

Fossil Capitalism's Lock-ins: The Natural Gas-Hydrogen Nexus

John Szabo^{a,b}

^aDepartment of Environmental Sciences and Policy, Central European University, Budapest, Hungary; ^bInstitute of World Economics, Centre for Economic and Regional Studies, Budapest, Hungary

ABSTRACT

This paper investigates the hypothesis that power relations in the current, fossil fuel-based capitalist system allow the natural gas industry to appropriate the notion of a hydrogen energy utopia and substitute a natural gas-based vision for a renewable-based one. Although the uptake of hydrogen as a fuel is still in its infancy, the push to decarbonise natural gas-consuming regions has spurred action by natural gas industry actors to capture future markets. In doing so, they are able to maintain their capital accumulation practices based on unsustainable resource exploitation. This paper looks at how the domains of economic competitiveness, infrastructures, (geo)politics, and ideology all underpin the power of the natural gas industry to the detriment of their renewable competitors. The European Union is discussed in more detail, since this is the first region where ambitious climate policy targets and natural gas consumption collide.

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Introduction

A looming threat of climate change has pushed global society to begin to decarbonise its energy system. Electrification and renewables are the key disruptors, but technical hurdles remain *en route* to the consolidation of a low carbon economy. Experts have touted hydrogen as the missing link: a non-emitting, high power density, transportable fuel that can replace fossil fuels in applications ranging from industry to transportation. It can also store energy over longer periods of time, while potentially allowing firms to utilise existing natural gas infrastructure to transport and distribute it. Upon first reading, hydrogen offers a solution to our climate woes; especially, if we consider that it can be produced from renewables via power-to-gas

CONTACT John Szabo  szabo_john@phd.ceu.edu

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technologies. Most have been excited about hydrogen's ability to shift our economies to sustainable ones by relying on renewable-based electricity generation. This paper proposes an alternative hypothesis: the current disposition of fossil fuel-based capitalism is set to pave the way for fossil fuel interests to capture hydrogen energy markets. The natural gas industry is especially well-positioned to appropriate the idea of a sustainable hydrogen utopia for a hydrocarbon-based one. We explore the various lock-ins that support a fossil fuel-based hydrogen society and assess this nascent market's developments in the European Union.

Scholars have only gradually reflected on the unique role energy plays in relations of production. Classical political economists were preoccupied with land's and labour's role in production, although the industrial revolution shifted their thinking to include raw materials as well. Karl Marx, for instance, paraphrases William Petty in stating that "labour is its [material wealth's] father and the earth its mother" (Marx 1887, n.p.). Energy resources are key inputs in industrial production, leading fossil fuels to mediate the social relations of fossil fuel-based capitalism, or simply *fossil capitalism* (Altvater 2006). This ever-expanding mode of social organisation faces planetary boundaries, as fossil fuels are non-renewable and their combustion has introduced the looming threat of climate change (IPCC 2018). Environmental constraints have not arrested the expansion of fossil capitalism, as fossil fuels continue to offer lucrative returns and mediate our modes of social organisation (Bellamy and Diamanti 2018; Szeman 2019). Social pressure is nonetheless mounting for climate action. The climate crisis offers us the opportunity to instate radical change by recalibrating fossil capitalist social relations predicated on exploitation. Alternatively, it could lead to incumbent actors stymieing the buds of transformation and maintaining prevalent social relations with a slight techno-fix – essentially substituting one fuel for another, *ceteris paribus*.

Hydrocarbon interests have begun to appropriate the notion of a sustainable hydrogen energy utopia for one based on natural gas. This paper traces the initial steps of this strategy and untangles how existing lock-ins empower the hydrocarbon sector. We first explore how the utopia of hydrogen has developed over the course of history. Then, we map the competing modes of hydrogen production, the power relations they encode, and the fuel's revolutionary potential. We then turn to the European case, where the fossil fuel industry has already leapt into action. This paper is based on the critical discourse analysis of policy and position papers issued by policy-makers, analysts, and energy industry incumbents (Fairclough 2013). It also draws on the analysis of presentations and discussions at the European Commission's (2018) prime natural gas industry event, The Madrid Forum. The author also conducted thirty-eight expert interviews with policy-makers, advocacy group representatives, industry experts, and academics to inform this paper's assessment of unfolding events.

