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Talking Hydrogen: Assessing Hydrogen Discourses in the European Union (EU) and its Member States

Friedrich Plank, Johannes Muntschick, Michèle Knodt and Arne Niemann

Abstract

Within the European Union (EU) and its member states, hydrogen as an energy carrier is assumed to be of key importance for decarbonising different sectors in the fight against climate change. Hence, state and private actors in Europe have engaged in a variety of attempts, strategies and policies, specifically after the EU has announced a specific hydrogen strategy recently. Against this backdrop, this paper seeks to provide an analysis on the debates generated by Europe´s bet on hydrogen, focusing specifically on the years 2019-2021. Drawing on a discourse analysis that is based on more than 32 000 media reports generated through the database Nexis for the discourse in Europe, it analyses the debates on hydrogen in the European Union from various perspectives and with a focus on a wide range of actors. The paper will specifically examine the debates emerging from the release of the EU hydrogen strategy. Building on a broad set of indicators, it puts an emphasis on discourses on the organisation, application, and opportunities of hydrogen as assigned by private and state actors and engages with debates legislation processes and strategic cooperation in the EU. It thus engages with the discourse on hydrogen in a complex environment with diverging interests of stakeholders, and thus examines debates that still need further empirical research.

Keywords: Hydrogen, Energy Transition, European Union, Discourse

1. Introduction

The global commitment to decarbonize different sectors in the fight against climate change has grown stronger in the recent years, with the signing of the landmark Paris Agreement in 2015 and major economies passing laws to reach net-zero CO_2 emissions in the next forty years. The Russian invasion of Ukraine and Moscow's policy of reducing and cutting off gas supplies to Bulgaria, Poland and Germany have increased awareness of reducing energy dependency from Russia as well as energy vulnerabilities in fossil fuels across Europe. With the need to decarbonize sectors that have hard-to-abate emissions, hydrogen as energy carrier has increasingly gained attention globally, and in the European Union (EU) as largest economic organization specifically. With a dedicated hydrogen strategy published in July 2020, the EU has placed its bet on hydrogen as energy carrier to decarbonize sectors such as iron and steel production, high-temperature heat for industrial processes, aviation, shipping, long-distance road transportation, and heat for buildings (Nuñez-Jimenez and De Blasio 2022), which are sectors that account for over one fourth of all global CO2 emissions (Davis et al. 2018). Equally, several member states such as Spain, France, Portugal, or Germany have published their own hydrogen strategies and engaged in specific support mechanisms. Overall, hydrogen has become a key energy carrier for the EU´s ambitious plans to achieve net-zero emissions in the future and receives high attention across European politics, economics, and societies today.

With the growing salience of hydrogen for the global and European energy transition, academic research has equally acknowledged hydrogen as relevant field of interest and for investigation beyond energy governance more generally (Knodt and Kemmerzell 2022). While research has focused on the global level of hydrogen relations such as socio-technical assessments (Griffiths et al. 2021), implications for regional economies (Mukelabai et al. 2022), or geopolitical relations (Van de Graaf et al. 2020), a specific EU approach to hydrogen has also been in the focus of research. Besides general investigations and scenarios for the EU´s hydrogen approach that have led to rich findings (Nuñez-Jimenez and De Blasio 2022; Seck et al. 2022), scholars have investigated the EU´s hydrogen policy frameworks (Bleischwitz and Bader 2010; Barnes and Yafimava 2020), public attitudes and understandings towards hydrogen usage (Roche et al. 2010; Sherry-Brennan et al. 2010), potential policy structures such as tax favors (Hansen 2010), the regional level of hydrogen policies (Madsen and Andersen 2010; Knodt et al. 2022), or engaged with hydrogen policies in specific European states (Samsatli et al. 2016; Löhr et al. 2021; Belova et al. 2023). In addition, some studies have embarked on the potentials and risks of third partner countries for EU hydrogen imports (Daum 2020; van der Zwaan et al., 2021; Timmerberg and Kaltschmitt 2019; Kolb et al. 2022; Plank et al. 2023), given the fact that the EU continues to rely on energy imports in the short and medium term.

Against this background, this study embarks on an analysis on the debates generated by Europe´s bet on hydrogen, focusing specifically on the years 2019-2021, the period around the publication of the EU´s hydrogen strategy. Drawing on a discourse analysis that is based on more than 32,000 media reports generated through the database Nexis, it analyses the debates on hydrogen in the European Union from various perspectives and with a focus on a wide range of actors. It specifically examines the following research question: H*ow does the discourse on hydrogen in the European Union unfold in terms of actors, the application, the opportunities, and the organisation of hydrogen policies?* The main research objective of this study is thus a mapping of the discourse on hydrogen in the EU more generally.

We argue that such an engagement with the hydrogen discourse in the European Union is relevant due to several reasons. Theoretically, the focus of the paper allows to generate insights on the hydrogen discourse in a deductive and inductive manner. Building on a broad set of indicators, it puts a deductive emphasis on discourses on the organisation, application, and opportunities of hydrogen as assigned by private and state actors and also engages with debates on legislation processes, and strategic cooperation in the EU. It thus seeks to bridge the literature on the EU´s energy policies and hydrogen as a specific energy carrier technology. The inductive approach that is additionally put forward, allows to identify key actors, interests, and debates, and thus enables the generation of new theoretical assumptions specific to these debates. Methodologically, a discourse analysis seems well suited to engage with the still emerging field of hydrogen. Whereas many studies have analysed the discursive practice and framing mechanisms of EU energy policies (Hofmann and Staeger 2019; Natorksi and Herranz Surallés 2008) or in the context of energy transitions in specific member states (Löhr 2020), a detailed mapping of the discourse on EU hydrogen policies has to our knowledge not being undertaken so far. Empirically, such an analysis generates relevant knowledge on hydrogen debates in a complex environment with diverging interests of stakeholders, and thus examines and provides insights to debates that still need further empirical research.

