stakeholders may patent their inventions in order to maintain exclusive rights, reduce competition, or provide basis for investment or licensing the patent as an owned asset. Patenting can therefore often be seen as the first step towards investment, as filing for a patent itself entails financial costs.

The patent analysis is meant as a complementary data analysis tool for the projects analysis, which aims to gain insight into actors in the sector independently of if they are active in collaborative publicly funded projects or not. This entails making a scan of all patents related to key aspects of the value chain, which has again been done using the search engine tool WheesBee.

The corpus of patents is primarily classified under two systems: the International Patent Classification (IPC) system and the Cooperative Patent Classification (CPC) system. Both systems have different nuances but do not significantly differ for the purpose of this type of analysis. As such, the CPC system was applied. It comprises around 200,000 patent subgroups and has been widely used in the patent industry for many years.

Identifying the relevant corpus of patents is done by screening the sections, classes and subgroups of the CPC system of 200.000 existing corpus’. This entailed checking the whole corpus of patents on a high-level category basis, which were refined category by category. Once the relevant corpus of patents was identified, a complete search of the patent database for all patents filed under the corpus was performed. The patent analysis is available in Chapter 6.

3.1.4 Networks drivers

Network drivers can be seen as stakeholders that drive progress in a particular field or sector, or that could benefit from a technology or project result. These types of stakeholders can vary significantly in type, and can be more challenging to identify. In some cases end-users of value chains can be involved in the innovation process, but they would not be reflected in the EU projects database nor the patent database. In general the market consists of consolidated actors that are backed by robust and longstanding business models and are entangled in many areas of a sector.

These types of stakeholders might potentially enter into business deals with consortia that demonstrate or apply technologies in order to widen their own business portfolios further. There currently is no known single database to consider for the identification of potential network drivers. As such, throughout both the EU projects analysis and the patent analysis, a focus has been to identify such relevant stakeholders where possible. In order to increase the potential outreach of these types of stakeholders that drive business further, a focus in this stakeholder analysis has been put on associations.

Associations that have close relevance to the steel and aluminum sector, or alternatively with a focus on hydrogen, have been of prime consideration. The identification of associations has been based on extensive work experience in the consultancy field, and aided by the networking intelligence of PNO Innovation. This has further been developed by analyzing consortium member partnerships as well as performing extensive desktop research. The analysis of the network drivers is provided in Chapter 7.

4 Value chain analysis

4.1 Boundaries of value chain

As detailed in above, the initial step of the analysis was to develop a value chain that provided a confined description of the project activities that HyInHeat will encompass, considering both upstream and downstream stakeholder categories. For HyInHeat, this was defined as the use of hydrogen as a fuel in the steel and aluminium process industries. This essentially followed the entire value chain, defining the start phase of the value chain as resource supply, and the end phase as wider adaptation with several phases in between (see Figure 3).

Figure 3 shows the main stakeholder groups related to HyInHeat, and illustrates their role, their relevance to HyInHeat and their flow of value. The relevance rating was defined as such:

- 1st level relevance: Stakeholders that are directly related to the HyInHeat innovation approach. The segments are the steel and aluminum industry, refractory developers, combustion and measurement equipment, as well as the furnace and equipment developers.
- 2nd level of relevance: Stakeholders that could potentially be directly related to the HyInHeat innovation approach in different ways. The optimization experts, hydrogen suppliers, policy actors as well as steel and aluminum users are potential segments in this part of the value chain.
- 3rd level of relevance: Stakeholders that are indirectly affected by the HyInHeat innovation approach. This includes energy suppliers, raw materials providers and wider public.

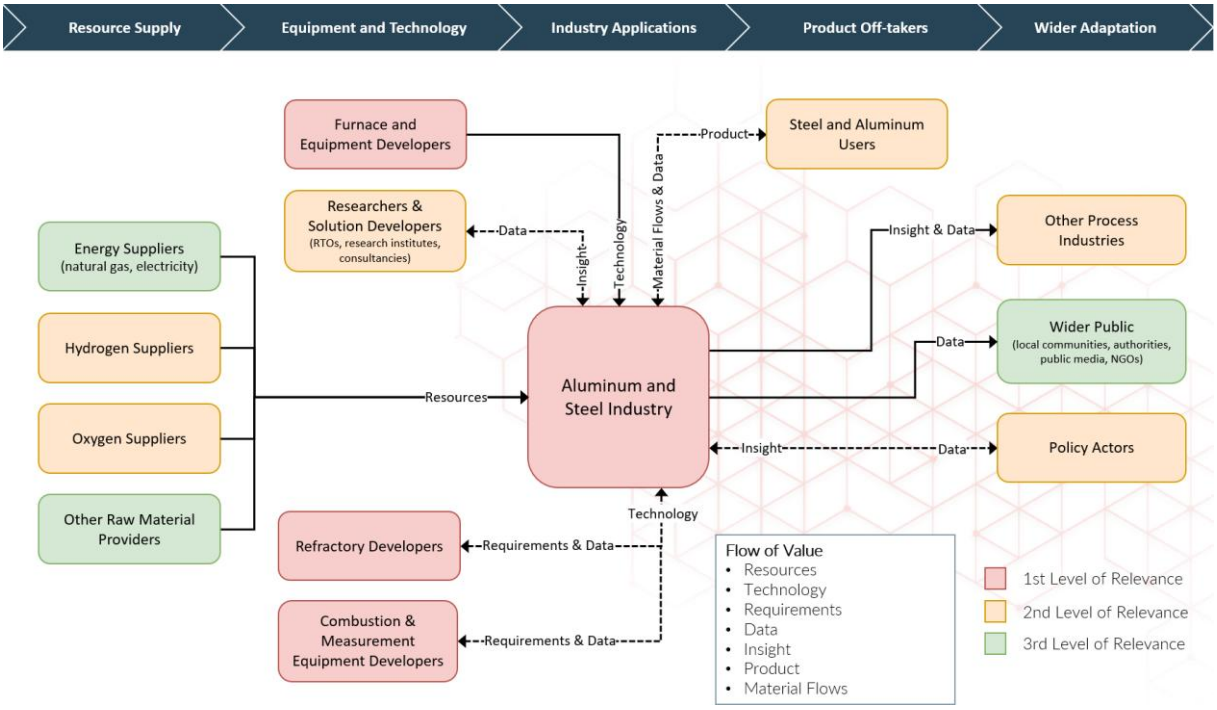

Figure 3: Visualization of the entire value chain showing the phases of the value chain at the top, and each stakeholder group represented by a box colored with its relevance rating. The flow of value is also represented, where a stippled line indicates that the flow is bi-directional.

4.1.1 First level relevance stakeholders

Aluminum and steel industry

The aluminum and steel industry segment represents the core actors for the HyInHeat project. It is here that the technology and equipment will be installed and tested over the course of the project. Both steel and aluminum are notoriously heavy polluting industries, and adoption of zero or low-emission technology in these sectors are highly sought after. These industries could benefit greatly from the data, knowledge, technology and insights generated by the HyInHeat project, which in turn could yield greater advancements towards a more sustainable sector.

Being at the heart of the operations, this segment would touch practically all flows of value in the HyInHeat project. The resource inputs would be combined with technology from different segments of the value chain, where it is combined and processed in the industry. During this process data that is produced would be used to further optimize the equipment, sensors, systems or other aspects of the process. The outputs of this will produce steel and aluminum that will be used by current or future prospective off-takers.

Lastly, the non-tangible outcomes of the operation will result in both insight and data to other segments of the value chain. Certain barriers could arise from already well-established actors in the sector that see potential market disruption using this technology, but overall the benefits are expected to be impactful for most.

Furnace and equipment developers

The furnaces that will be developed and installed in the aluminum and steel industry will utilize hydrogen (H_2)/oxygen (O_2) burners, a switch away from the traditional NG/air burners. This segment will provide the needed technology to the industry, where it will be installed and tested. The outcomes of the HyInHeat project would be impactful for the furnace and equipment developers, as successful implementation in this project could lead to future markets for these actors. Some barriers might arise from well-established actors in the industry, through increased production costs, or from technological limitations.

Refractory developers

Refractory materials are very important in furnaces that will experience very high temperatures. The material inside furnaces needs to consist of particular properties that can resist these high temperatures while also complying with the switch to hydrogen as the main burner fuel. The flow of value in this segment is bi-directional, where they provide technology to the industry, but also in return require information about what requirements are necessary. This could also include certain data that might be useful to adapt the requirements from the industry if necessary. These actors would benefit from any advances resulting from the HyInHeat project, as it opens new market opportunities.

Combustion & measurement equipment developers

The combustion equipment is key in the hydrogen ignition process. This segment will also include actors who provide important measurement and sensing equipment to monitor the process and ensure reliability. The bi-directional flow is similar to refractory developers, where they need requirements from the industry to provide their technology. Data is another important flow of value, as changes in for example measurement technology might be needed to ensure stable performance. As such, they would benefit from the successful uptake of H_2/O_2 burners in the industry, as this would lead to new market opportunities in the future.

4.1.2 Second level relevance stakeholders

Hydrogen suppliers

The supply of hydrogen will play an essential role in the HyInHeat project, as it is necessary to power the new innovative burners in the project. Hydrogen suppliers will benefit from the outcomes of the project, as a successful outcome is likely to increase demand for hydrogen in the wider industry. They however also play an important sustainability role in the project, as depending on how the hydrogen is produced, also affect the sustainability of the entire value chain.

Oxygen suppliers

Another key fuel to the project is industrially produced oxygen, which will be used in the combustion process of the burners in the industry. Similar to hydrogen suppliers, uptake in oxygen for burners in the sector would provide increased benefits for these suppliers. It should however be differentiated against hydrogen suppliers, as the oxygen production market is more stable and not necessarily as innovative as the aforementioned one.

Researchers & solution developers

This segment provides research into the process and develop solutions that result of the HyInHeat project. This includes research organizations, institutes, consultancies or similar institutions. These actors will benefit from the HyInHeat project as it's outcomes will result in learning opportunities and advances in research, equipment innovation, alternative fuel advances and possible new academia teaching opportunities. This

segment therefore provide insight into the industry through the aforementioned activities, and in return gather data which is further processed into insights for the industry.

Steel and aluminum users

The off-takers of steel and aluminum is very relevant to the outcomes of the HyInHeat project. The benefits for this segment is apparent, as having steel and aluminum which is a notoriously polluting industry being produced with renewable energy and through a more sustainable process would provide major benefits for the off-takers.

The steel and aluminum that is produced using hydrogen burners will therefore be an important aspect in the respective clients' sustainability portfolio. The users will receive the product but might also provide potential backflow of materials or data that might be useful for further improving the product or process according to their requirements. Barrier for engagement would likely be increased product costs, which even if more sustainably produced would incur too high investment costs to offset its benefits.

Other process industries

The greater process industry would also be interested in the insights and data generated by the HyInHeat project in order to improve their own process industries. Should the outcomes of the HyInHeat project be adaptable to other process industries, then they could benefit through also using similar technology in their own industry.

Policy actors

Lastly, policy actors will play a very important role as mediator for uptake of the technology in the future. Policymakers can use the recommendations and results produced throughout the HyInHeat project to develop and/or adjust policies related to hydrogen adoption in the industry. This could include regulatory changes, funding opportunities, incentive issues, energy market changes, innovation policy aspects, or many another themes. The HyInHeat project will therefore supply data to policy actors, while in return expect insight into policy changes for the industry.

4.1.3 Third level relevance stakeholders

Energy suppliers

The energy supplier is an actor that supplies energy (electricity, gas, etc.) to the industry. The industry actors then in turn pay for their energy consumption, which is not insubstantial in steel and aluminum production. The source of the energy provided will also have a cascading effect on the rest of the HyInHeat project. Should the energy be produced by fossil sources, then also the hydrogen that is being used would also then utilize non-renewable energy and the same goes if renewable energy is used. With fluctuating energy prices and increasing demand for green energy, their role becomes important, while at the same time more supply is being built to fill the gaps. Since hydrogen burners will require substantial amounts of energy, energy suppliers will naturally have a strong interest in meeting this growing demand.

Other raw material providers

This segment entails general resources such as raw ore materials or other process materials that is essential in the production of steel and aluminum. While these actors are important in the facilitation and production of steel and aluminum, the project is not expected to experience increased raw materials needs in its production, and demand and supply should be relatively unaffected.

Wider public

The stakeholders in the wider public would include local communities, authorities, public media, NGOs, or other relevant entities. These actors could be interested in the project but are not directly related to the HyInHeat project. Benefits they might be interested in could be societal reduction of CO_2 in heavy-polluting steel and aluminum industries, or the capabilities of the hydrogen technology developed throughout the project.

5 EU projects analysis

As outlined in above, the project analysis was based on a selection of keywords and terms that was deemed the most relevant to the HyInHeat project. Based on the methodological approach, the following 16 keyword combinations were used to narrow down the project search. It resulted in a list of projects with a focus on steel and aluminum industries, regarding hydrogen usage for varying usages.

Table 1: Table showing the entire combination of keywords used in the search for EU projects on WheesBee.

(hydrogen AND steel) OR	(hydrogen AND process industries) OR	(hydrogen AND aluminium) OR
(hydrogen AND burner) OR	(hydrogen AND energy intensive) OR	(H2 AND steel) OR
(H2 AND aluminum) OR	(decarbonisation AND steel industry) OR	(hydrogen AND furnace) OR
(H2 AND aluminium) OR	(decarbonization AND steel industry) OR	(hydrogen AND aluminum) OR
(hydrogen AND steelmaking) OR	(hydrogen AND process industry) OR	(hydrogen AND heating steel)

The EU projects analysis in the first stakeholder analysis focused on projects during the period of 01/01/2019 to 12/04/2023, while the EU projects analysis in the second stakeholder analysis focused on projects during the period of 01/01/2023 to 18/07/2025. The first months of 2023 are included in both analyses to ensure that no projects are missed, as some projects may have already started during those months but had not yet been made public at the time of the first analysis. The integrated results of both analyses are presented below.