Fossil Capitalism's Lock-ins

Marx wrote that the earth is material wealth's mother a century and a half ago, but the scale of its exploitation has considerably changed since then. Pre-industrial societies had relatively modest energy demands. They established *organic economies*, where source-fuels comprised of power extracted from phytomass, hydro, wind power, and limited quantities of coal (Wrigley 2010). The rise of industrial capitalism in the late-18th century rewrote these arrangements. Producers turned to coal to meet their demand for a steady supply of power dense energy resources enabling the proliferation of capital accumulation. Capitalist social relations were forged through the mediation of fossil fuels, paving the way for fossil capitalism (Malm 2016). Coal essentially constituted all additional energy demand growth between 1800 and 1900, and its role in global energy supply grew from 2 percent to 47 percent during that century (Smil 2010). Industrial production continued to rapidly expand in the 20th century, yielding an average annual economic growth rate of more than 3 percent – double the preceding century's average (Piketty 2017). Industrialising societies quickly conflated economic growth, industrialisation, and fossil fuel consumption to structurally institute fossil capitalist relations (Bellamy and Diamanti 2018).

The 20th century brought a rapid expansion of the oil and natural gas industries. Hydrocarbons proved to be an even more condensed and convenient source of energy, while allowing for the substitution of labour with technology during their production (Mitchell 2009). Their role rapidly grew in the global circuits of production. The tentacles of fossil capitalism expanded with the launch of electrification, motorisation, and the ascent of the petrochemicals industry (Malm 2018). Energy demand increased eleven-fold during the 20th century, with 81 percent of this met via fossil fuels (Fouquet 2016). A social structure predicated on expanding fossil capitalism also brought with it the rising concentration of wealth through control of resources in the hands of a limited number of entities. Monopoly capitalism accelerated (Lenin 1970). Oil and natural gas companies grew to become the largest and most profitable corporations in the world, controlling vast deposits of resources and underpinning industrial output. Currently, six of the largest ten companies by consolidated revenue are oil and gas corporations, according to the Fortune (2019) Global 500 tally. The power these entities have accrued allows them to exert a disproportionately large influence over the structures that maintain fossil capital's economic, political, ideological, and cultural relations in contemporary society (Wilson, Carlson, and Szeman 2017).

Fossil capitalism's disposition is reified through what Unruh (2000) identifies as a *carbon lock-in*. This is comprised of *scale economies* (decreasing

costs with increasing production), *learning economies* (specialised skills reducing production costs), *adaptive expectations* (consumers and producers assume the stability of the system), and *network economies* (the development of interrelated technological systems). Unruh focuses on the economic and socio-technological dimensions of a lock-in, but these aspects should be extended to include the political and ideological factors that reproduce of fossil capitalism (Boyer 2014). This paper argues that fossil fuel interests depend on four heavily intertwined analytical dimensions of power to maintain their lock-in: (1) they can exploit resource bases economically; (2) infrastructure, including hard (e.g. pipelines) and soft infrastructure (e.g. the legal-technical means to produce, trade, etc.); (3) (geo)political factors; and (4) ideological inscription. These facilitate the continuation of a structural setting, where fossil fuel interests can continue to capitalise on their resource bases and impede a radical shift away from *fossil monopoly capitalism*. Stakeholders' claims and ability to exploit energy resources, as well as their push to utilise existing infrastructure, hinders their willingness to pursue a radical shift. (Geo)political factors are also crucial, insofar as those operating in fossil capitalism will look to uphold political stability to ensure capital accumulation. And lastly, society's widely adopted practices and ethical judgements pertaining to the desirability of fossil capitalism maintain and reify the system's structures.