We proceed as follows: We engage with hydrogen as energy carrier and the EU´s approach towards this technology before we describe our methodological approach and data acquisition. The detailed analysis of the discourse in the EU embarks on actors, hydrogen application, and opportunities related to the energy carrier, before the conclusion discusses the findings, reflects on their implications, and provides avenues for further research and next steps.

2. Hydrogen as Energy Carrier and the EU's Bet on Hydrogen

Besides other innovative energy carriers such as iron (Debiagi et al. 2022), hydrogen has increasingly gained attention for the decarbonization of the EU´s industry. Hydrogen is a highly flexible energy carrier and currently an intermediate in several processes. Worldwide, around 73 Mt of pure hydrogen are produced annually, of which 38 Mt are used in the refining of petrol and 31 Mt in the production of ammonia. Only around 4 Mt are used in other applications, including transportation and heat generation (International Energy Agency 2019). At present, the hydrogen required is mainly produced from fossil sources such as oil, gas and coal. CO_2 is produced in the various processes, which leads to emissions unless it is captured and stored. Hydrogen from renewable sources, on the other hand, is the basis for the transformation from a fossil-fuel based economy to a hydrogen economy (Turner, 1999; Crabtree et al., 2004). So-called green hydrogen is produced by the electrolysis of water, i.e. the splitting of water into hydrogen and oxygen. The electricity used in this process comes exclusively from renewable 'green' sources such as wind and solar energy, therefore green hydrogen is considered CO_2-free. Other hydrogen production processes (grey, blue, turquoise) are not considered CO_2-neutral at all or only under certain conditions in the overall balance, e.g. blue hydrogen is CO_2-neutral because the CO_2 is completely captured and stored (Carbon Capture and Storage (CCS)) (Crabtree et al., 2004).

The European Union (EU) as major economic integration project and key market in the energy sector has put forward hydrogen in order to fulfil its ambitious goals to fight climate change. Many countries have published dedicated hydrogen strategies (see Sadik-Zada 2021; Chen and Lee 2022) and the EU has likewise placed its bet on the energy carrier. Its dedicated hydrogen strategy, published on 8 July 2020, has laid the ground for a European hydrogen market that spans globally (Barnes and Yafimava 2020). The strategy makes a clear reference to renewable hydrogen:

> "The priority for the EU is to develop renewable hydrogen, produced using mainly wind and solar energy. Renewable hydrogen is the most compatible option with the EU's climate neutrality and zero pollution goal in the long term and the most coherent with an integrated energy system" (European Commission 2020, 5).

Only in the "short and medium term, however, other forms of low-carbon hydrogen are needed" (European Commission 2020, 5). The strategy only expects 3-18 billion € in investment for low-carbon hydrogen until 2050, whereas the total investments in renewable hydrogen capacity is estimated 180-470 billion €. The strategy further sets the target of 6GW electrolysers by 2014, 40GW by 2030 with 40GW imported by external countries, and 500GW by 2050, making the investment in hydrogen production a major effort (European Commission 2020, 5-7). These goals already include those set by the EU member states (Sadik-Zada 2021). The strategy further envisages the construction of a hydrogen infrastructure, the creation of dedicated alliances such as the European Clean Hydrogen Alliance (ECHA), or several financing and support instruments (see Barnes and Yafimava 2020). As international dimension, the EU seeks to develop cooperation with its southern and eastern neighbourhood, community neighbourhoods such as Ukraine, and a dedicated cooperation framework for renewable hydrogen with the African Union (AU) within the Africa-Europe Green Energy Initiative.

Against this background, the EU´s bet on hydrogen has been accompanied by an increased interest and awareness of this highly combustible element as energy carrier and an intense discourse among many stakeholders in Europe. This bet might be followed by other energy carriers such as iron (Debiagi et al. 2022). It is this discourse this study intends to grasp in a thorough analysis.

3. Methodological Approach and Data Analysis

This study seeks to analyse the discourse on hydrogen in the European Union. Consequently, it embarks on a systematic analysis of discourses using media data. There exists a wide range of literature of how we can analyse discourses (Tannen et al. 2015; Keller et al. 2008). For instance, scholars embark on the linguistic characteristics of a discourse, power-relations in discourses, or engage with the language in a critical manner. What these approaches have in common is that they seek to illustrate how "textual and social processes are intrinsically connected and to describe, in specific contexts, the implications of this connection for the way we think and act in the contemporary world" (George 1994, 191). Drawing on Gerhards (2008, 334-335), this study will place an emphasis on discourses understood as publicly held conversations of actors about topics and positions, reasoning, and interpretations that relate to these topics. These conversations take place in public arenas with the mass-media being the most prominent of those arenas. The role of these actors is then also related to their standing and framing. Discourse is then a set of relationships existing between discursive events and text in context (see Wodak 2008, 5). Most importantly, the collection of the text material and the interpretation of this material should be conducted in a systematic manner. Rather than embarking on a critical discourse analysis or a detailed account of power-relations in the discourse, this study seeks to analyse a specific discourse on a recently developing topic, namely

hydrogen, through a systematic content analysis as discourse analysis. This serves merely to map and capture the essentials of the discourse before conducting more extensive research in a finer-grained manner in a subsequent step.