The search query resulted in a total of 513 project results from both the first and second stakeholder analyses. This included projects from the European Union (339), but also from the United Kingdom (48), France (29), Norway (33), Germany (21), Belgium (17), Austria (12), Switzerland (7), and The Netherlands (2). The search results include European Commission programs, as well as regional and national programs. Identical to the first value chain & stakeholder analysis, the projects were qualitatively evaluated for relevance to HyInHeat based on this relevance rating:

- Relevance 1: Directly related to HyInHeat activities.
- Relevance 2: Indirectly related to HyInHeat activities.
- Relevance 3: Tangentially related to HyInHeat activities.
- Relevance 4: Not related to HyInHeat activities.

Based on these relevance ratings: 26 projects were classified as relevance rating 1, 13 projects as relevance rating 2, 76 projects as relevance rating 3, and 398 projects as relevance rating 4 (see Fehler! Verweisquelle konnte nicht gefunden werden.). It should be noted that as seen in the evaluation criteria above, it is not based on absolute objective criteria, and as such the top projects should not be seen as exclusively the most important projects at this stage. Consequently, it was decided to include both relevance 1 and 2 projects for the purpose of analyzing stakeholder participation. This meant that all projects with a relevance of 3 or 4 were discarded, resulting in a total list of 39 projects to be analyzed further in this stakeholder analysis. Of these projects to be analyzed further, 27 were identified in the first stakeholder analysis, while 12 have been identified in this second (and final) stakeholder analysis.

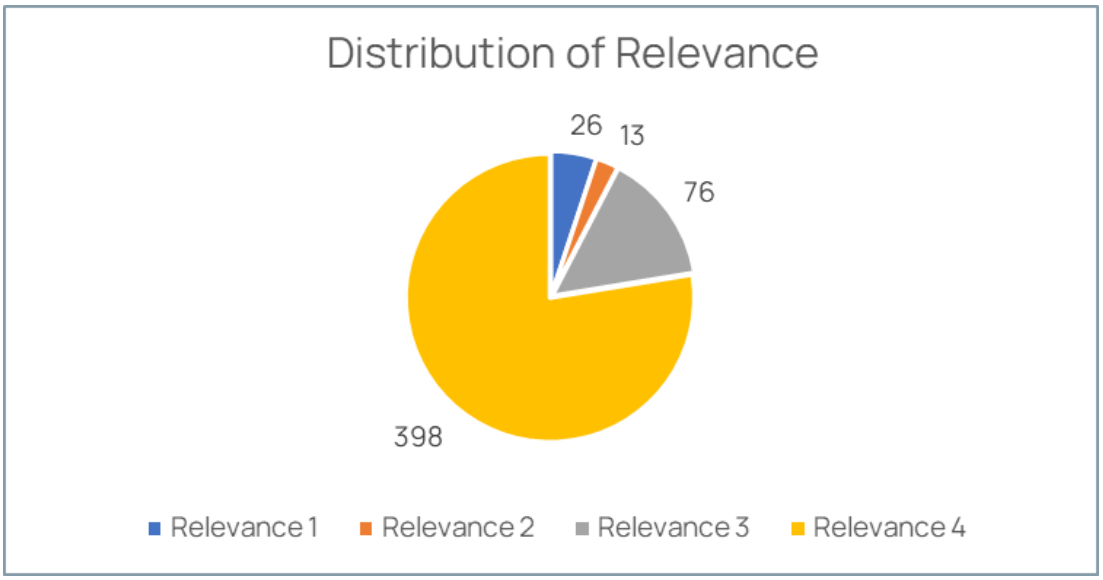

Figure 4: Distribution of relevance ratings among the 513 identified projects.

The following list of projects is intended to be used as input to the overall communication, dissemination and exploitation strategy of the project in order to create higher impact for HyInHeat project results. As part of these activities, efforts will be made to engage with these projects and their stakeholders to explore synergies and activities that might be beneficial to both sides. Table 2 and Table 3 show the relevance 1 and 2 projects that were identified during the second stakeholder analysis, while Table 4 and Table 5 show the relevance 1 and 2 projects that were identified during the first stakeholder analysis.

5.1 Relevant projects to HyInHeat from Stakeholder Analyses 2 and 1

5.1.1 Stakeholder Analysis 2

*Table 2: Indicative list of the 7 most relevant projects to HyInHeat constituting those of highest relevance in stakeholder analysis 2 only (**relevance 1**).*

The second stakeholder analysis identified 7 projects with relevance rating 1.

Acronym	Project title	Start date	End date	Funding body	Project funding	Funding program
BeWiSeR	Joint project BeWiSer: Accompanying research project Hydrogen in Steel Production II **Website:** https://foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=03EW0030E **Contact:** info@fit.fraunhofer.de	01/07/2023	30/06/2026	Germany	€ 10.740.139	FOERDER
E-ECO Downstream	Development of heating technologies for the Efficient renewable Energy COnsumption of CO2-neutral DOWNSTREAM-processes **Website:** https://e-eco-downstream.eu/ **Contact:** e.ecodownstream@bfi.de	01/01/2025	30/06/2028	European Commission	€ 4.940.583	Horizon Europe
H2AL	Full-scale Demonstration of Replicable Technologies for Hydrogen Combustion in Hard to Abate Industries: The Aluminium use-case **Website:** https://h2al.ulb.be/ **Contact:** h2al@ulb.be	01/01/2024	31/12/2026	European Commission	€ 5.993.812	Horizon Europe
KlimPro – Subproject 6	Joint project KlimPro: Development of an innovative hydrogen-based furnace technology for the production of clay-ceramic materials (H2TO) - Subproject 6: Development of a hydrogen-powered tunnel kiln technology and commissioning of a pilot plant **Website:** https://foerderportal.bund.de/foekat/jsp/SucheAction.do?actionMode=view&fkz=01LJ2105F **Contact:** Not available	01/01/2023	31/12/2025	Germany	€ 1.679.989	FOERDER
LIFE23-CCM-IT-LIFE H2Reuse	Highly efficient and sustainable decarbonisation of bright annealing process by recovery and reuse of H2 **Website:** https://h2reuse.eu/en/h2reuse **Contact:** mauro.leali@dmvtubes.com	01/07/2024	31/12/2026	European Commission	€ 2.022.210	LIFE
SYRIUS	SOEC hydrogen integration and circular use in steelmaking process **Website:** https://syrius-project.eu/project/ **Contact:** syrius.eu.project@gmail.com	01/01/2025	30/06/2029	European Commission	€ 9.999.165	Horizon Europe
ZEUS	Zero Emissions throUgh Sectorcoupling **Website:** https://projekte.ffg.at/projekt/4822648 **Contact:** office@k1-met.com	02/10/2023	01/10/2027	Klima- und Energiefonds	N/A	Energieforschung

*Table 3: Indicative list of the 5 second most relevant projects to HyInHeat constituting those of second highest relevance in **stakeholder analysis 2** only (relevance 2).*

The second stakeholder analysis identified 5 projects with relevance rating 2.

Acronym	Project title	Start date	End date	Funding body	Project funding	Funding program
AgiFlex	Agent-based models minimizing carbon usage in flexible and efficient future integrated steelworks **Website:** https://cordis.europa.eu/project/id/101138813 **Contact:** agiflexproject@gmail.com	01/12/2023	30/11/2028	European Commission	€ 4.691.795	Horizon Europe
DCMH	Development of a new generation detailed hydrogen combustion mechanism **Website:** https://cordis.europa.eu/project/id/101152035 **Contact:** N/A	01/06/2024	31/05/2026	European Commission	€ 157.622	Horizon Europe
HELIOS	The adoption of hydrogen metallurgy in the climate-neutral production of steel **Website:** https://helios-dn.eu/ **Contact:** info@helios-dn.eu	01/10/2023	30/09/2027	European Commission	€ 2.716.898	Horizon Europe
HERC	Reducing natural gas needs and carbon emissions in industrial usage and transforming industry towards hydrogen with HERC, a novel plasma-assisted combustion (PAC) **Website:** https://cordis.europa.eu/project/id/190188980 **Contact:** info@efenco.eu	01/02/2023	31/07/2025	European Commission	€ 2.496.592	European Innovation Council (Horizon Europe)
RESPOND2030	Regional Energy System Pathways for decarbONised inDustry 2030 **Website:** https://prosjektbanken.forskningsradet.no/en/project/FORISS/352992 **Contact:** info@sintef.no	01/01/2025	31/12/2028	Norway	€ 951.722	Research Council of Norway

5.1.2 Stakeholder Analysis 1

Table 4: Indicative list of the 19 most relevant projects to HyInHeat constituting those of highest relevance in stakeholder analysis 1 only ***(relevance 1****).*

The first stakeholder analysis identified 19 projects with relevance rating 1.

Acronym	Project title	Start date	End date	Funding body	Project funding	Funding program
CESAREF	Concerted European action on Sustainable Applications of REFractories **Website:** https://www.cesaref.eu/ **Contact:** marc.huger@unilim.fr	01/10/2022	30/09/2026	European Commission	€ 4.103.866	Horizon Europe
ENCODING	ENabling sustainable COmbustion technologies using hybrid physics-based Data-driven modelING **Website:** https://encoding.ulb.be/ **Contact:** Currently unavailable	01/01/2023	31/12/2026	European Commission	€ 2.645.172	Horizon Europe
FlexHeat2Anneal	Joint project: Flexible use of hydrogen on continuous annealing lines and hot-dip coating plants in the steel industry to reduce CO2 emissions. **Website:** https://www.iob.rwth-aachen.de/en/projects/flexheat2anneal/ **Contact:** busson@iob.rwth-aachen.de	01/04/2022	31/03/2025	Germany	€ 817.144	FOERDER
FRIS study	Revealing the effect of inhibitors on gaseous hydrogen uptake and related hydrogen embrittlement of steels **Website:** https://research.ugent.be/project/ **Contact:** Kim.Verbeken@UGent.be	01/10/2021	31/08/2027	Belgium	N/A	Research Foundation Flanders
FullH2ReHeat	Demonstrator of Industrial Transformation with Hydrogen for HAV long products rolling mills **Website:** EU Funding & Tenders Portal **Contact:** Currently unavailable	01/02/2023	31/07/2027	European Commission	€ 8.176.592	RFCS Big Ticket
GreenHeatEAF	Gradual integration of REnewable non-fossil ENergy sources and modular HEATing technologies in EAF for progressive CO2 decrease **Website:** https://www.estep.eu/greenheateaf/ **Contact:** secretariat@steelresearch-estep.eu	01/01/2023	30/06/2026	European Commission	€ 3.564.245	Horizon Europe
H2-DisTherPro	Avoidance of CO2 emissions in the steel industry through the use of hydrogen at discontinuously operated thermal process plants using the example of hood annealing. **Website:** https://www.bfi.de/en/projects/h2-distherpro/ **Contact:** sebastian.bialek@bfi.de	01/04/2022	31/03/2025	Germany	€ 916.747	FOERDER

H2GLASS	Advancing Hydrogen (H2) technologies and smart production systems TO decarbonise the GLass and Aluminium SectorS **Website:** https://www.h2glass.com/ **Contact:** info@h2glass.com	01/01/2023	31/12/2026	European Commission	€ 31.862.996	Horizon Europe
H2Stahl	Joint project: Real-world laboratory: H2Stahl - Hydrogen technologies for the gradual decarbonisation of the steel industry, Sub-project: Research project for the hydrogen blast furnace **Website:** https://h2steelproject.eu/ **Contact:** david.chiaramonti@polito.it	01/09/2021	31/08/2026	Germany	€ 37.127.085	FOERDER
H2STEEL	Green H2 and circular bio-coal from biowaste for cost-competitive sustainable Steel **Website:** https://h2steelproject.eu/ **Contact:** david.chiaramonti@polito.it	01/10/2022	30/09/2025	European Commission	€ 2.368.910	Horizon Europe
HYBRIT	Hydrogen Breakthrough Ironmaking Technology **Website:** https://www.hybritdevelopment.se/en/ **Contact:** fossilfree@ssab.com	01/01/2020	31/12/2026	European Commission	€ 143.000.000	Innovation Fund
HYDROGENATE	Hydrogen-Based Intrinsic-Flame-Instability-Controlled Clean and Efficient Combustion **Website:** https://www.rwth-aachen.de/EU-Projekte/HYDROGENATE/ **Contact:** h.pitsch@itv.rwth-aachen.de	01/06/2022	31/05/2027	European Commission	€ 2.498.727	Horizon Europe
HyDreams	Clean Hydrogen and Digital tools for Reheating And heat treatment for Steel **Website:** EU Funding & Tenders Portal **Contact:** info@ugitech.com	01/04/2023	30/09/2027	European Commission	€ 4.022.211	RFCS Big Ticket
HyInnoBurn	HYDROGEN: Industrial gas burner development for natural gas-hydrogen mixtures (HyInnoBurn) **Website:** https://dap-aachen.de/en/hyinnoburn-project **Contact:** sebastian.bold@dap.rwth-aachen.de	01/10/2021	30/09/2024	Germany	€ 720.096	FOERDER
HyTecHeat	HYbrid TEChnologies for sustainable steel reheating **Website:** https://www.hybritdevelopment.se/en/ **Contact:** fossilfree@ssab.com	01/12/2022	31/05/2026	European Commission	€ 3.357.137	Horizon Europe
MODIPLANT	MODular hybrid technology in the Steel PLANT production **Website:** https://www.modiplant.eu/ **Contact:** edoardo.damanzo@rina.org	01/03/2023	31/08/2027	European Commission	€ 7.973.731	RFCS Big Ticket
RecHycle	Recycling renewable hydrogen for climate neutrality **Website:** https://www.rechycle.eu/ **Contact:** contact.belgium@arcelormittal.com	01/06/2022	31/05/2026	European Commission	€ 6.226.743	Horizon Europe
SCIROCCO	Simulation and Control of Renewable COmbustion (SCIROCCO) **Website:** https://www.scirocco-project.eu/ **Contact:** info@scirocco-project.eu	01/10/2019	30/09/2024	European Commission	€ 2.495.335	Horizon 2020

TWINGHY	Digital Twins for Green Hydrogen Transition **Website:** https://twinghy.eu/ **Contact:** info@celsagroup.com	01/02/2023	01/07/2027	European Commission	€ 4.287.660	RFCS Big Ticket

*Table 5: Indicative list of the 8 second most relevant projects to HyInHeat constituting those of second highest relevance in stakeholder analysis 1 only (**relevance 2**).*

The first stakeholder analysis identified 8 projects with relevance rating 1.