Proliferating fossil fuel combustion has led to heightened greenhouse gas emissions, ushering in an era of anthropogenic climate change. This has turned into a climate crisis that poses a rupture to the dominant power relations predicated on fossil fuels, since most of global society's efforts to decarbonise will have to be directed at its energy system (Scrase et al. 2009). Renewables, such as solar photovoltaics and wind power plants, carry disruptive potential that recalibrate carbon lock-ins. However, they are unable to institute all-encompassing change, in-part due to technological limitations. We are unable to (economically) electrify social practices currently in place, while electricity storage to enable electrification on a grand scale is also lacking (Sivaram 2018). This is further inhibited with the existing lock-ins of fossil capitalism. Key fossil fuel actors have drawn on the carbon lock-in to promulgate their vision of the future. Hydrogen is at the heart of this strategy, since it is a source of energy that sustains *decarbonised fossil capitalism*.

The Utopia of a Hydrogen Society

Hydrogen has a long-standing history of being a sustainable fuel utopia. This vision is based on the ability to use renewable-based electricity for the electrolysis of water, yielding *green hydrogen*. Verne (1874, ch. 11) was among the first who wrote about the idea in *The Mysterious Island*:

“And what will they burn instead of coal?”

“Water,” replied Harding.

“Water!” cried Pencroft, “water as fuel for steamers and engines! Water to heat water!”

“Yes, but water decomposed into its primitive elements,” replied Cyrus Harding, “and decomposed doubtless, by electricity, which will then have become a powerful and manageable force, for all great discoveries, by some inexplicable laws, appear to agree and become complete at the same time. Yes, my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable. Some day the coalrooms of steamers and the tenders of locomotives will, instead of coal, be stored with these two condensed gases, which will burn in the furnaces with enormous calorific power.”

The narrative of a *hydrogen society* became a staple of science fiction writers and technocrats by the middle of the 20th century, despite society making little progress on the fuel’s wide-scale adoption (Zubrin 2007). These narratives strengthened the fuel’s positive connotation and reified its ideological lock-in.

Experts saw hydrogen as the *ultimate fuel* (Dell and Bridger 1975) by the 1970s, but the oil crises did not disrupt the lock-ins of a fossil fuel economy. Environmentalism’s rising momentum and the growing awareness of climate change beginning in the 1980s pushed some countries and corporations to explore fossil fuel alternatives. Car manufacturers and the U.S. navy took steps to deploy fuel cells in the 1980s and 1990s, but ultimately halted these undertakings (Romm 2004). Oil’s role in transportation was too pervasive to substitute. In 1998 the Icelandic Parliament was the first to lead a large-scale inquiry into what a hydrogen society might look like (Hultman 2009). This is a still-ongoing experiment, but its impact has been limited. Hydrogen has not displaced oil consumption and is being crowded out by electricity’s use as an energy carrier in Iceland. President George W. Bush reinvigorated the discourse of hydrogen as the *future energy source* in the U.S.A. when he launched the National Energy Policy Development Group (2001) to explore and promote the fuel’s potential. This was followed by the U.S. Department of Energy’s (2002) report arguing that hydrogen is the only energy form that can help sustain current modes of living, while averting climate change. U.S. efforts to promote hydrogen’s uptake were thwarted by the shale gas revolution that offered the country ample supplies of a relatively clean fuel and was supported by existing lock-ins.