We hold that the European Union constitutes a key case of examining the discourse on hydrogen. As major organization in world economy and with an ambitious program to fight climate change and decarbonize several sectors ranging from industry to private transport, the EU constitutes a main player in a (future) hydrogen market (Nuñez-Jimenez and De Blasio 2022). Accordingly, the EU has published a dedicated hydrogen strategy in July 2020 that mirrors the key role the EU attributes to hydrogen. Focusing specifically on the period around the publication of this strategy, this analysis can generate empirical insights for assessing how the discourse on hydrogen unfolds in the EU and its member states.

The discourse analysis is based on 32,231 reports generated by the database Nexis. Nexis is the largest media database in the world and provides access to wide a variety of more than 40,000 global media sources in multiple languages (LexisNexis 2021). They include news from international news agencies such as Agence France-Presse (AFP), Associated Press (AP), Reuters, Deutsche Presse-Agentur (DPA), Interfax, or the Xinhua News Agency, major international broadcasters such as the British Broadcasting Corporation (BBC), the Cable News Network (CNN), or the Deutsche Welle (DW), national and local newspapers, market outlooks, firm reports, energy reports, and other written publications. This collection therefore captures the main advantages of using media reports for discourse analysis since they include a reflection of the social mainstream and the dissemination to large audiences (Mautner 2008). All available reports were searched for on a broad basis in order to capture a full picture of the discourse on hydrogen that is unfolding in the European Union. Using the query "[European Union] AND [Hydrogen]" in the period January 2019 until August 2021, the mostly English reports gather the discourse during a period in which the EU published its hydrogen strategy in July 2020, and show the growing emphasis put on the energy carrier. During this period, the salience of hydrogen increased with a small peak around the publication of the EU´s hydrogen strategy and further increased in the following months and years (see figure 1).

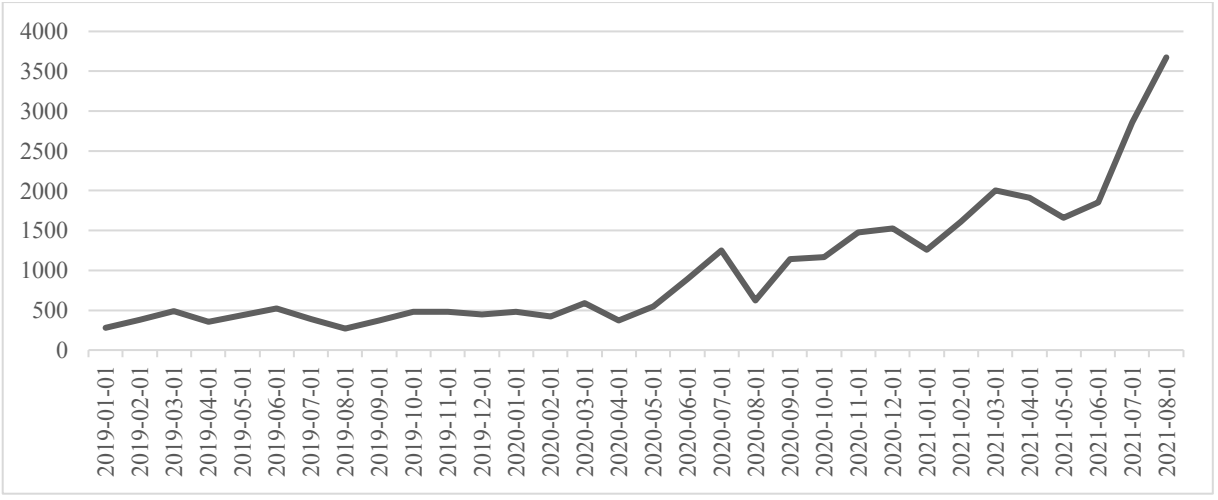

Figure 1. Number of Nexis reports collected (n=32,231)

In order to engage with the discourse on hydrogen in terms of actors, application, and opportunities, , the reports were structured for each month and coded using the software atlas.ti. Based on a coding system that draws to some extent on previous research (Löhr et al. 2021; Belova et al. 2023) and includes both inductively and deductively collected codes, 350 codes were developed (see table 1). These codes are generated and applied in order to enable a systematic analysis of the text material while also providing space and flexibility to include processes and development that we were not able to anticipate previously.

Main-codes	Sub-codes	Additional information
Opportunities	- General - Climate - Economy - Storage - Transition - Sector Coupling	Deductively developed codes
Application	- Blending - Industry - Heating - Electricity - E-fuels - Transportation in different sectors (shipment, planes, cars, trucks, buses)	Deductively developed codes (few codes added inductively)
Organisation	- Funding - Implementation - Import - Domestic production - Regulation Change - Research - Regulation Change - Cooperation - Technology Openness - Infrastructure different sectors (Filling stations, transport, grid, terminals	Deductively developed codes (few codes added inductively)
Actors		Inductively developed codes: Each actor that is referred to in the discourse (in total 247 actors)
Hydrogen colour	- Blue hydrogen - Green hydrogen - Grey hydrogen - Purple hydrogen - Turquoise hydrogen	Inductively developed codes: Each colour referred to in the discourse
Other	- EU legislation - EU conflict - Specification needed	Inductively developed codes when found to be relevant

Table 1. Code system generated deductively and inductively

Analysing hydrogen discourses in the European Union

Against the background of a growing debate on hydrogen in the EU, this study embarks on the question how the discourse in hydrogen in the European Union unfolds in terms of actors, the application, opportunities, and organisation of hydrogen policies. In this analytical chapter, we will therefore present and discuss key actors and key topics that have been identified as relevant in the discourse.