Acronym	Project title	Start date	End date	Funding body	Project funding	Funding program
4FH2Max	Optimization of the existing combustion system of the Siemens Energy Gas Turbine 4000F for safe operation with hydrogen content >50% vol for CO2 emission reduction **Website:** https://www.enargus.de/detail/?id=10541148 **Contact:** Currently unavailable	01/10/2022	30/09/2026	Germany	€ 2.592.433	FOERDER
BREINSTORM	Boosting Reduction of Energy Intensity in cleaN STeelwork platfORM **Website:** https://gtr.ukri.org/projects?ref=EP/S030654/1 **Contact:** Currently unavailable	30/06/2019	29/06/2023	United Kingdom	€ 991.692	Engineering and Physical Sciences Research Council (EPSRC)
CABEZO GREENH2	MW-scale green hydrogen production plant to decarbonize the treatment of meat residuals in Spain **Website:** https://www.lifecabezogreenh2.eu/ **Contact:** msanchezd@enagas.es	01/07/2021	31/12/2024	European Commission	€ 2.509.072	LIFE programme
HyNet	Essar Oil UK Stanlow Refinery net zero ready furnace replacement **Website:** https://hynet.co.uk/ **Contact:** info@hynet.co.uk	30/04/2021	29/04/2023	United Kingdom	€ 8.223.843	Local Enterprise Partnerships (LEPs)
HYPER	An electrochemically produced oxidiser for modular, onsite generation of HYdrogen PERoxide **Website:** https://www.lifecabezogreenh2.eu/ **Contact:** msanchezd@enagas.es	01/01/2023	31/12/2026	European Commission	€ 7.254.450	Horizon Europe
MegaSyn	Megawatt scale co-electrolysis as syngas generation for e-fuels synthesis **Website:** https://www.megasyn.eu/ **Contact:** minc@dtu.dk	01/04/2021	31/03/2025	European Commission	€ 4.999.449	Horizon 2020
MultiPLHY	Multimegawatt high-temperature electrolyser to generate green hydrogen for production of high-quality biofuels **Website:** https://multiplhy-project.eu/ **Contact:** Currently unavailable	01/01/2020	31/12/2024	European Commission	€ 6.993.725	Horizon 2020
TRUFLOW	TRansfers at tiny scales in tUrbulent multiphase FLOW	01/06/2020	31/05/2025	European Commission	€ 2.490.585	Horizon 2020

5.2 Project scheduling

Figure 5 and Figure 6 list the projects mentioned in 5.1 Relevant projects to HyInHeat from Stakeholder Analyses 2 and 1

5.1.1 Stakeholder Analysis 2

Table 2, 3, 4 and 5 in a horizontal scheduling view, respectively. HyInHeat is listed at the top with a project duration of 48 months, where each of the other relevant projects' duration is shown in parallel. As a part of the communication, dissemination and exploitation strategy a final event will be organized in Brussels in M45 of the project, where other projects might be invited to attend. For this purpose, utilizing the scheduling view above it is possible to more easily identify to which events a project is able to attend or most likely interested to participate.

5.2.1 Stakeholder Analysis 2

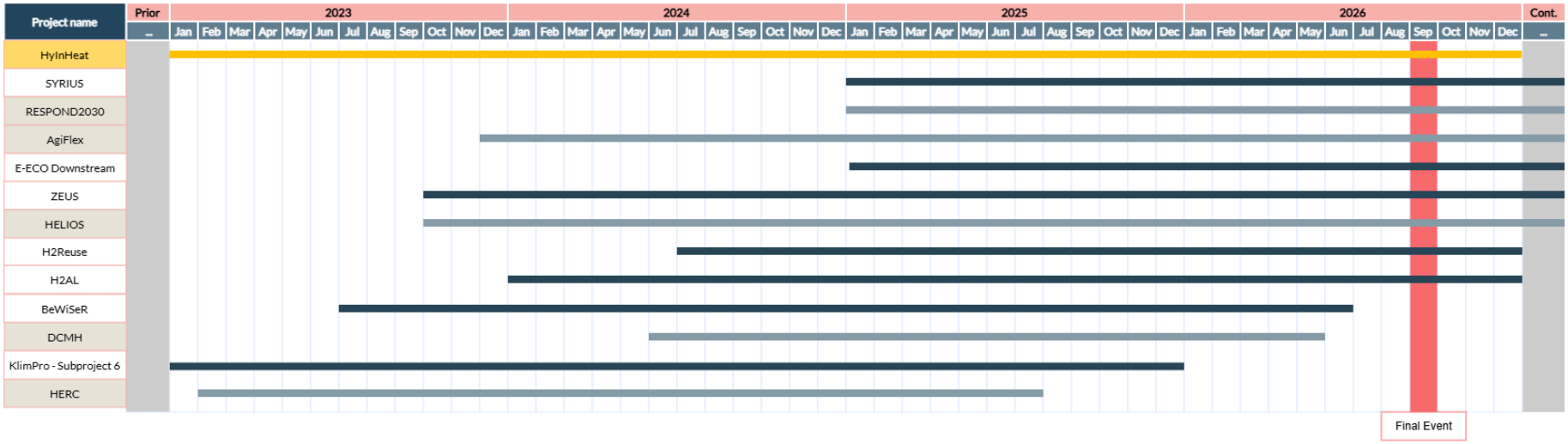

*Figure 5: Scheduling view of the top 12 most relevant projects to engage with, from **stakeholder analysis 2** (white/dark blue = relevance 1 projects, brown/light grey = relevance 2 projects). The final event of the project is expected to take place in M45 in Brussels, where other potential projects might be invited to join.*

5.2.2 Stakeholder Analysis 1

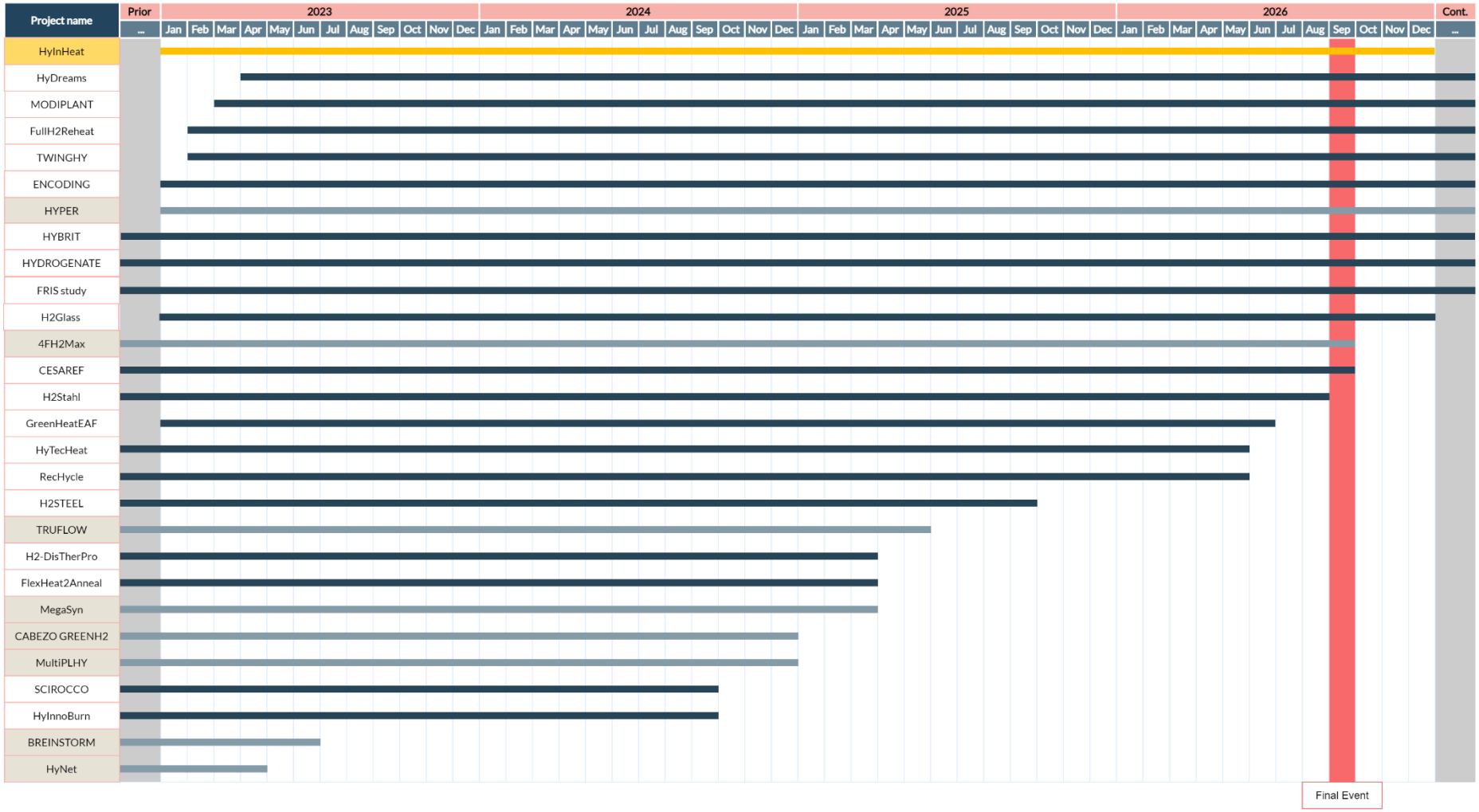

*Figure 6: Scheduling view of the top 27 most relevant projects to engage with, from **stakeholder analysis 1** (white/dark blue = relevance 1 projects, brown/light grey = relevance 2 projects). The final event of the project is expected to take place in M45 in Brussels, where other potential projects might be invited to join.*

5.3 Most active stakeholders in projects

In order to identify the most central stakeholders for HyInHeat to engage with from the relevant projects, both relevance 1 and relevance 2 from stakeholder analyses 1 and 2 were combined into a total of 39 Highest Relevance Projects (HRP). Look at the distribution at a geographic level gives insights into where the partners in other projects are located (see Figure 7). Among the 245 participants in the HRP, the majority comes from Germany, second being Italy, followed by France, Austria and Sweden. Many European countries engage in diverse partnerships for projects within HyInHeat's value chain, although several countries do so to a lesser extent than those mentioned above.

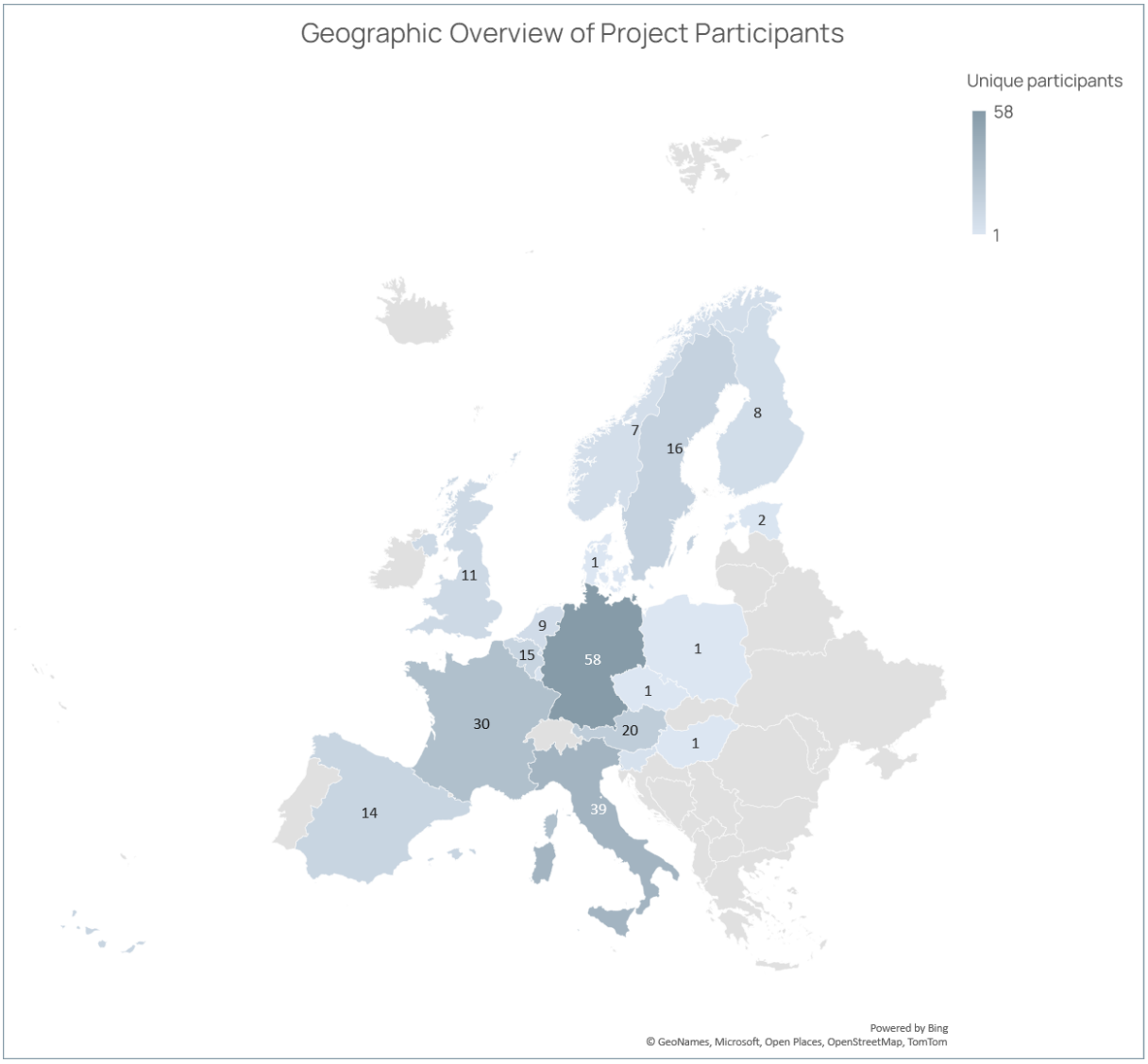

Figure 7: Geographic overview of where the most participant countries originate. Not shown on the map is that one project partner each from Canada, Hong Kong SAR, and Republic of Korea was also in the data. It should be made clear that one organization can appear multiple times in the data; for example RWTH-Aachen participated in 7 of the HRP and so was also mentioned 7 times in the data.[1]