Europe had also been a front-runner in developing a hydrogen economy, given its vast reliance on imported fossil fuels and its bid to lead global climate action (Oberthür and Kelly 2008; Eurostat 2019). The European

Commission launched the High Level Group on Hydrogen and Fuel Cell technologies in the early-2000s. Research Commissioner Philippe Busquin claimed that

[u]p until now in the ‘fossil fuel civilisation,’ we have been trying to strike a balance between the need to foster economic growth and at the same time to ensure this has a minimum impact on the environment. With an extensive use of hydrogen as an energy carrier, this conflict will be resolved. (European Commission 2002)

The Group argued that member states of the European Union should shift to an energy system based on renewable electricity generation, nuclear-based energy, as well as fossil fuel combustion paired with carbon capture and storage technologies, and use hydrogen as an energy carrier (European Commission 2003). The report was followed by the European Council’s decision to establish the Fuel Cells and Hydrogen Joint Undertaking in 2008, providing a platform to explore hydrogen’s future role (Council of the European Union 2008). The leaders of the EU reconfirmed their commitment to exploring hydrogen’s potential at an informal meeting in Linz, Austria in September 2018, when they launched the non-binding Hydrogen Initiative (EU Energy Ministers 2018) and the European Commission (2020) has followed up on this with a Hydrogen Strategy. Initiatives in the U.S. and Europe reflect the deep-seated culturally-inscribed understanding that hydrogen could underpin a sustainable utopia, but the fuel’s inability to gain momentum reflects the fact that we have not witnessed a sufficiently strong rupture in fossil capitalism’s lock-ins.

Why Hydrogen?

Researchers have long understood hydrogen to be a high power density energy carrier that yields no pollutants when combusted, and an element that can be produced via the electrolysis of water (IEA 2019). It can also be stored for longer periods of time without degrading – in contrast to most currently available energy and electricity storage technologies. Historically, hydrogen was consumed as a component of manufactured gas since the beginning of the 19th century – typically produced from coal or oil (Thomas 2018). Urban residents and industrial consumers in Western Europe quickly adopted its coal-based variant, town gas, due to the availability of coal, its convenience for lighting and other applications, and the fuel’s ability to alleviate air pollution by moving combustion sites outside urban areas. The 20th century brought the demise of town gas, as high coal prices and discoveries of large natural gas deposits led most European consumers to switch from coal-based town gas to natural gas (Peebles 1980). Meanwhile, European companies and governments undertook large-scale infrastructure upgrades necessary to enable a rapid switch from one fuel to the other (Williams 1981).

These actions show that policy-makers, the energy industry, and the wider population saw gas as a key and favourable source of energy. Countries were willing to adapt their infrastructure to accommodate the transit and distribution of the new fuel. This disrupted town gas' lock-in, but reinforced the lock-in of gas more broadly. The natural gas industry argues that many of these actions can essentially be reverse-engineered, allowing hydrogen to be transited and distributed through natural gas infrastructure (once again). This would yield tremendous economic savings for society, since with such a transition alternative infrastructure does not have to be constructed, with gas transmission system and other gas infrastructure operators kept in business. Legal-technical lock-ins also surface, as policy-makers expect that they can anchor hydrogen's regulations into those of natural gas. Policy-makers have extensive experience with engineering natural gas markets, which streamlines their approach to developing hydrogen markets.

The feasibility and the costs of the shift from natural gas to hydrogen infrastructure are not clear yet, as the industry is only beginning to conduct related experiments. Expert findings are promising, but much work still has to be done (IEA 2019). A methane-hydrogen admixture between 5 and 15 vol percent in existing natural gas infrastructure has been proven possible, but factors ranging from the age of the infrastructure to national regulations shape these figures (Ogden et al. 2018). Interviewees also pointed out that many unresolved issues remain with regards to the pipelines, for example the extremely high costs of switching pipeline fittings to suit the requirements of hydrogen. Moreover, Meng et al. (2017) find that “[t]he fatigue life of the X80 steel pipeline [a popular natural gas pipeline choice] was dramatically degraded by the added hydrogen” (7411). Various companies and researchers are also exploring how hydrogen can be stored in different geological formations. Salt caverns offer the most promise; although, researchers are heavily engaged in understanding how depleted natural gas and oil fields can store hydrogen, since they constitute the bulk of current natural gas storage capacities (Tarkowski 2019). Lastly, adapting end-user appliances to hydrogen or hydrogen-methane admixtures is a further crucial challenge (de Vries, Mokhov, and Levinsky 2017). Such experiments are at the top of the agendas of both company executives and policy-makers, indicating how great a lock-in investment into infrastructure yields.