Identifying key actors

A wide range of actors and interests unfold in the hydrogen discourse in the European Union. With the growing relevance of hydrogen for the energy transition in the EU (Nuñez-Jimenez and De Blasio 2022), many actors have placed their bet on the energy carrier and the potentials unfolding with the implementation of a hydrogen economy in Europe and beyond. First, this analysis will point to the actors participating in the discourse more generally, including their affiliations.

In terms of actors, the discourse on hydrogen in the European Union unfolds specifically in communication by private actors from the economy and their associations, and, to a lesser extent, communication by non-governmental organizations and political actors (see figure 2). Quite prominently, a debate on the application, opportunities, and governance of hydrogen is put forward by actors from the economy.

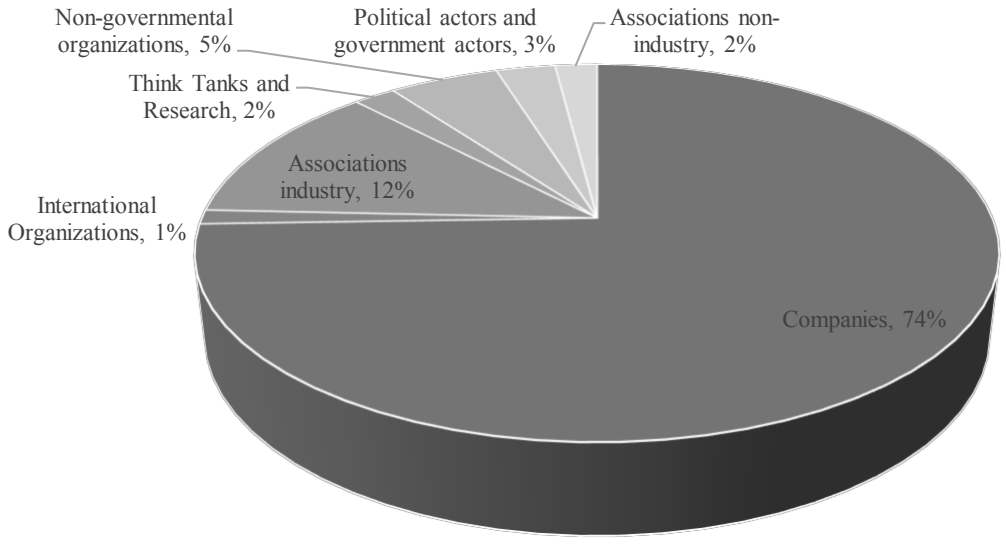

Figure 2. Actors mentioned in the discourse analysis (n=247)

Overall, 247 actors participate in the discourse between January 2019 and August 2021, indicating the broad interests and projects raised with regard to the energy carrier. 74 % of these actors are private companies and 12 % associations built by these companies, whereas only 5 % of these actors are non-governmental organizations and only 3 % are governmental and political actors. Although the latter have increasingly been mentioned or participated in the discourse in 2021, the overall discourse is mainly driven and shaped by the economy.

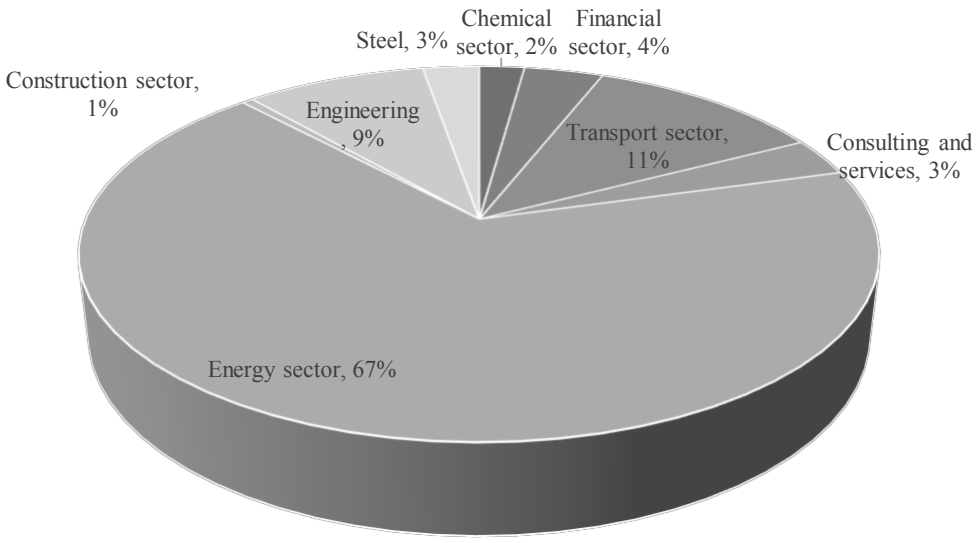

Figure 3. Sectors of companies mentioned in the discourse analysis (n=184)

A more detailed look on the business sectors in which these companies work indicates a strong interest in the energy carrier by the energy sector (67 %), while the transportation sector (11 %) and engineering companies (9 %) haver also engaged in the discourse (see figure 3). However, these quantitative findings do merely show that a wide range of actors, most of them companies from the energy, transportation and engineering sectors, participate in the discourse in terms of absolute number. When analysing who is participating in the discourse in which context, the picture becomes more complex. The debate is to a large extent shaped by companies from the gas sector such as GRTgaz, GRDF, Elengy, Uniper, or Gas Infrastructure Europe (SNL 2020b; Eolas Magazine 2019; EurActiv 2019c), the evolving hydrogen sector by companies such as Ballard Power Systems (PortsEurope 2021b), the transportation sector including both manufacturers such as BMW and Hyundai (Contify Automotive News 2021; Autocar 2019) as well as service companies such as Deutsche Bahn or Norled (Financial Times 2021a; Marketline 2019), or engineering companies such as Bosch and Airbus (Financial Times 2021b; EurActiv 2020b). Likewise, companies such as Gazprom (WPS 2020a), Rosatom (M-Brain Russia News 2020), Naftogaz (Platts European Power Daily 2021b), or the Kazakh Invest National Company (Newstex Blogs 2021) from outside Europe engage in the debate as well, merely in the context of cooperating in order to export hydrogen to the EU. With the same interest in mind, third partner countries and their government officials have promoted these opportunities (Agence Marocaine de Presse 2021b; Business Day 2021a; Intellinews 2021).