Analyzing this information further we can process the partners with the most participation in the HRP into a reference graph. This is done by extracting participation information and seeing how many unique projects that partner participates in. For the purpose of this analysis we have excluded any participants that have 1

[1] Participants involved in a project with entities from multiple countries are counted once for each country. Participants involved with multiple entities from the same country in a project are counted only once for that country.

project participation, as well as excluding any partners that are already involved in HyInHeat (see

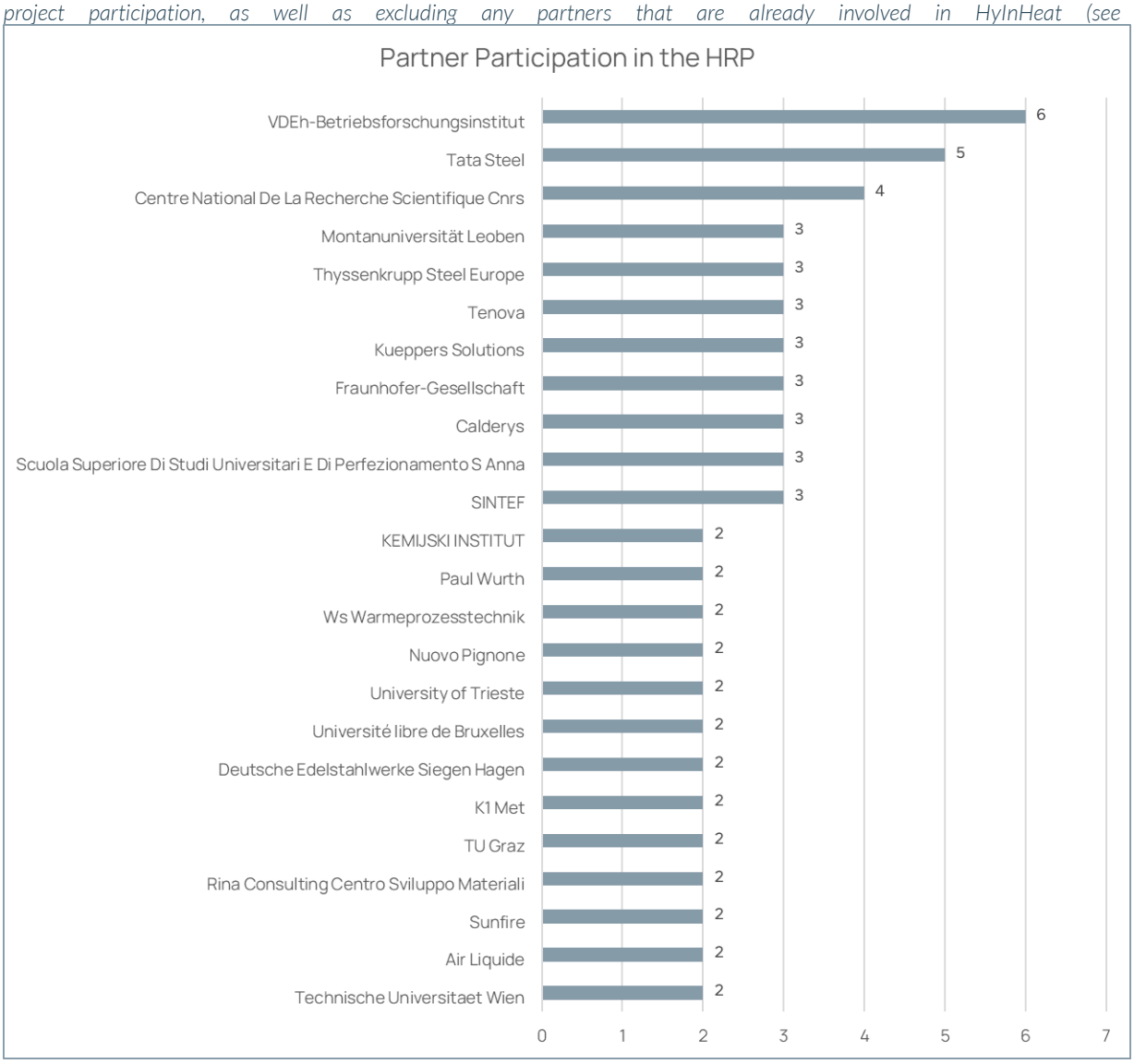

Figure 8). From the analysis we can synthesize a new table of relevant stakeholders for HyInHeat to engage with based on project stakeholders.

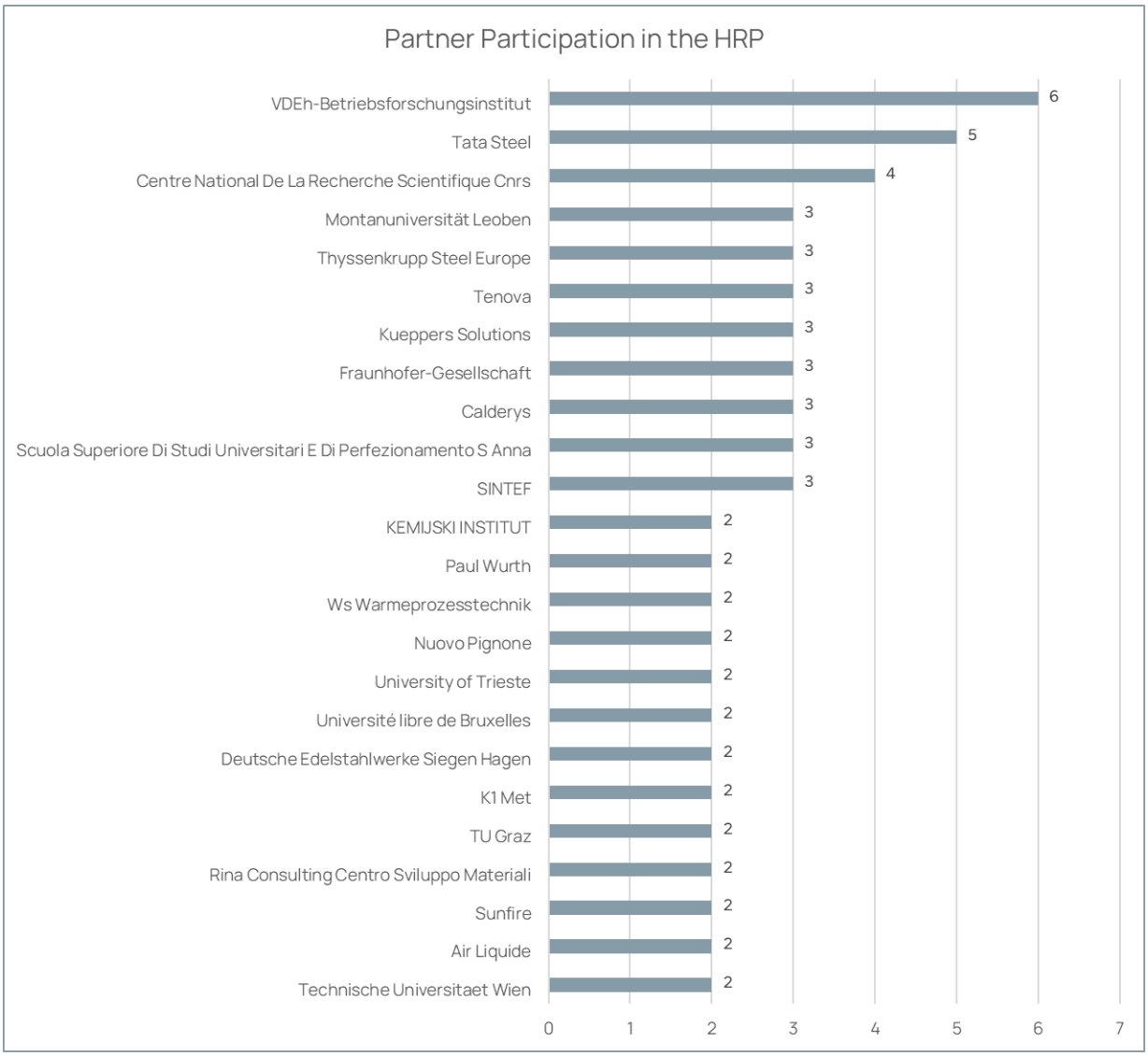

Figure 8: Partner participation among the Highest Relevance Projects (HRP) for HyInHeat, and with participation of >1 projects. Only partners that are currently not involved in HyInHeat are displayed.[2]

[2] Participants involved with multiple entities in one project (e.g., entities from different countries) are counted only once per project.

5.3 Stakeholder tables from projects analysis

The following tables gives a brief overview of identified stakeholders based on the top participants (participating in ≥ 3 projects) from

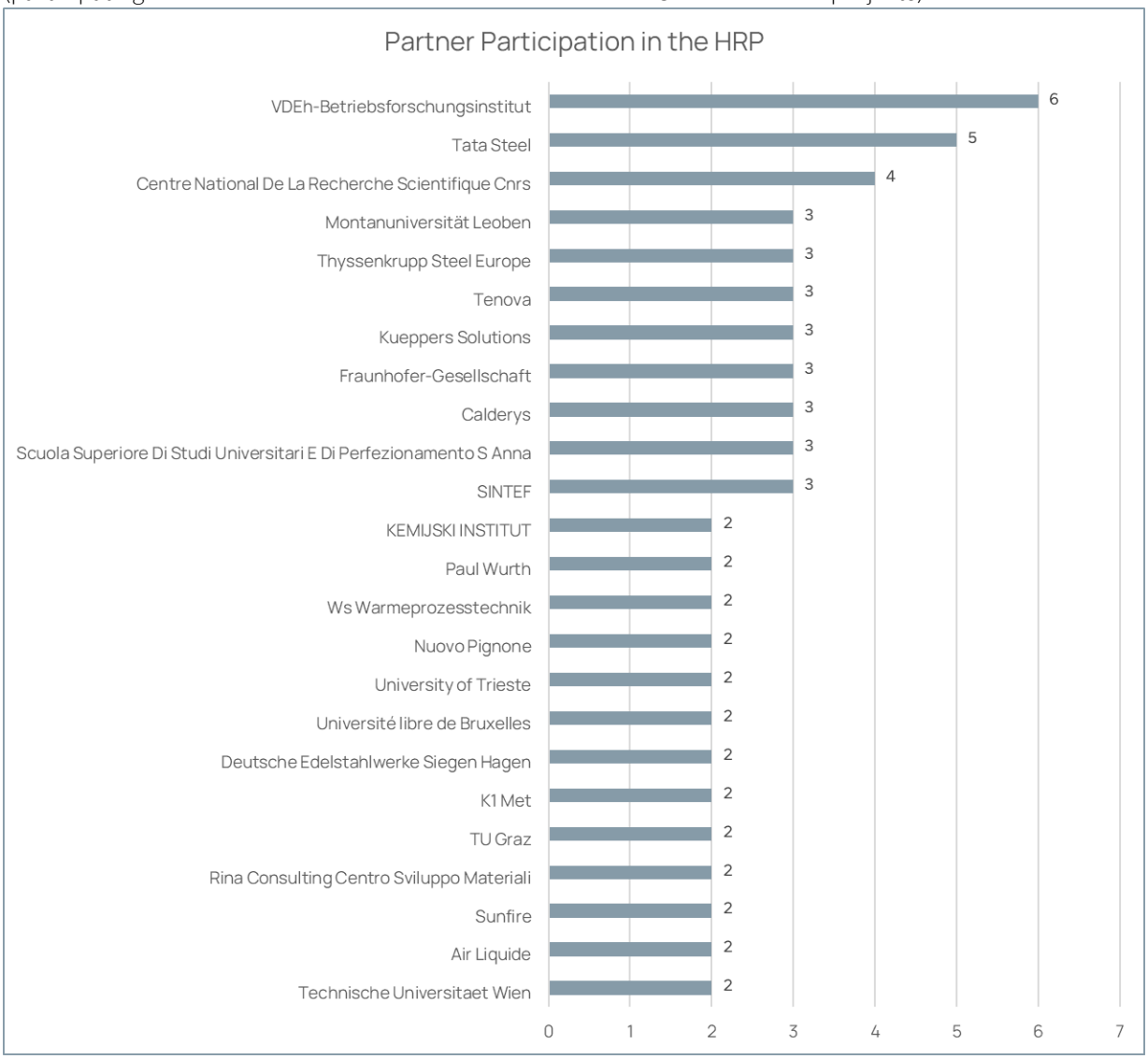

Figure 8. Each table contains some general information about the stakeholder, such as industry type, country and brief description. As previously mentioned, the tables do not include any stakeholders that are already a HyInHeat partner.

5.3.1 Stakeholder Analysis 2

This section contains stakeholders that were identified in this second version of the stakeholder analysis.

Table 6: Stakeholder table – Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna.

Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna	
Type:	University
Country	Italy

Website	https://www.santannapisa.it/en/
Description	Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna in Pisa is an Italian public university institute that focuses on applied sciences and interdisciplinary research. Its areas of activity include engineering, robotics, medicine, law, economics, and agricultural sciences. The school combines education with research and maintains collaborations with both public institutions and industry.

Table 7: Stakeholder table – Calderys

Calderys	
Type:	Multinational company
Country	France
Website	https://calderys.com/
Description	Calderys is a French technology provider specializing in refractory materials and engineered solutions for high-temperature industrial processes. The company designs, manufactures, and installs refractory linings and thermal protection systems used in furnaces, kilns, and reactors across sectors such as steel, cement, foundry, and energy.

Table 8: Stakeholder table – Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung	
Type:	Research institute
Country	Germany
Website	https://www.fraunhofer.de/en.html
Description	The Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung is a German applied research organization consisting of multiple institutes across the country. Its activities cover a wide range of scientific and engineering disciplines, including materials science, energy, manufacturing, information technology, and life sciences. It focuses on applied research and technology transfer in cooperation with industry and public institutions.

Table 9: Stakeholder table – Kueppers Solutions GmbH

Kueppers Solutions GmbH	
Type:	Multinational company
Country	Germany
Website	https://www.kueppers.solutions/
Description	Kueppers Solutions is a German company that develops industrial burners and heating systems. Its work includes solutions for hydrogen combustion and technologies aimed at reducing emissions and increasing energy efficiency in industrial heating processes.