The invention of the fuel cell allows hydrogen's applications to go beyond that of an energy carrier capable of producing heat and light. Fuel cells use hydrogen to generate electricity by converting the energy of a chemical reaction between hydrogen and an oxidant into electrical energy. Its application has been most promising in transportation, where engineers have sought a carbon neutral source of energy that has a power density higher than the lithium ion batteries – currently limiting the range of electric vehicles.

KPMG's (2018) authoritative automotive survey indicated that executives in major companies expected that the future of personal vehicles may be hydrogen fuel cells, as opposed to electric. The surprising development reflects the lock-ins predicated on systemic interconnections between the transportation sector and a fuel that behaves similar to oil. Hydrogen offers similar power density, range, transmission and distribution system to its hydrocarbon counterparts. And, as we will argue below, it relies on the power relations prevalent in fossil capitalism.

The Different Colours of Hydrogen

Hydrogen is already a key feedstock in the circuits of global production. 2018 dedicated pure hydrogen output amounted to 73.9 million tonnes, which was consumed by the oil refining (52 percent), ammonia production (43 percent), and other (5 percent) sectors (IEA 2019). Additionally, industries such as steel and methanol production consumed a further 45 million tonnes of hydrogen which was not separated from other gases – this is primarily sourced from non-dedicated hydrogen output. 76 percent of dedicated hydrogen production is reliant on natural gas, with the remainder on coal, while carbon capture and storage/utilisation (CCUS) technologies only playing an experimental role in the supply chain. As industrialisation continues in a large number of countries, the IEA (2019) anticipates that hydrogen demand for industrial uses will continue to grow, but this is not the domain that we are concerned with in this paper. Instead, we are curious about the energy disposition into which hydrogen is being introduced: a fossil capitalist setting where global society needs to urgently decarbonise its energy system. This constitutes an undertaking much greater than current industrial consumption. Energy-specific applications of hydrogen may currently be scarce, but, as remarked by the Executive Director of the IEA, Birol (2019), “hydrogen offers tantalising promises of cleaner industry and emissions-free power: turning it into energy produces only water, not greenhouse gases. It’s also the most abundant element in the universe. What’s not to like?”

Experts such Birol, build on the long-standing idea that a hydrogen utopia will be green, but the realities of our carbon lock-in suggest that it will be fossil fuel-based for the foreseeable future. Green hydrogen production is in its infancy, meaning that it is not yet economically viable, nor has it been scaled up to produce energy on a large scale. The largest hydrogen electrolyser has an installed capacity of 6 MW, which is set to be followed by other projects adding 5–30 MW apiece (Collins 2020). These are dwarfed by the existing hydrogen production capacities already used by oil refineries, for example. Dedicated pure hydrogen production is currently intimately linked to the hydrocarbon industry, since the oil refining industry is the

prime user of hydrogen as a petrochemical for hydrocracking and desulphurisation. Industry incumbents carry the know-how and have already constructed vast hydrogen production infrastructures. The oil and ammonia industries predominantly rely on steam methane reformers to produce pure hydrogen, a natural gas-based process with a high operational efficiency and low production costs (IEA 2019).