Identifying key topics

Hydrogen as an energy carrier involves several opportunities and potentials, but also involves questions in terms of application, technical solutions, and its colour. Consequently, a complex discourse on hydrogen in the European Union has unfolded that centre around several core topics. In a first step, we will examine these topics of the discourse which point to the application, organisation, the opportunities, and the 'colour' of hydrogen when analysing the coded quotations. As previously outlined, these single topics cover a wide range of sub-codes (see table 1).

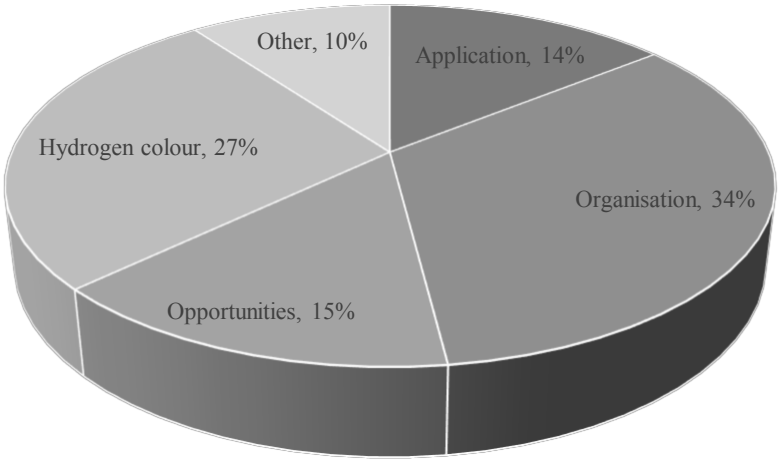

Figure 4. Frequency of coded quotations associated with topics (n=723)

In addition, we will contextualise these debates which involve general patterns but also some key debates. First, in the discourse, actors engage with the organisation of hydrogen in the EU. One major aspect of this debate reflects the import of hydrogen from partner countries which this study will examine in a specific subsection. Other aspects mainly point to general debates of the discourse such as the costs of hydrogen, the competitiveness of the energy carrier, and calls for EU action - debates this study will capture in the topics subsections.

Second, the discourse develops with reference to the application of hydrogen, mainly its use in the industry and transportation sector. Especially, the use of hydrogen in the energy-intensive steel and chemical industry has been pointed out by stakeholders. Whereas some industrial-gases providers such as Messer have referred to hydrogen's potential in these sectors (Contify Energy News 2020c), others have emphasised the overall relevance of the industrial sector such as a representative from Heide, a German refinery company: "I am deeply convinced that if you really want to scale up hydrogen you need to look into industrial applications" (SNL 2020c). More generally, the application in the industry has also been favoured by the Greens in the European Parliament preferring the use of green hydrogen in specific sectors: "Let's save those precious renewables and biogases for applications like heavy industry, long-distance transport, aviation and shipping where electrification is not possible in the short-term", Jutta Paulus was quoted (EurActiv 2020g). The application of hydrogen constitutes an important aspect of heavy energy industry. It "can become an important low-carbon building block for the chemical industry's production processes," according to Marco Mensink, director general at CEFIC, the EU chemical industry association (EurActiv 2020c). In this sense, chemical producers promote their hydrogen projects alongside their regional governments such as the Bavarian Wacker, also while welcoming EU support (Menafn 2021). The European Cement Association also referred to hydrogen as playing a key role in their industry (World Gas Intelligence 2020). Another prominent sector for the industrial use of hydrogen is steel. This has been also acknowledged by actors from this industry, for instance by Axel Eggert, Director General of the European Steel Association: "The benefits to society from the availability of hydrogen and green industrial products, such as green steel, are huge" (Impact News Service 2020d). Steel producers have also pointed to hydrogen as "way forward" such as SSAB (Cision 2020) and "ideal solution to decarbonize some key industrial sectors, in particular to produce zero-emissions steel in the long term", as Michele Della Briotta, president of Tenaris, was quoted (Metal Bulletin 2021). The still largely project-related character of green steel production through the use of hydrogen is, however, an important context in which actors such as ThyssenKrupp or the German government praise their efforts (EurActiv 2021e).

The discourse also points to the transportation sector as potential user of hydrogen. Specifically in areas in which an electrification might be challenging, stakeholders emphasise the use of hydrogen. Hydrogen has been mentioned with regard to its use in the railway sector where stakeholders such as Alstom or the Deutsche Bahn focus on hydrogen-trains especially for long distances (Financial Times 2021a). For instance, Spain has been identified as potentially suitable for hydrogen trains for railway lines without electrification and with support by the EU through the post-Covid-19 funds (Noticias Financieras 2021).