Table 10: Stakeholder table – Tenova

Tenova	
Type:	Multinational company
Country	Italy
Website	https://tenova.com/

Description	Tenova is an Italian technology provider that develops sustainable solutions and equipment for the metals and mining industries. The company offers advanced technologies for iron and steel production, including electric arc furnaces, heat treatment systems, and automation for process optimization and energy efficiency.

Table 11: Stakeholder table – Thyssenkrupp Steel Europe

Thyssenkrupp Steel Europe	
Type:	Multinational company
Country	Germany
Website	https://www.thyssenkrupp-steel.com/de/
Description	Thyssenkrupp Steel Europe is a subsidiary of the German industrial conglomerate Thyssenkrupp AG, which operates globally across engineering, materials, and industrial technologies. The company is one of Europe's largest producers of flat carbon steel, serving sectors such as automotive, construction, energy, and packaging.

Table 12: Stakeholder table – Montanuniversität Leoben

Montanuniversität Leoben	
Type:	University
Country	Austria
Website	https://www.unileoben.ac.at/
Description	Montanuniversität Leoben is a technical university in Austria that specializes in mining, metallurgy, materials science, and related engineering fields. It conducts research and provides education on resource management, sustainable industrial processes, and new technologies including hydrogen applications.

5.3.1 Stakeholder Analysis 1

This section contains stakeholders that were already identified in the first version of the stakeholder analysis.

Table 13: Stakeholder table – SINTEF.

SINTEF AS	
Type:	Research institute
Country	Norway
Website	https://www.sintef.no/en/
Description	SINTEF is the leading research organization in Norway, providing innovative solutions across various sectors. They focus on sustainable development, digitalization and social well-being, and is known for collaborating with industry, academia and government to advance technology. They provide a supporting role to industry through high-quality research and commitment to knowledge generation.

Table 14: Stakeholder table – VDEh Betriebsforschungsinstitut GmbH

VDEh Betriebsforschungsinstitut GmbH	
Type:	Research institute
Country	Germany
Website	https://www.bfi.de/en/
Description	VDEh Betriebsforschungsinstitut is connected to the steel industry, especially through their shareholder, the Steel Institute VDEh, enabling a wide reach to its associations

	and federations. They tackle relevant topics in energy efficiency, process optimization, measurement technology and Industry 4.0 and make them the focal points of their work.

Table 15: Stakeholder table – CNRS.

Centre national de la recherche scientifique (CNRS)	
Type:	Research institute
Country	France
Website	https://www.cnrs.fr/fr
Description	The CNRS is a renowned research institution and is the largest governmental research organization in France. It conducts fundamental research across various disciplines with a vast network of research laboratories and partnerships nationally and internationally. The CNRS aims to foster scientific excellence and contribute to advancing knowledge, innovation and societal progress.

Table 16: Stakeholder table – Engie.

Engie	
Type:	Multinational company
Country	France
Website	https://www.engie.com/
Description	Engie is headquartered in France but operates globally. It is a major player in the energy sector and is investing in sustainable technologies for decarbonization. They focus on three areas of business: electricity, natural gas, and energy services. Engie has expertise in innovation to provide clean, reliable, and affordable energy solutions to its customers.

Table 17: Stakeholder table – Tata Steel.

Tata Steel	
Type:	Multinational company
Country	India
Website	https://www.tatasteel.com/
Description	Tata Steel is a subsidiary of the Indian conglomerate Tata Group, and is one of the world's largest steel producers. The company operates globally and serve many sectors including automotive, construction, infrastructure, packaging and engineering. It is renowned for high-quality steel products combined with innovative solutions. It is a well-established and trusted name in the global steel market.

Table 18: Stakeholder table – Neste.

Neste	
Type:	Multinational company
Country	Finland
Website	https://www.neste.com/

Description	Neste is a leading producer of renewable fuels, chemicals, and sustainable solutions. It has a strong sustainability focus, such as in transforming waste and residue materials into renewable products or enabling production of high-quality renewable fuels.

6 Patent analysis of Y02P10/134

An analysis of a corpus of patents was performed as described in above. Every patent document, application and granted patent is listed in the CPC database with its own classification code. This code indicates which specific area of technology the patent is relevant for. It should be noted, however, that one patent may be filed under one or multiple classification codes, which has been accounted for in this analysis through cross-referencing. The following patent CPC classification code was chosen for analysis due to its very close proximity to project activities:

Y02P10/134 - Technologies related to metal processing by avoiding CO_2, e.g. using hydrogen

Based on the overall topic of the HyInHeat project, Y02P10/134 was selected as the patent CPC classification code for this analysis and entails reduction of greenhouse gas emissions such as through hydrogen usage in the metal processing industry. The selected code was based on the patent corpus subgroups available, and is illustrated in Figure 99. A total of five corpus patent categories were traversed to get to the corpus of patents. Once the CPC code was identified, a search was performed which resulted in a total of 18,881 results under this corpus. Certain patents, however, occur multiple times in the data due to the filings at multiple patent offices. When controlling for patent families and excluding patent search reports[3], a total of 3,259 unique patents were identified. This number reflects the number of patents since the start of data collection around 1900 until 21/10/2025.

These results were thereafter exported to Excel for analysis.

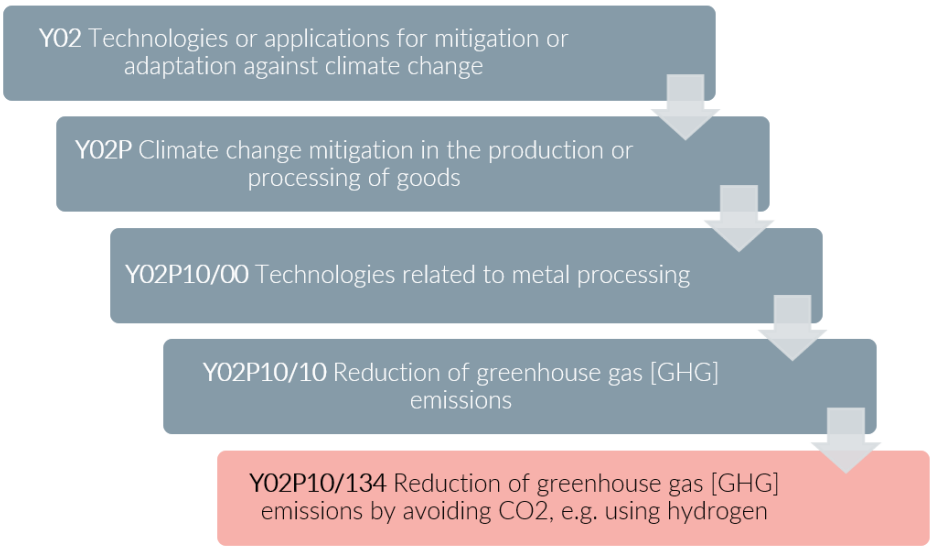

Figure 9: The selection of a corpus of patents entails navigating multiple sub groups to find the corpus of highest relevance. For HyInHeat this was identified to be Y02P10/134.

This patent corpus encompasses technologies related to metal processing by avoiding CO_2, e.g. using hydrogen, and was selected due to its close proximity to the overall aims of the HyInHeat project. The data from this CPC code was extracted using WheesBee and thereafter analyzed providing basis for a patent analysis.

To analyze the innovation activity by country and organization throughout time using patent data, the priority claim country and priority claim dates have been chosen as key measures, as opposed to the patent offices and publication dates. This is because the priority information reflects where and when an invention was first filed, providing a more accurate indication of the origin and timing of the underlying innovation rather than the administrative processes of subsequent filings or publications.

[3] The patent data from the Wheesbee tool includes patent search reports. These do not constitute patent applications; therefore, 170 results consisting solely of patent search reports were omitted from the dataset.

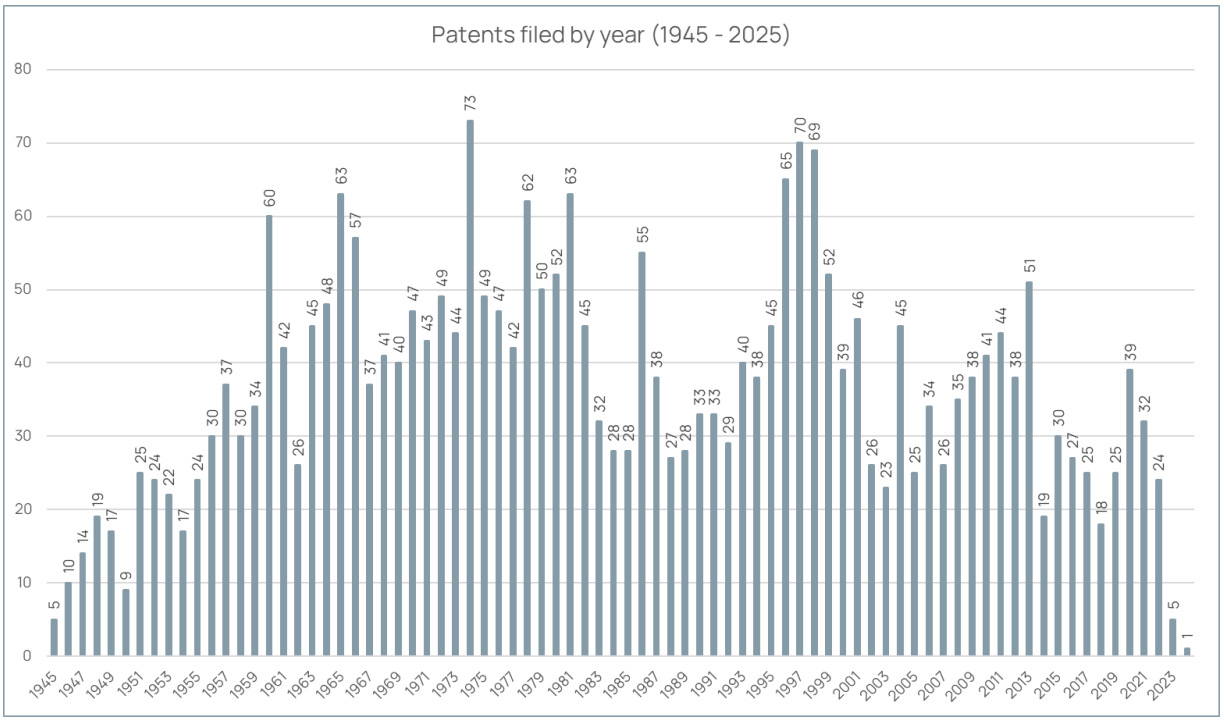

Figure 10: Data visualization of all patents posted under Y02P10/134 from 1945 up until 2025.[4]

Firstly, we visualise the total number of patents filed each year (Figure 10). The data includes records of patent filings dating back to 1904. However, up until the post–World War II period, there was minimal activity. Therefore, results prior to 1946 have been excluded.

The data shows a clear pattern of increasing filings around 1956, followed by a more pronounced rise starting around 1960, reaching a distinct peak in 1974. Thereafter, the overall number of filings appears to have declined until around 1993, after which patent filings peaked again around 1997, and to a lesser extent, in 2013. Since then, the overall number of filings has gradually declined once more. It is important to note that the data for 2023, 2024, and 2025 are incomplete. A significant number of patent applications from these years are still pending publication and are therefore not included in the dataset.

A first step to understand this data better is to look at the priority claim countries of the patents filed under this patent corpus. We can do this by visualising the top 10 priority claim countries of the filed patents under the Y02P10/134 CPC-code since 1946.

[4] The vast majority of patents filed in 2023 and later are not included due to the publication lag inherent in patent databases. Therefore, no conclusions can be drawn from patent data covering those years.

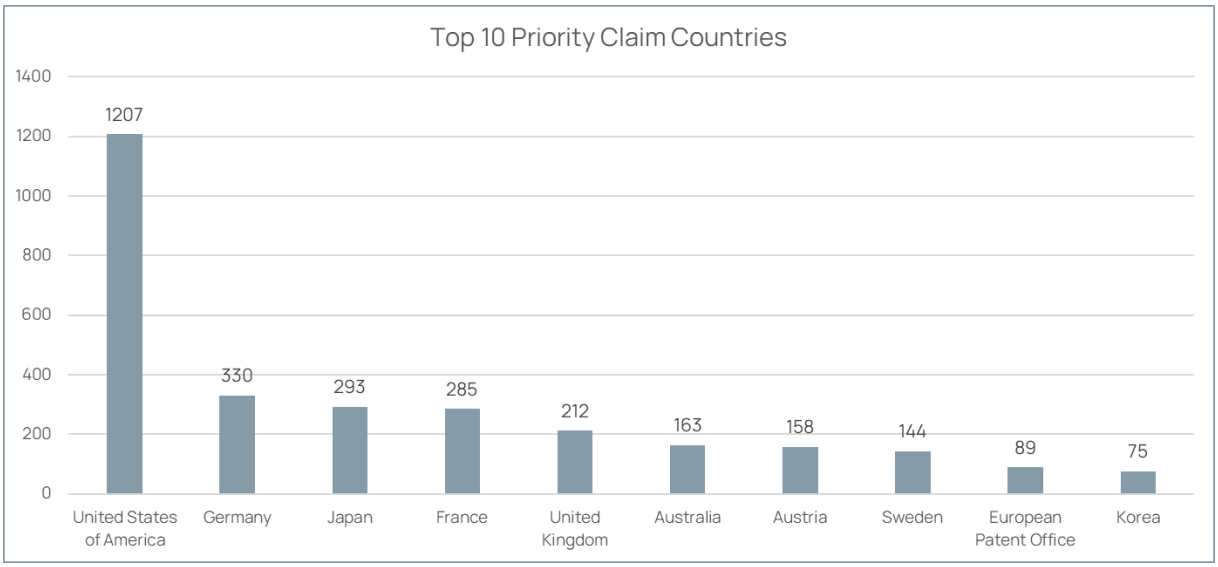

Figure 11: Top 10 priority claim countries for registered patent filings under Y02P10/134. The United States leads in the number of filings, followed by strong activity from several European countries, Japan, and Australia.