Steam methane reforming offers the cheapest form of hydrogen, but it leads to emissions. Natural gas-based emitting hydrogen production yields so-called *grey hydrogen*. Other emitting forms of hydrogen include *black* and *brown*, for which producers rely on hard coal and lignite, respectively, as feedstock. Coal gasification is in use or being considered as source of energy production in coal-abundant regions such as China or Poland, and rely on a long-standing technology used for town gas production already popular two centuries ago. Governments have begun to frame the technology in a positive manner, with Polish MP Sitarski (2018) claiming at COP 24 in Katowice that Poland will become “hydrogen Kuwait.” The fossil fuel industry can draw on both its access and ability to exploit natural resources and existing infrastructure to establish its role at the heart of a hydrogen society. Additionally, geopolitics comes into play, as the cases of Poland and China show, since their governments are laying the foundations to maintain their energy self-sufficiency.

The emissions of black, grey, and brown hydrogen have led involved industries to devise ways to decarbonise fossil fuel-based hydrogen. These still cannot offer sustainable modes of energy production, but they can potentially alleviate air pollution, eliminate greenhouse gas emissions, supply hydrogen in large quantities, and keep fossil capitalism intact. Emissions can be eliminated if producers apply carbon capture and utilisation/storage (CCUS) technologies, leading to *blue hydrogen*. Oil and natural gas firms have a competitive edge in deploying CCUS, given their long-standing experience with the technology involved. Most CCUS projects currently in operation are linked to enhanced oil recovery (EOR), which oil and natural gas companies have been deploying since 1972 (Herzog 2011). The economics are also in favour of fossil fuel-based hydrogen production, since these are generally 2–4 times less expensive than green hydrogen, even with the costs of CCUS included (Götz et al. 2016; Zero Emissions Platform 2017; IEA 2019). This competitive advantage hinges on numerous factors, ranging from the costs of renewables, their utilisation rates, location, and linkages to the grid, as well as the costs and utilisation rates of electrolyzers. However, they depict the uphill battle green hydrogen faces against its grey and blue variants on solely economic grounds.

Green hydrogen’s prospects are boosted by maturing renewables and electrolyser technologies, as well as the inability of private and public actors to develop and deploy CCUS. Glenk and Reichelstein (2019) surveyed cases

in Germany and Texas, where wind-based power-to-gas production proved to be competitive on a small and medium scale. As electrolyzers become more efficient, renewables become cheaper, and technology allows a more precise synchronisation of various systems, green hydrogen production may challenge its fossil fuel-based counterparts on economic grounds in the coming 10–15 years (Staffell et al. 2019). Additionally, large-scale CCUS has been very slow to materialise, despite it being a prerequisite to meeting commitments made in the Paris Agreement (Anderson 2015). The shaky economic foundations for it, the lack of coherent national, regional, or global strategies for its development, and barriers posed by social acceptability still hinder its expansion (Braun et al. 2018; European Court of Auditors 2018; Herzog 2018). The IEA (2017) claimed that “the global portfolio of CCS projects is not expanding at anything like the rate that would be needed to meet long-term climate goals” (61). In principle, green hydrogen could become economically competitive in the foreseeable future, but it will have to have a more forceful impact to disrupt the lock-ins of fossil capitalism.

Europe, the First Battleground for Hydrogen Markets

European Union policy-makers are taking action to establish hydrogen as a pillar of decarbonisation; an opportunity on which the hydrocarbon industry has been quick to pounce. At the root of this dynamic is the EU’s leading role in the battle against climate change, which has become even more prominent following the 2015 Paris Climate Agreement and the European Commission’s (2016) decision to accelerate the diffusion of renewables and electrification with the Clean Energy for All European policy package. This stands in contrast to the lock-in of natural gas EU member states have developed. They consume immense amounts of the fuel and have a vast infrastructure network traversing the continent to deliver the fuel to end-users (Alvera 2017; Eurostat 2019). The European Commission and national governments have also developed and implemented extensive rules and regulations to facilitate the trade of the fuel (Glachant, Hallac, and Vazquez 2013), which, in turn, have played a central role in maintaining the geopolitical stability between Europe and Russia (Gustafson 2020). The natural gas industry has a long-standing strong presence in the region, empowering industry incumbents to assert their power to capture hydrogen markets.