Moreover, stakeholders refer to the use of hydrogen in cars, although for instance VW has focused heavily on electric cars and ruled out the use of hydrogen (Die Welt 2019a). Within the debate on the future engines for cars, other manufacturers have focused on hydrogen such as BMW and Opel which hold that hydrogen cars might be suited for long distances (Contify Automotive News 2021; News Aktuell 2021). For instance, Albert Biermann, development chief at Hyundai, referred to the potential of hydrogen for the energy transition: "We are fully convinced that, to meet the 2050 CO2 targets, without hydrogen it will not be possible to get there" (Autocar 2019). In this context, stakeholders such as the European Automobile Manufacturers' Association (ACEA) have particularly called on the EU and its member states to increase efforts to build filling stations for hydrogen (Contify Automotive News 2019). Others such as Europe´s largest car parts supplier Bosch have criticised the EU for being too fixated on electric vehicles (Financial Times 2021b). Specifically in Germany as major car manufacturer hotspot, the government has also called for hydrogen cars such as the then federal transportation minister Andreas Scheuer:

"I am also calling for much more passion for hydrogen. Battery-powered electric mobility will not be suitable for everyone. In the future, too, there will be people who prefer to refuel rather than charge, be it hydrogen, natural gas or e-fuels. It is therefore important that we remain open to technology, conduct research in all directions and set up the necessary tank and loading infrastructure across the board" (Die Welt 2019b).

In addition, the use of hydrogen in trucks has gained momentum in the debate. Likewise for the use in cars, stakeholders such as Hydrogen Europe or the International Road Transport Union have called for filling stations across the EU (Impact News Service 2019). This debate even led to an infringement procedure by the European Commission against Germany, which referred to the low development of a filling and charging infrastructure (Die Welt 2019c). More generally, specifically manufacturers have engaged in debating the application of hydrogen in trucks such as Volvo or Daimler (Platts LNG Daily 2020b). One major aspect of the debate constitutes the competitiveness in terms of costs and the availability of green hydrogen.

Hydrogen has been also discussed with regard to its use in aviation. While stakeholders such as T&E have called for aviation and shipment as prioritised areas of hydrogen use (EurActiv 2020h), companies in the aviation sector such as Airbus have emphasised the opportunities of hydrogen for the energy transition (EurActiv 2020b).

Finally, hydrogen powered ships have been debated as well. In this sector several projects such as by Norled have been implemented (Marketline 2019). Quite prominently, green associations and NGOs such as NABU or T&E have argued for the use of hydrogen in shipping to replace existing diesel engines (Die Welt 2020b; EurActiv 2020h). In the context of the EU´s maritime fuels policy, these stakeholders, including shipping companies DFDS, CMB and Viking Cruises, commodities trader Trafigura, and T&E jointly called for a clear signal for investors to focus on green hydrogen for ship engines (PortsEurope 2021a).

In the context of the discussions on hydrogen application in transport, stakeholders such as Hydrogen Europe, Lufthansa, or T&E have also called on the EU for specific targets in the maritime and aviation sector (Platts European Gas Daily 2021b; Thai News Service 2021b). To a very limited extent, the discourse has also referred to the use of hydrogen in heating merely in the context of another option for the application as brought forward by EON (Platts Power in Europe 2021b).

Third, the discourse references the opportunities associated with the use of hydrogen. Most prominently, actors emphasise the general opportunities of hydrogen. Stakeholders of companies engaged in the market refer to a "desire for hydrogen" such as Spain´s energy giant Iberdrola (EurActiv 2019a), as "energy carrier of the future" (EON) (Contify Energy News 2020a), "most promising technology" (Airbus) (EurActiv 2020b), or "low-carbon building block" (European Chemical Industry Council) (EurActiv 2020c). For instance, Pierre-Etienne Franc, Hydrogen Council Co-Secretary, referred to the general promises of the energy carrier: "As confidence in hydrogen continues to grow, investors are coming to the table to back innovations and turn them into a reality. Hydrogen Council members recognize the strong business case for hydrogen" (Thai News Service 2019). Likewise, political actors have referred to the general opportunities of hydrogen as "central element" such as EU Commissioner Simson (EurActiv 2020d), Commission President von der Leyen (Thai News Service 2021a), or the then German energy minister Altmaier (Tendersinfo 2021).

Moreover, opportunities of a transition to hydrogen for the economy have been repeatedly expressed. For instance, Gas for Climate pointed to the chances for employment, also in rural areas (Targeted News Service 2019), with 1,7 to 2,4 million jobs created in the EU (Energy Monitor Worldwide 2019). German hydrogen association DWV even saw the potential of 5,4 million jobs being generated by the growing hydrogen economy (Energie & Management 2019). Opportunities for the transition of a hydrogen market have been primarily emphasised in the context of natural gas as a bridging technology towards a green hydrogen economy. Specifically, companies from the fossil fuels sector have lobbied for such a transition (EurActiv 2020f; Platts European Power Daily 2021c). Such a role for blue hydrogen has been also pointed out by Commissioner Timmermans referring to EU member states where there are no other affordable solutions such as Poland (Platts Power Europe 2021).

Quite astonishingly, the opportunities of hydrogen to fight climate change have been emphasised only to a limited extent. Only some actors have referred to "hydrogen as cornerstone to fight climate change" such as Linde (Indian Oil and Gas News 2021) and key for transition to carbon-free market such as Italian gas transporter Snam or German energy minister Altmaier (TradeArabia 2021; Tendersinfo 2021). In the context of energy storage as important factor for the transition of energy, hydrogen might be a technology to store energy in seasonal periods as pointed out by Hydrogen Europe (Foreign Direct Investment 2020).