Figure 11 shows that the United States is the most active nation in terms of priority claims for registered patent filings under Y02P10/134, with Japan, Australia, and several European countries following at a distance. In this report, however, we focus on analysing European patent activity as a whole rather than that of individual European countries. This decision was made because the objective of the analysis is to compare Europe's collective innovation performance to other regions, rather than to compare individual European countries. When combining all patents filed through the European Patent Office and the national patent offices of its member states[5], a different picture emerges. As shown in Figure 12, Europe collectively leads in the number of registered patent filings under Y02P10/134. The United States follows closely, while Japan, Australia, and China remain further behind. The low number of patents filed with China as a priority claim country is somewhat unexpected, given China's prominent industrial activity, including the metal processing industries.[6] A possible explanation is given further below.

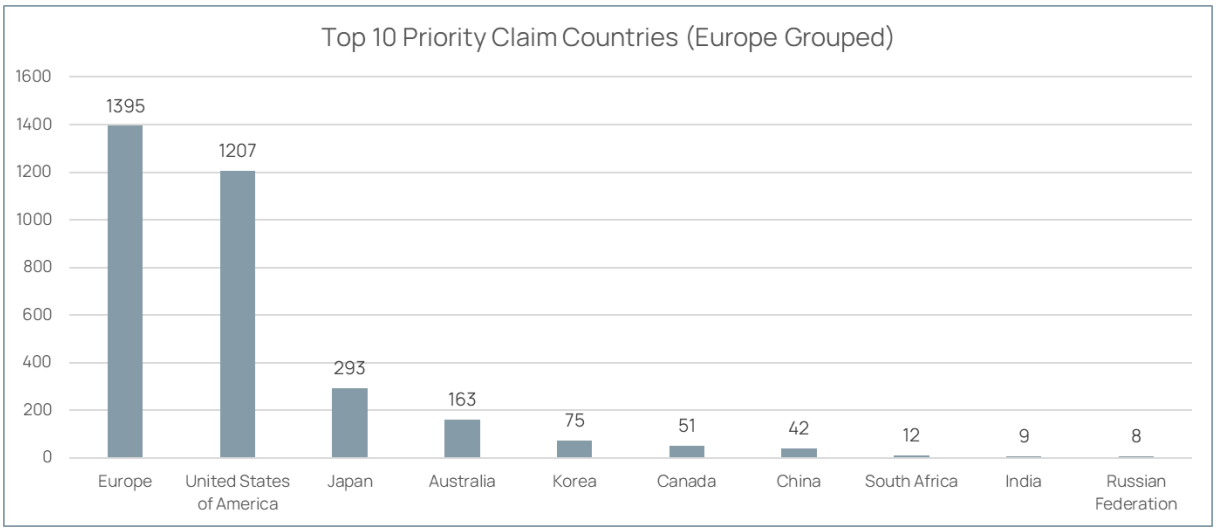

Figure 12; Top 10 priority claim countries for registered patent filings under Y02P10/134, with Europe as a single region consisting of patents with a priority claim of the EPO or any of its member countries.

[5] Patents can have multiple priority claim countries. If a single patent listed several European countries among its priority claims, it was counted only once as a European patent to avoid double counting.

[6] For example, many Chinese companies rank among the world's 15 largest steel producers by production volume, with China's Baowu Group being the largest in the world. Source: Leading steel producers worldwide 2024| Statista

To further understand the patent activity of different countries, we compare Europe's patent activity over the years with that of three other countries with notable activity: the United States, Japan, and Australia. We also include China in the comparison, given its prominent position in the metal processing industries.

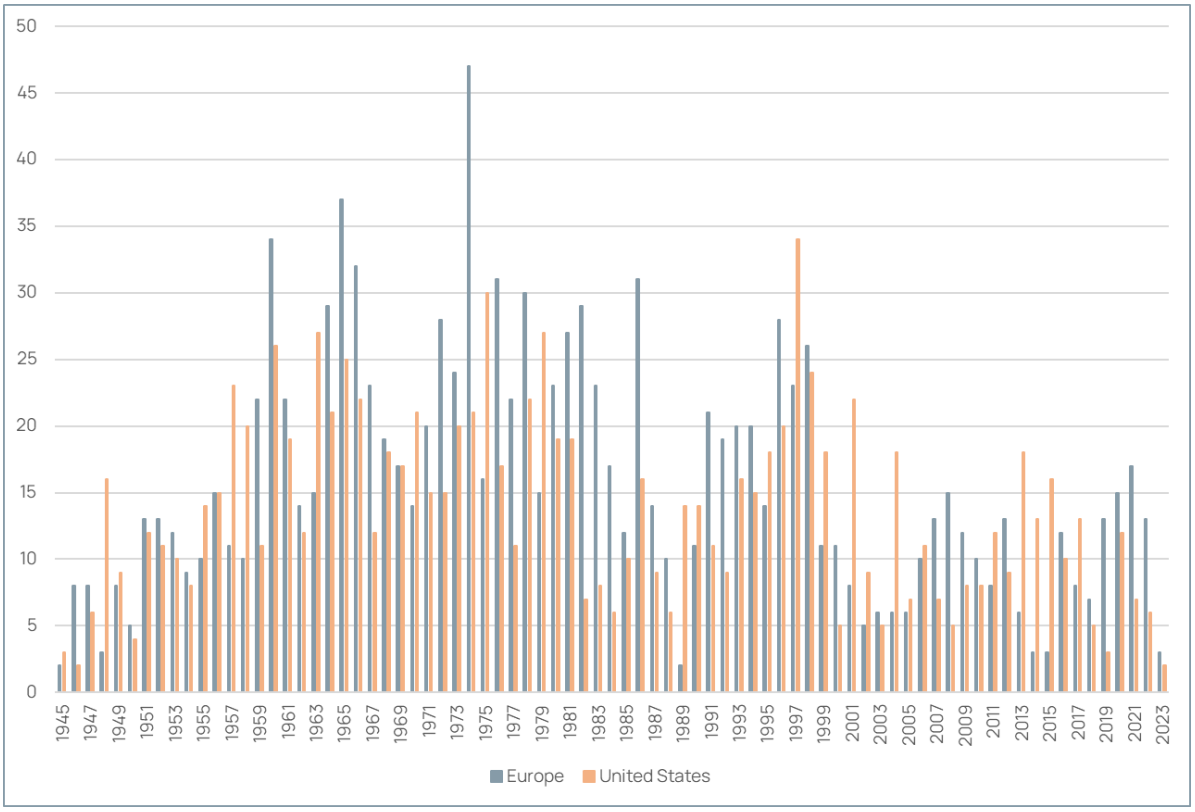

Figure 13: Europe compared to the United States under patent Y02P10/134.

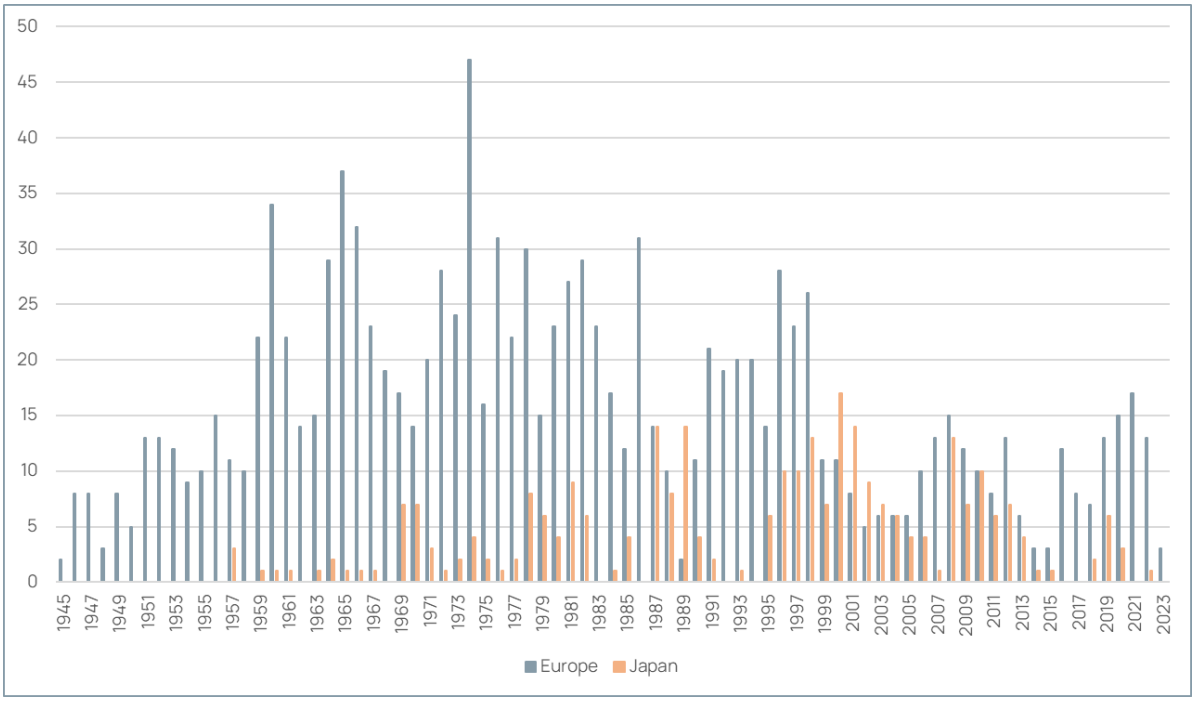

Figure 14: Europe compared to Japan under patent Y02P10/134.

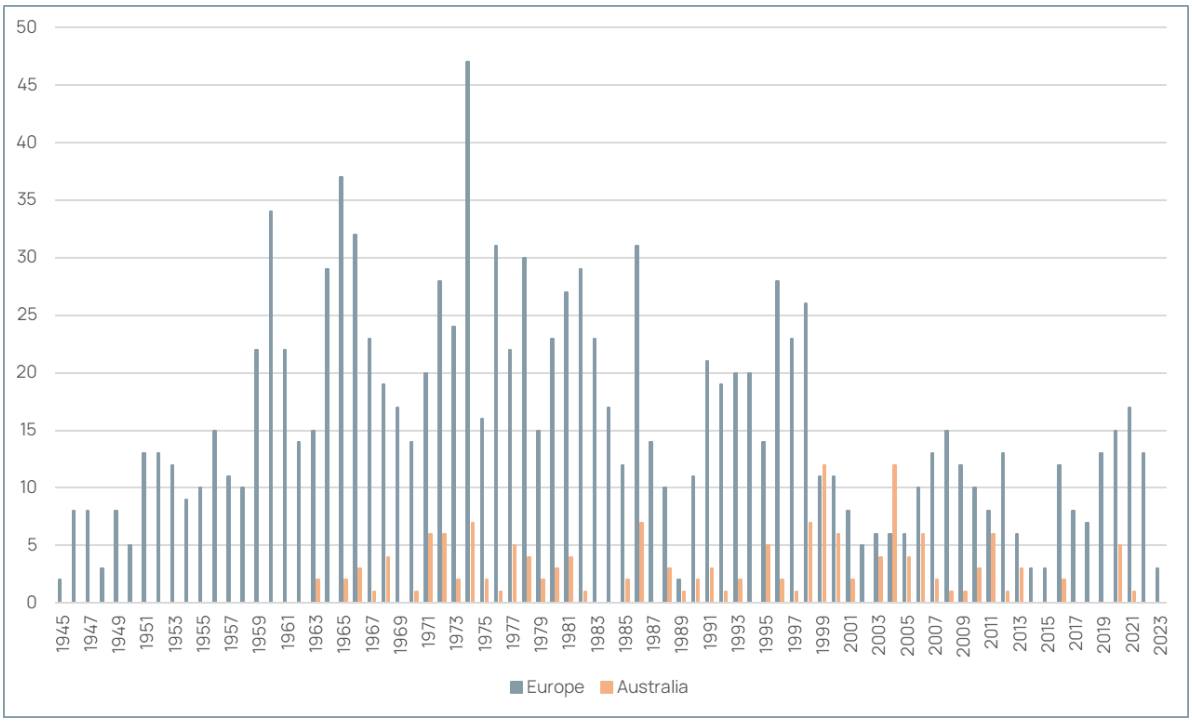

Figure 15: Europe compared to Australia under patent Y02P10/134.

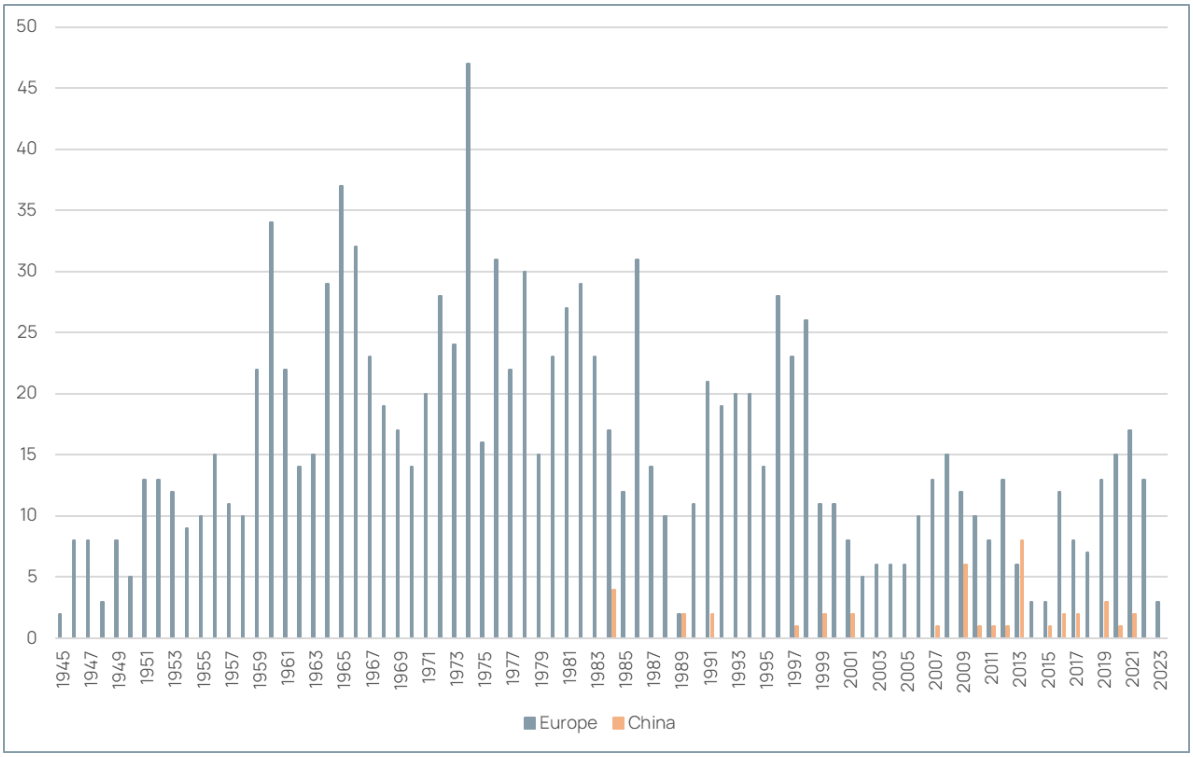

Figure 16: Europe compared to China under patent Y02P10/134.