Natural gas industry actors have devised a relatively coherent message in response to the EU’s climate ambitions: they can facilitate the energy transition by decarbonising natural gas and utilising available infrastructure. The industry pushed to be included in the EU’s energy future. Their motion was supported by Eurelectric’s (2018) – the EU electricity generators’ advocacy group – influential position that existing technologies only allow a

maximum of 60 percent electrification in the EU; therefore, additional source-fuels and energy carriers will be necessary in coming decades. Given the hydrocarbon industry's strategic interests to continue their capital accumulation based on the resource bases at their disposal, actors launched a campaign supportive of blue hydrogen. The matter was led by transmission system operators, since their businesses would default without any gas flowing through their pipelines. They were the leaders in devising and promulgating the message that Europe requires some form of natural gas to meet its energy needs (Stern 2019).

In principle, natural gas producers have slightly greater maneuverability, since they can export their resources to alternative geographies, but the European market is so vast, and its lock-ins so extensive, that major suppliers have taken a large interest in adapting to the EU's needs. Equinor has been a vocal proponent of hydrogen, since it is in a good position to capture this market (Eikaas 2017; Szalai 2017). It has vast natural gas deposits, expansive infrastructure, experience with steam methane reforming, and a long history in using CCUS. Not only has it fine-tuned CCUS for EOR, but most of its hydrocarbon production takes place offshore, providing it the opportunity to store CO₂ in a socially acceptable manner. Unsurprisingly, the company has become the leader of multiple hydrogen projects in Europe (e.g. H21, H-vision, Magnum, and the Net Zero U.K. partnership) (European Commission 2017; Equinor 2020).

The EU's largest natural gas supplier, Gazprom has looked to methane pyrolysis (methane cracking) to decarbonise its natural gas supplies (Shiryaevskaya 2018). This technology splits methane into carbon and hydrogen without combusting the molecule – avoiding CO₂ emissions. During methane pyrolysis, bubbles of methane (CH₄) rise through a plasma (various liquid metals can play this role), breaking the chemical bond between carbon and hydrogen. The reaction deposits carbon on the inner surface of the hydrogen bubbles. When the bubble pops at the surface of the plasma, the carbon – in the form of carbon black – is deposited on top of the plasma, while the hydrogen gas rises and is captured (Weger, Abanades, and Butler 2017). Methane cracking provides a palatable technology for Gazprom to continue the exploitation of its natural gas resources while meeting the EU's requirements to deliver a decarbonised gas. The technology may still be in its infancy, but it offers great promise and, in comparison to Equinor's strategy – reliant on CCUS, Gazprom would not have to develop and maintain costly CO₂ storage facilities. Furthermore, the Russian firm would have access to additional revenues from the sales of carbon black, which is used in industrial applications ranging from tire manufacturing to, potentially, carbon fibre production (Chung 2017; Duke University 2019). These companies have developed the contours of strategies allowing them to capture hydrogen energy markets as soon as they emerge.

Power and Platform

A hydrogen society is still far from a sure thing and many still perceive it as mere hype. The industry and policy-makers have to overcome numerous technical hurdles before the fuel's consumption can take off. Irrespective of its future trajectory, we see how a threatened industry has mobilised to maintain its prominent role in fossil capitalism by capturing a new market that perpetuates its activities. Its actions are also coupled with attempts to shape policy agendas; most prominently, the industry has attempted to steer discussions of the European Commission's (2018) Madrid Forum. This has been annual convention of key natural gas stakeholders (policy-makers, producers, infrastructure owners, and a few academics), where discussions have focused on the technical codes regulating the EU's natural gas markets. The 2018 Forum reoriented this focus to the future of natural gas, and participants presented hydrogen as a palatable option to meet the region's energy demand in an economic manner, while maintaining that it would also sustain their businesses. The Fuel Cells and Hydrogen Joint Undertaking may still be a key platform to discuss the explicit applications and technical hurdles related to hydrogen, but the Madrid Forum's inclusion of the issue reflects the natural gas industry's push to include itself as a key stakeholder in the EU's hydrogen future. In doing so, it is actively shaping the policy-making agenda, which, coupled with its political clout reliant on extensive lobbying (Balanya and Sabido 2017) and its lock-in, reflects its bid to maintain its role in the broader system by decarbonising the fuel it supplies. The natural gas industry has been eager to shape the hydrogen policy agenda, irrespective of the fuel's prospects amounting to mere hype or more, while advocacy groups of green hydrogen are notably left out of these discussions.