It is noteworthy that the opportunities of hydrogen have primarily been emphasised in the context of green hydrogen. This specifically applies to political actors such as Commission President von der Leyen who elaborated on the economical, transitional, and general potential of hydrogen in terms of green hydrogen being the "best-choice" and attributing only a limited role of other 'colours' such as blue hydrogen during a speech before the Hydrogen Council (Thai News Service 2021a). This approach mirrors the direction of the EU´s Hydrogen Strategy. Opportunities for the economy have been linked primarily to green hydrogen by stakeholders such as Greenpeace or the European Environmental Bureau who emphasise that renewable energy projects create ten times the jobs than fossil ones (EurActiv 2020e), whereas companies such as Iberdrola, SolarPower Europe or Akuo Energy point to the creation of jobs and economic growth through green hydrogen production (Contify Energy News 2020b; Just-Auto Global News 2020). When the European Commission launched the Clean Hydrogen Alliance in early 2020, green hydrogen´s potential for the economy has been explicitly linked to sustainable solutions and the EU´s climate goals (Impact News Service 2020c). To a lesser extent, stakeholders such as German engineering association VDMA have emphasised the economic opportunities for blue hydrogen (Impact News Service 2020b) or the opportunities for a transitional period such as the International Association of Oil and Gas Producers (IOGP) (EurActiv 2020f). The discourse moreover puts these opportunities repeatedly in the context of a competitive market that still needs time as put forward by Uniper (SNL 2020b) or BNP Paribas (Financial Times 2020).

Finally, some other codes are noteworthy for the context in which key debates take place. These specifically refer to the role attributed to the EU. While many expressions of actors follow EU decision-making such as in the context of the EU´s revision of the Renewable Energy Directive which Global Witness welcomed as it kept hydrogen produced from fossil fuels out (Impact News Service 2021b), the main debates mirrored the key topics found in this discourse analysis and their links with calls for EU specification. This has been industry" (Impact News Service 2021b) but also associations such as Hydrogen Europe calling for a concrete framework (Platts European Gas Daily 2021b).

As a third step, we engage in an analysis of some key topics associated with hydrogen. These involve the debate on so-called hydrogen colours and the publication of the EU´s hydrogen strategy. One key debate the discourse analysis shows is the question which colour of hydrogen should be used. Whereas green hydrogen is considered CO_2-free, other hydrogen production processes (grey, blue, turquoise) are not considered CO_2-neutral at all or only under certain conditions. Hence, the color of hydrogen is considered highly relevant in the discourse and one major aspect of debate.

Grey hydrogen, generated from natural gas or methane, is merely considered as starting technology for green hydrogen, such as by German refiner Heide (Impact Financial News 2020) or as potentially limiting the investments in green hydrogen due to costs as analysed by BNP Paribas (Noticias Financieras 2020a). Moreover, Gazprom has been pushing for grey hydrogen to be exported to the EU (Platts European Gas Daily 2020a).

This is also the case for another colour. Specifically with regard to Russia as potential exporting country of hydrogen to the EU, *turquoise hydrogen* has been referenced, meaning that instead of CO_2 emissions stemming from the use fossil fuels (grey hydrogen), the production with methane separation will have solid carbon as a by-product that could be used as fertiliser (Energy Monitor Worldwide 2020a). Put forward by Russian energy giants Rosatom and Gazprom, turquoise hydrogen has merely been placed by Russian actors in the debate (WPS 2020a).

Purple hydrogen which refers to hydrogen produced through electrolysis powered by nuclear energy, has been pushed for particularly by nuclear energy firms. Whereas EU-based actors such as French senators (Nuclear Fuels 2021), Slovakian officials (Platts European Power Daily 2021a), or European nuclear association Foratom in the context of the EU taxonomy debate (Platts European Gas Daily 2021a) have pushed for the use of purple hydrogen, a debate has also evolved in the context of (Russian) imports to the EU, most notably brought forward by Rosatom (M-Brain Russia News 2020).

The main colour debate, however, has evolved concerning *blue* and *green hydrogen*. Blue hydrogen which refers to hydrogen produced generated from the steam reduction of natural gas, has been referred to primarily in the context of existing gas infrastructure which should be used also for hydrogen (Eolas Magzine 2019). In this vein, some actors have also preferred to use the term "low-carbon hydrogen" instead of blue hydrogen such as Russian firm Gazprom in the context of imports to the EU (Nefte Compass 2020). The debate on blue hydrogen as transitional technology has gained ground specifically since 2021. A transition through blue hydrogen has been framed as substantial and highly necessary by energy stakeholders such as Zukunft Gas (Platts European Power Daily 2021c), the International Association of Oil and Gas Producers (IOGP) (EurActiv 2020f), or as "low-cost intermediate solution" by several companies such as Wintershall, BP, ENI, OMV, GIE, or Exxon Mobil (EurActiv 2021d; Eolas Magazine 2019). The statement by Al Cook from Equinor, sums the arguments well up:

"Green is the destination, but we'll get there on a blue highway. At some point, green hydrogen might well be lower cost than blue, but that will likely not be for at least a decade" (Gulf Business 2021).

Potential low costs of blue hydrogen have been particularly put forward in the context of using existing gas infrastructure, including pipelines and LNG terminals. Unsurprisingly, mainly companies from the gas sector such as GRTgaz, GRDF, Elengy, Uniper, or Gas Infrastructure Europe have argued for such a use (SNL 2020b; Eolas Magazine 2019; EurActiv 2019c). This framing has been also linked to technology openness by which actors mean a flexible approach mainly to blue hydrogen as such a transition technology. Throughout the discourse, this has been emphasised by many stakeholders such as Power to X (Impact News Service 2020b) or GIE (Eolas Magzine 2019). One striking example constitutes the argument made by VDMA spokesperson Matthias Zelinger:

"the profitability of energy sources must be determined by the price of CO2 and the conditions of their various applications. A technology neutral, competitive approach promotes innovation and is a good basis for us on the global market." (Impact News Service 2020b).