When comparing European patent activity with that of the United States, we observe broadly similar trends. Both Europe and the United States began patenting under corpus Y02P10/134 in a more structured manner around 1955, with European patent activity reaching a distinct peak in 1974. Thereafter, both regions reduced their patent activity under this corpus before picking it up again around 1995. This pattern aligns with the overall patent activity trends observed for this corpus. In recent years, Europe and the United States have displayed comparable levels of activity, with between five and fifteen patents filed annually under the corpus.

Japan and Australia show somewhat similar patterns of patent activity, with filings beginning in the 1960s and peaking around the 2000s, followed by a gradual decline. While the overall trends for Japan and Australia are similar, Japan is the priority claim country for significantly more patents than Australia, as shown earlier in Figure 12. China, on the other hand, is not listed as the priority claim country for many patents.

A small number of patents with China as the priority claim country were filed in 1984 and sporadically thereafter. Since 2009, however, patent filings with China as the priority claim country have become more consistent, although still in much smaller quantities than those of the major industrial competitors. A possible explanation for this somewhat unexpected finding could be China's later adoption of hydrogen-based decarbonization strategies, which may have resulted in many foundational patents already being secured by organizations from other countries.[7] Another explanation could be that domestic Chinese patents may not always receive CPC codes. The CPC is a more detailed classification system than the IPC and is jointly developed and applied by the EPO and USPTO. While the CPC is widely used within these offices, an EPO study found that only about one third of the patent families classified in the IPC were also classified in the CPC, and that most of the families not classified in the CPC were national applications filed at the major Asian offices, including SIPO (China's patent office). The study further estimated that only around 16% of Chinese patent documents were classified in the CPC as of 2017. Although this percentage is likely to be higher in 2025, the incomplete CPC coverage of Chinese filings may still help explain the relatively small number of Chinese patents observed in the dataset, especially for patents filed prior to the introduction of the CPC in 2013.[8]

A possible reason for the decline over the past decade may be that the technologies developed around the 1997 and 2013 peaks have reached maturity and are now well-established in the applications where they were previously tested. These technologies are currently being deployed and utilized, resulting in fewer new patent investments compared to the previous two decades. However, this does not exclude the possibility of a new wave of innovative activity that could lead to future peaks in patent filings under corpus Y02P10/134, as occurred following the gradual decline in patent filings between 1982 and 1995. To understand which companies may have the innovative capacity to contribute to this, it is valuable to identify the stakeholders that have developed most of these patents, in order to assess where the majority of the intellectual property resides.

Looking at the top 10 patent filers in this particular corpus of patents, there are several stakeholders with significant patent activity. Figure 17 indicates that both Midrex Corporation and Voestalpine Stahl have significant intellectual property, followed by Esso/Exxon, Technological Resources, Kobe Steel and Pohang Iron & Steel. It must be noted that Metallgesellschaft AG is a former company whose activities in metallurgical industries are no longer continued under its successor, GEA Group AG.

[7] *For example, China released its first medium- and long-term hydrogen roadmap only in 2022. Source: https://climatecooperation.cn/climate/china-released-the-first-medium-and-long-term-hydrogen-roadmap*

[8] *Degroote, B., & Held, P. (2018). Analysis of the patent documentation coverage of the CPC in comparison with the IPC with a focus on Asian documentation. World Patent Information, 54, S78–S84. https://doi.org/10.1016/j.wpi.2017.10.001*

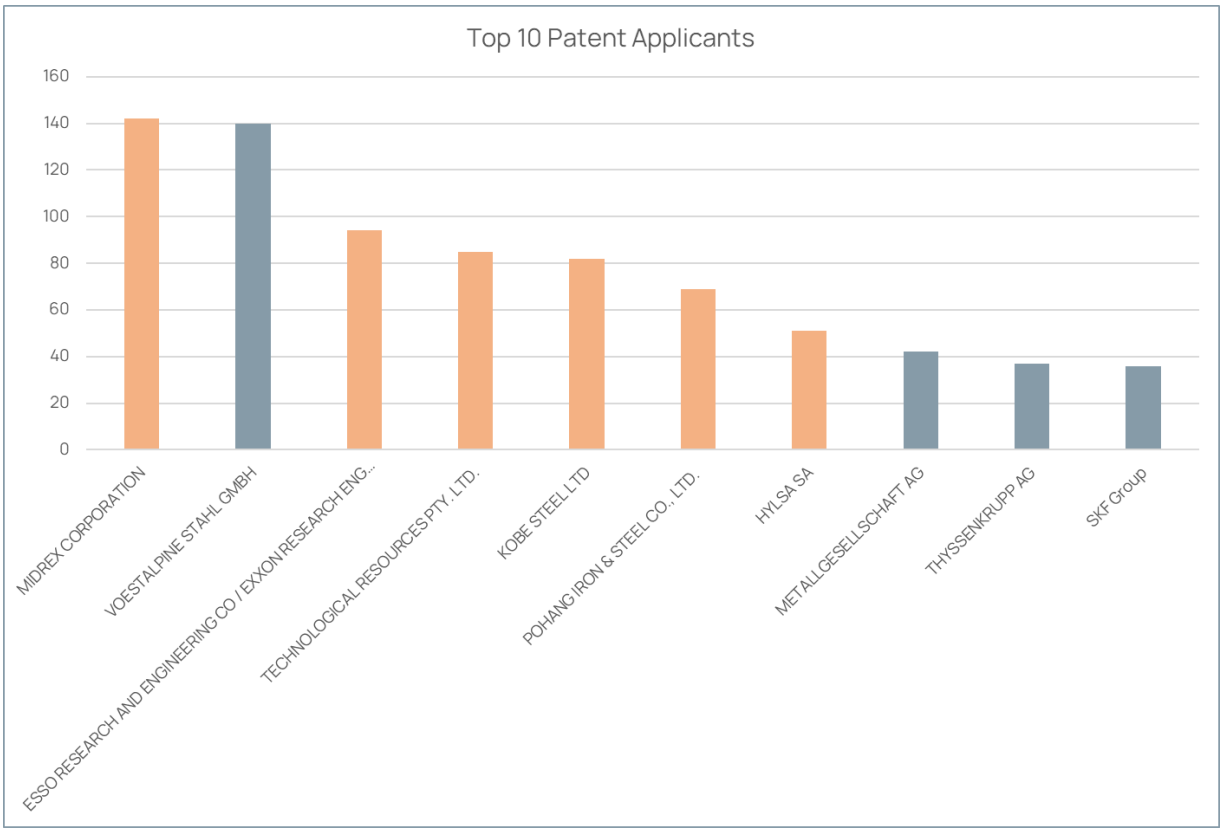

Figure 17: Top 10 stakeholders that filed for patents under Y02P10/134. (light blue = EU, orange = non-EU)

The figure above displays the top 10 patent filers across the entire dataset, dating back to 1946 (post–World War II). However, to identify relevant stakeholders for HyInHeat, it is also important to determine which organisations have been recently involved in innovative activities within the Y02P10/134 corpus.

Figure 18 therefore presents the top 10 patent filers over the past 10 years, revealing an entirely different picture. Whereas Midrex remains the leading patent applicant, Voestalpine Stahl disappears entirely from the top 10. In fact, only three organisations that ranked among the top 10 since 1946 remain in the top 10 in the past decade. Notable new entrants include Hybrit Development, Primetals Technologies, and Paul Wurth, all of which have thus been relatively active under the Y02P10/134 patent corpus in recent years.

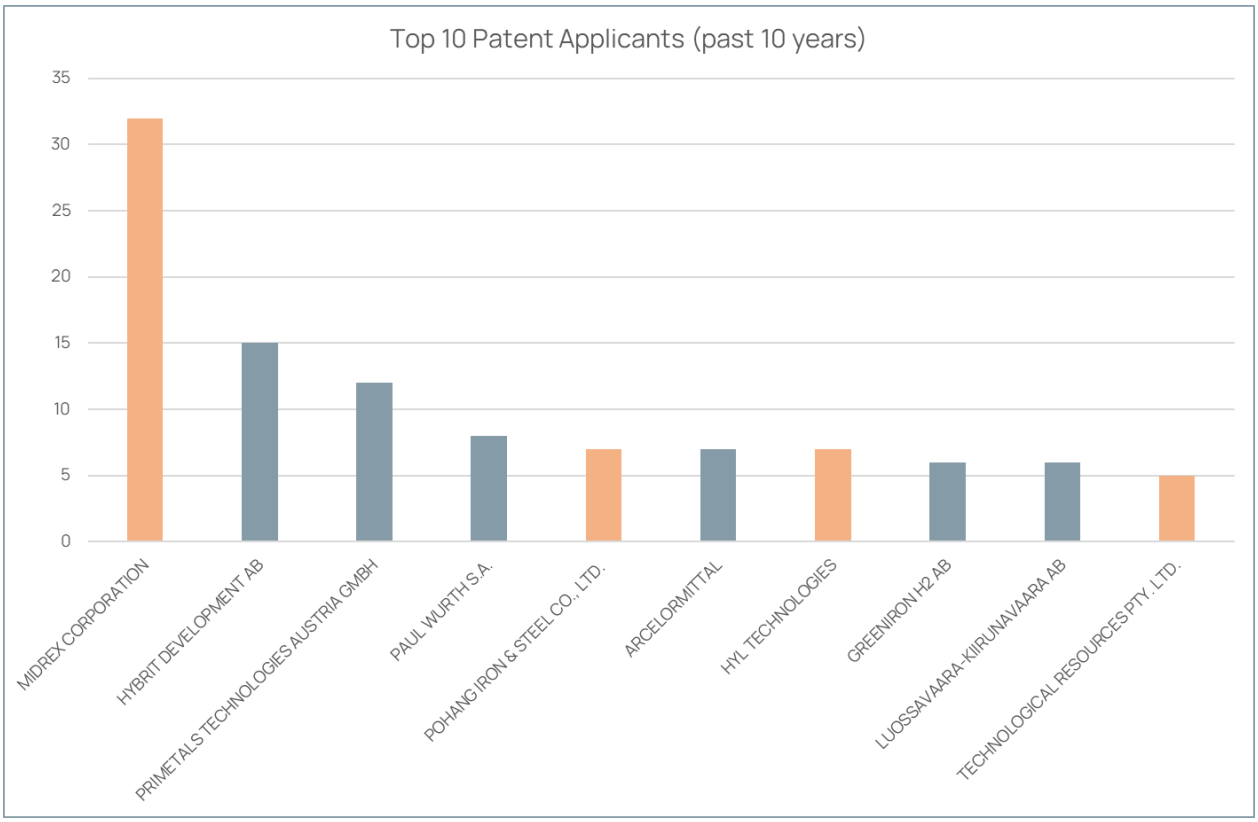

Figure 18: Top 10 stakeholders that filed for patents under Y02P10/134 in the past 10 years. (light blue = EU, orange = non-EU)

The next chapter shares the most important stakeholders for HyInHeat, based on the patent analysis.

6.1 Stakeholder tables from patent analysis

Based on the data collected through the patent analysis, information about a collection of relevant European stakeholders has been processed and saved. Please note that non-European stakeholders are excluded from this chapter, as they fall outside the scope. The following tables provide a brief overview of these stakeholders based on the patent analysis. Each table contains some general information about the stakeholder, such as industry type, country, brief description as well as some contact information if available. As previously mentioned, the tables do not include any stakeholders that are already a HyInHeat partner. Since HYBRIT Development AB is a separate joint venture, it is included below despite one of its co-founders, SSAB, being a partner of HyInHeat. In addition, Metallgesellschaft AG is not included, as it is a former company whose successor, GEA Group AG, no longer operates in metallurgical industries.

Table 19: HYBRIT development AB.

HYBRIT development AB	
Type	Technology developer
Country	Sweden
Website	https://www.hybritdevelopment.se/en/
Description	HYBRIT Development AB is a joint venture between SSAB, LKAB and Vattenfall. HYBRIT is developing technologies for fossil-free, hydrogen-based, iron and steel production.

Table 20: Primetal Technologies

Primetal Technologies	
Type:	Engineering and plant construction company
Country	United Kingdom
Website	https://www.primetals.com/en
Description	Primetals Technologies is a joint venture of Siemens, Mitsubishi Heavy Industries, and partners. Primetals Technologies offers a broad portfolio for the metals industry, encompassing integrated solutions, mechanical equipment, automation, digitalization, and lifecycle services for iron and steel production.

Table 21: Paul Wurth SA

Paul Wurth SA	
Type:	Steel equipment technology
Country	Luxembourg
Website	https://www.paulwurth.com/en/
Description	Paul Wurth is an engineering company that provides advanced technology and equipment for the iron and steel industry. They have a long-standing history of innovation and expertise in the sector and offer a range of solutions, including blast furnace technologies, coke oven plants, and environmental technologies for sustainable steel production.

Table 22: Greeniron H2 AB

Greeniron H2 AB	
Type:	Technology company
Country	Sweden

Website	https://greeniron.se/
Description	GreenIron H2 AB is a Swedish company with a patented and proven, energy-efficient technology for reducing metal oxides to pure metals. The process is suitable for the extraction of metals from ore, residues, and waste. The technology is hydrogen-based and thus the only residual product is water. GreenIron has a strong CO2-minimizing focus and strives to shape circular business cycles and increased resource efficiency.