Moreover, blue hydrogen has been associated, for instance by Eurogas, to the ability to produce higher volumes (Platts European Gas Daily 2020b). In contrast, blue hydrogen has been framed in a more negative way as transitional with green hydrogen as future by many political actors. It has been attributed only a "marginal role" as expressed by Commissioner Timmermans or Comission President von der Leyen (Platts Power Europe 2021; Thai News Service 2021a) and for the European Commission, green hydrogen is the priority (Platts European Power Daily 2021d), a prioritisation mirrored in the EU´s Hydrogen Strategy (Barnes and Yafimava 2020).

It is the debate between green hydrogen framed as more sustainable and with more opportunities and blue hydrogen merely emphasised by stakeholders from the energy sector that is a main finding of the analysis. For instance, NGOs such as Greenpeace or the European Environmental Bureau have argued for the economic opportunities of green hydrogen in a sustainable green economy (EurActiv 2020e), whereas companies from the renewable energy sector such as SolarPower Europe or Akuo Energy have argued in the same manner (Contify Energy News 2020b; Just-Auto Global News 2020). The cost-factor of green hydrogen, at least in the short-term, has been an issue of debate as well. In order to speed up the production of green hydrogen, stakeholders such as Agora have called for specific quotas for green hydrogen which "would create a stable demand for green hydrogen and ensure the financing of the technology" (EurActiv 2019c). Against this background, the costs of green hydrogen and its volume potential has been debated by several stakeholders including WWF (EurActic 2019b), and some actors such as the German association for renewable energy have argued for green hydrogen imports in order to keep the European renewable sector competitive (Energy Monitor Worldwide 2020b). The argument for green hydrogen has also included calls for a clear labelling of the hydrogen colour (Seenews 2020). The main advocates for green hydrogen use and prioritisation are energy companies from the renewables sector such as WindEurope, MHI Vestas, BayWa, Enel, Solar EuropePower or Akuo (Targeted News Service 2020; Noticias Financieras 2020b), but also companies such as BMW (Contify Automotive News 2021). One good example of the debate on green hydrogen versus other colours constitutes the motion passed by the European Parliament in May 2021, which backed the use of "low-carbon hydrogen" as bridge towards green hydrogen and was supported by the faction EPP, Renew Europe, S&D. This motion was heavily criticised by NGOs such Climate Action network Europe or WWF, the latter stating that "so-called 'low-carbon' 'bridging technology' hydrogen is a high-carbon bridge to nowhere" (EurActiv 2020i).

Finally, a detailed look at the debate on the EU´s Hydrogen Strategy is important as well. This strategy has been welcomed by a wide range of stakeholders including Airbus which pointed to the document as "enabling the ambitions" of the company (EurActiv 2020b), the CEFIC which saw it as important building-block (EurActiv 2020c), T&E which welcomed the focus on zero-emissions transport (EurActziv 2020c), and the European Steel Association which embraced it to introduce green steelmaking (Impact News Service 2020d). Only few actors such as the European Environmental Bureau criticised the strategy as "gift to fossil fuels companies" (EurActiv 2020c). Other industrial actors pointed out gaps in the strategy, especially around carbon capture, utilization and storage, which the European cement Association called "absolutely crucial to decarbonize our sector" (World Gas Intelligence 2020).

4. Conclusion

Starting from the observation that hydrogen plays a key role in the EU´s efforts to decarbonize sectors that have hard-to-abate emissions, this study has engaged in a discourse analysis of the debate on hydrogen in the European Union across actors, and topics. It has focused on the research question how the discourse on hydrogen in the European Union unfolds in terms of actors, the application, opportunities, and organisation of hydrogen policies. Analysing the discourse based on more than 32,000 media reports, this study has the following key findings. First, specifically actors from the economic sector, companies and their associations, engage in the debate on hydrogen, whereas non-governmental organisations and political stakeholders are also present, although to a lesser extent. Second, the discourse focuses on a wide range of topics including the so-called colour of hydrogen, its application, opportunities, and organisation. Main discussions centre on green versus blue hydrogen, EU legislation and specification, and the application of hydrogen.

Against the backdrop of the complex environment in which the discourse unfolds, a critical reflection on these findings is relevant. As one potential impact on the findings of this study, the COVID-19 pandemic might have generated effects on the debate. By analysing the data material, a main effect is an increase in funding sources and opportunities for EU member states with the post-pandemic recovery fund that is used in some countries such as Spain and Italy for hydrogen projects (Noticias Financieras 2021). Moreover, it is relevant to reflect on the methodological approach used. Rather than a fully-fledged discourse analysis, this study has focused on capturing and mapping the debates. It will be thus necessary to engage in a more thorough manner with the contexts, power-relations and languages of this discourse in future studies. Moreover, the Nexis search has to some extent also included state-owned media agencies such as WPS in the case of Russian media reports. While the output generated from these agencies is rather limited, a future data analysis should have a detailed look on potential effects.

Finally, we have sought to engage with a first mapping and analysis of the discourse on hydrogen in the EU. In next steps, we seek to enlarge the period of investigation, engage with an examination that is linked in a more thorough manner with a theoretical framework, for instance to analyse frames generated in the discourse, and embark on discourse analyses in specific EU member states. The latter might then be also used to generate network analyses in the EU and its member states on who is engaging in the discourse to what extent, to which topics and in which contexts.

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