Table 23: Luossavaara-Kiirunavaara AB

Luossavaara-Kiirunavaara AB	
Type:	Mining and raw materials company
Country	Sweden
Website	https://www.lkab.com/
Description	LKAB (Luossavaara-Kiirunavaara AB) is a Swedish state-owned mining company and one of the world's leading producers of upgraded iron ore products. It supplies high-quality iron ore pellets and fines to the steel industry and plays a central role in fossil-free steel production initiatives such as HYBRIT.

Table 24: Voestalpine Stahl.

VoestAlpine	
Type:	Steel production
Country	Austria
Website	https://www.voestalpine.com/group/en/
Description	Voestalpine is an Austrian industrial company with expertise in steel production, metal processing, and high-tech solutions. They offer a diverse range of products and services, including special steel, automotive components, railway systems, energy solutions, and more.

Table 25: Thyssenkrupp AG

Thyssenkrupp AG	
Type:	Steel manufacturer and engineering company
Country	Germany
Website	https://www.thyssenkrupp.com/
Description	Thyssenkrupp AG is a German multinational industrial group based in Essen. It operates across steel production, automotive technology, materials trading, and industrial engineering. Thyssenkrupp is one of Europe's largest steel manufacturers and is actively developing hydrogen-based and low-carbon steel technologies.

Table 26: SKF (Svenska Kullagerfabriken).

SKF (Svenska Kullagerfabriken)	
Type:	Component manufacturing
Country	Sweden
Website	https://www.skf.com/

Description	SKF is a Swedish multinational company specializing in bearings, seals, lubrication systems and related solutions. They focus on producing high-quality products with applications in industrial machinery, automotive, aerospace, and energy sectors.

7 Networks drivers

With relevant stakeholders in EU projects and patents identified, the analysis has been complemented by a look into potential network drivers. As explained in the methodology section (above), the approach has been to identify stakeholders that could benefit from technologies or results from projects. The focus has been on international association or clusters primarily with European focus, as these most often have networks of businesses or entities on both national and international level.

Below follows a non-exhaustive list of associations, including relevant information, and in total encompasses around 1400+ members. The associations have connections primarily to either; hydrogen, steel-, or aluminum industry in Europe with extensive networks. Some of the identified associations are partners of HyInHeat. Tables Table 27 to Table 38 only shows associations at International level, however associations focused primarily at national level were also identified. An overview of these can be found under Annex I.

7.1 International network drivers

Table 27: ESTEP – European Steel Technology Platform.

ESTEP – European Steel Technology Platform	
Sector focus:	Steel industry
Website	https://www.estep.eu/
Contact	secretariat@steelresearch-estep.eu; Klaus.Peters@estep.eu
Members	60
Description	ESTEP is a technology platform established to support and promote innovation in the European steel industry. It serves as a collaborative network bringing together industry stakeholders, research organizations, and academia to address common challenges and drive technological advancements in the steel sector.

Table 28: EAA – European Aluminum.

EAA – European Aluminum	
Sector focus:	Aluminum industry
Website	https://european-aluminium.eu/
Contact	info@european-aluminium.eu
Members	113
Description	European Aluminium is an industry association representing the entire value chain of the aluminum industry in Europe. It works to promote the sustainable growth of the aluminum sector, addresses policy issues, and advocates for the industry's interests at the European level.

Table 29: EUROFER – European Steel Association.

EUROFER – European Steel Association	
Sector focus:	Steel industry
Website	https://www.eurofer.eu/
Contact	mail@eurofer.eu
Members	55
Description	The European Steel Association (Eurofer) represents the European steel industry and works to promote its interests at the European Union level. It acts as a voice for the

	steel producers in Europe, advocating for fair trade, sustainable development, and a competitive business environment.

Table 30: EIGA – European Industrial Gases Association.

EIGA – European Industrial Gases Association	
Sector focus:	Industrial gases industry
Website	https://www.eiga.eu/
Contact	info@eiga.eu
Members	24
Description	The European Industrial Gases Association (EIGA) represents the industrial and medical gases sector in Europe. It brings together companies involved in the production, distribution, and use of industrial, medical, and specialty gases. EIGA promotes safety, environmental care, and best practices across the gases value chain. The association also provides guidance and standards to ensure safe operations and supports regulatory dialogue at the European level to foster sustainable and innovative growth in the gases industry.

Table 31: IAI – International Aluminium Institute.

IAI – International Aluminium Institute	
Sector focus:	Aluminum industry
Website	https://international-aluminium.org/
Contact	info@international-aluminium.org
Members	25
Description	IAI member companies are engaged in the production of bauxite, alumina, aluminium, the recycling of aluminium, or fabrication of aluminium or as joint venture partners in such. Through the IAI, the aluminium industry aims to promote a wider understanding of its activities and to demonstrate both its responsibility in producing the metal and the potential benefits to be realised through its use in sustainable applications and recycling.

Table 32: IFRF – International Flame Research Foundation.

IFRF – International Flame Research Foundation	
Sector focus:	Combustion and energy industry
Website	https://www.ifrf.net/
Contact	administration@ifrf.net
Members	N/A
Description	The International Flame Research Foundation (IFRF) is a global network dedicated to advancing industrial combustion research and technology. It connects researchers, industry professionals, and academics to promote knowledge exchange and innovation in combustion science, energy efficiency, and emission reduction. IFRF conducts research projects, hosts technical meetings, and disseminates best practices to support the development of cleaner and more efficient combustion processes across various industrial sectors.

Table 33: Worldsteel – World Steel Association.

Worldsteel – World Steel Association	
Sector focus:	Steel industry
Website	https://worldsteel.org/
Contact	steel@worldsteel.org
Members	152
Description	Although not exclusive based in Europe, the World Steel Association (worldsteel) is a global industry association representing steel producers worldwide, including many European companies. It serves as a platform for collaboration, information exchange, and advocacy on issues related to the steel industry.

Table 34: Hydrogen Europe.

Hydrogen Europe	
Sector focus:	Hydrogen
Website	https://hydrogeneurope.eu/
Contact	secretariat@hydrogeneurope.eu
Members	503
Description	Hydrogen Europe is the European industry association representing the entire hydrogen value chain. It brings together companies and organizations from various sectors, including hydrogen production, storage, transportation, and utilization. The association aims to accelerate the deployment of hydrogen technologies and advocate for supportive policies at the European Union level.

Table 35: A.SPIRE – European Association for Sustainable Process Industry through Resource and Energy Efficiency.

A.SPIRE – European Association for Sustainable Process Industry through Resource and Energy Efficiency	
Sector focus:	Process industry
Website	https://www.aspire2050.eu/
Contact	info@aspire2050.eu
Members	180
Description	A.SPIRE aims to promote sustainable growth, resource efficiency, and energy efficiency in the European process industry. The association brings together key stakeholders, including industry leaders, research institutions, and academia, to collaborate on research, innovation, and policy development.

Table 36: ASI – Aluminium Stewardship Initiative.

ASI – Aluminium Stewardship Initiative	
Sector focus:	Aluminum industry
Website	https://aluminium-stewardship.org/
Contact info	info@aluminium-stewardship.org
Members	306
Description	The Aluminium Stewardship Initiative is an international non-profit organization that develops and oversees a global sustainability standard and certification program for the aluminum industry. The ASI was established in 2012 to address the environmental,

	social, and governance aspects of aluminum production and supply chains. The primary objective of the ASI is to promote responsible practices throughout the aluminum value chain, including mining, refining, smelting, processing, and manufacturing. It aims to minimize the industry's environmental impact, ensure social and labor rights, and promote good governance practices.

Table 37: EUGINE – European Engine Power Plants Association.

EUGINE – European Engine Power Plants Association	
Sector focus:	Hydrogen
Website	https://www.eugine.eu/
Contact info	https://8x5u1aptts.preview.infomaniak.website/board/secretariat/
Members	8
Description	EUGINE stands for a market that supports flexible solutions in the short, medium and long term. We advocate for an optimised business environment for engine power plants, which includes "H2-Readiness". To provide a clear view of what "hydrogen-readiness" means for engine-powered gas power plants, EUGINE and its members have developed a common H2-Ready definition and a checklist that can be used by industry, investors, and policymakers to evaluate existing plants.

Table 38: CENELEC – European Committee for Elecrotechnical Standardization.

CENELEC – European Committee for Elecrotechnical Standardization	
Sector focus:	Industry standardization
Website	https://www.cencenelec.eu/
Contact info	partners@cencenelec.eu
Members	N/A
Description	The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) are two distinct private international non-profit organizations. They aim to produce high-quality standards for products and services that incorporate quality, safety, environmental, interoperability and accessibility requirements. They adapt proactively to new developments and support European competitiveness, the protection of the environment and sustainable growth for the well-being of citizens and the strengthening of the single market (European Economic Area).

8 Conclusions

This stakeholder analysis provides information on potential stakeholders related to HyInHeat and the project's related activities. The main focus areas of this analysis have been on three overarching areas: steel industry, aluminum industry, and hydrogen industry. Several sub-topics and diverging keywords have been included and assessed in this analysis but have otherwise been combined in one of the abovementioned areas. The input of this stakeholder analysis will be used in the communication, dissemination and exploitation activities to understand stakeholder motives and needs, and increase the impact of the project.

A methodological approach has been used in this analysis, in order to more effectively and accurately identify relevant stakeholders (see Chapter 3). An analysis of the value chain was integral in identifying the boundaries and scope of the stakeholder analysis, while creating some fundamental basis to work off of (see Chapter 4). This evaluated each of the different stakeholder segments in the HyInHeat value chain, described their actions at a high level, and was used as input for the other parts of this analysis.

The EU projects analysis (see Chapter 5) identified a total of 513 projects. These projects were ranked and filtered down to 39 projects that engage in similar activities to HyInHeat and were considered to be potential partners to reach out to (see Table 2 - Table 5). Furthermore, a scheduling overview is presented in Figure 5 and 6, which shows all of the relevant projects listed by project duration. This allows for insight into if or when the project might be of interest during HyInHeat. An analysis on the partners for these projects was also performed, and a selection of the most frequently occurring and relevant partners are listed in Tables 6 to 18. The selection was based on stakeholders that could directly benefit from the project results or that might be interested in pursuing a synergetic business relationship with the HyInHeat consortium partners. While the list provided here is by no means exhaustive, it provides information and data on key stakeholders that can be of interest to HyInHeat project's activities.

The results of the patent analysis (see above) indicates that the particular field of technology that HyInHeat operates is well developed, with Europe taking the lead, but the United States following not far behind. The analysis indicates that the peaks of investment in this corpus of patents peaked around 1974 and again around 1997, and has been on a gradual decline since. The analysis shows that a handful of actors own a significant amount of the intellectual property in this field of technology. These actors were examined compared to past and current market developments and have been presented in tables in above.

An analysis of the networks drivers is also shown in this report (see Chapter 7), and was primarily focused on the impact of associations for the HyInHeat project. A list of highly relevant stakeholders in the form of international associations was identified and cover multiple different industry applications (see Tables 27 to 38), where several HyInHeat consortium partners are already involved with several of these associations. A list was also created for national associations as well, and have been listed in below.

Annex I – National network drivers

Table 39: Table overview of the identified network drivers (associations) that was found.

Country	Name	Sector focus	Website
Germany	DWV – Deutscher Wasserstoff- und Brennstoffzellen-Verband	Hydrogen	https://dwv-info.de/
Germany	H2.B – Wasserstoff- und Brennstoffzelleninitiative Hessen	Hydrogen	https://www.h2bz-hessen.de/
Germany	WS – Wirtschaftsvereinigung Stahl (Steel Federation)	Steel	https://stahl-online.de/
Germany	HySteel – DWV	Hydrogen	https://dwv-hysteel.de/
Germany	AD – Aluminum Deutschland	Aluminum	https://www.aluminiumdeutschland.de/
Austria	Austrian Steel Association (Österreichischer Stahlverband)	Steel	https://www.stahlbauverband.at/
Austria	Fachverband der Nichteisenmetallindustrie (Non-Ferrous Metal Industry Association)	Aluminum	https://www.wko.at/
Belgium	Aluminium Federation Belgium (Alufed)	Aluminum	https://alufed.com/
Belgium	Agoria Steel Construction	Steel	https://www.agoria.be/
France	Fédération Française de l'Acier (FFA)	Steel	https://www.a3ms.fr/
France	Union Française de l'Aluminium (UFA)	Aluminum	https://www.aluminium.fr/
France	Association Française pour l'Hydrogène et les Piles à Combustible (AFHYPAC)	Hydrogen	https://www.afhypac.org/
Spain	Confederación Española de Organizaciones Empresariales del Metal (CONFEMETAL)	Steel	https://confemetal.es/
Spain	Asociación Española del Aluminio y Tratamientos de Superficie (AEA)	Aluminum	https://www.asoc-aluminio.es/
Spain	Spanish Hydrogen Association (AeH2)	Hydrogen	https://www.aeh2.org/en/
Norway	Norsk Stålforbund (Norwegian Steel Association)	Steel	https://www.stalforbund.no/
Norway	Norsk Hydrogenforum (Norwegian Hydrogen Forum)	Hydrogen	https://www.hydrogen.no/en
Finland	Suomen Teräsrakenneyhdistys (Finnish Steel Structures Association)	Steel	https://www.terasrakenneyhdistys.fi/
Finland	H2 Cluster Finland	Hydrogen	https://h2cluster.fi/

Italy	Federacciai (Italian Federation of Steel)	Steel	https://federacciai.it/
Sweden	Jernkontoret (Swedish Steel Producers' Association)	Steel	https://www.jernkontoret.se/
Sweden	Svenskt Aluminium (Swedish Aluminium)	Aluminum	https://www.svensktaluminium.se/
Sweden	Hydrogen Sweden	Hydrogen	https://vatgas.se/en/
Greece	Hellenic Steelmakers Association	Steel	https://www.hellenicsteel.gr/
Greece	Aluminium Association of Greece (AAG)	Aluminum	https://aluminium.org.gr/
United Kingdom	UK Steel	Steel	https://www.makeuk.org/about/uk-steel
United Kingdom	Aluminium Federation (ALFED)	Aluminum	https://alfed.org.uk/
United Kingdom	UK Hydrogen and Fuel Cell Association (UK HFCA)	Hydrogen	https://ukhea.co.uk/

Get in touch

Website

http://hyinheat.eu/

Email address

info@hyinheat.eu