The European Commission requested that key stakeholders conduct studies to better understand the role of natural gas – and, by extension, natural gas-based hydrogen – in the EU's energy future during the 2018 Madrid Forum (Borchardt 2019). This both allows policy-makers to make informed decisions and grants industrial actors an opportunity to frame their fuel as a viable and desirable alternative. The International Association of Oil & Gas Producers, an oil and natural gas advocacy group, was commissioned to inquire about CCUS. SNAM, the Italian gas transmission system operator, will research how to blend various natural gas with other gases (e.g. biomethane, hydrogen, etc.) in the gas transmission system. Gas Infrastructure Europe (GIE), a storage advocacy group, will present a study on storing various gases in existing facilities. The European Network of Transmission System Operators for Electricity and Gas (ENTSO-E and ENTSO-G), the advocacy organisations of European electricity and natural gas transmission system operators, will explore the possibilities to integrate electricity

and natural gas infrastructure. The Commission's bid to include these advocacy groups into the policy-making process is set to provide them with an opportunity to actively shape hydrogen's policy framework, most likely in their favour. Their research and findings will be crucial in identifying what is possible in the future, but it is fundamentally shaped by lock-ins pertaining to the exploitability of their resource bases, existing infrastructure, avoiding radical changes in consumer-producer relations, and drawing on the idea that society can continue to consume vast amounts of energy without exacerbating climate change through the adoption of a non-emitting fuel.

Decarbonising Natural Gas to Accumulate Capital

Global industrial capitalism relies on the wide-scale exploitation and consumption of fossil fuels. The rise of climate change as a paramount obstacle has pitted the survival of our civilisation and the interests of the fossil fuel industry – in its current form – against one another. Pressured by climate action, the hydrocarbon industry can maintain its relevance by capitalising on carbon-neutral fossil fuels. A power struggle is unfolding between green and grey/blue hydrogen to capture nascent hydrogen markets. The natural gas industry has a good chance at dominating this struggle, supported by factors stemming from four intertwined domains: (1) resource bases and production, (2) infrastructure, (3) (geo-)politics, and (4) ideology. Fossil fuel-based hydrogen remains economically competitive as it continues fossil capitalism's long-standing practice of exploiting *cheap nature* (Moore 2016). Natural gas prices have plummeted in recent years (BP 2019), enabling grey and blue hydrogen to maintain their competitive edge vis-à-vis green hydrogen production. The prices of renewables have also collapsed, but they are still frequently outcompeted by low natural gas prices. Additionally, steam methane reforming remains cheaper than hydrogen produced via electrolyzers. However, not only does the combination of renewables and electrolyzers have to be competitive, but they have to break lock-ins posed by long-term investment commitments that companies have already made in fossil fuel assets.

European actors have responded to the risk of a fossil fuel phase-out by emphasising the benefits of utilising existing infrastructure. Hard infrastructure owners – mostly transmission system operators, distribution system operators, storage facility operators, and liquified natural gas facility operators – responded by claiming that gas will be a part of the solution, but the form of this gas is yet to be identified. The form of the gas is not particularly important for them, since they can adapt to transit and distribute other fuels, although, the upstream, midstream, and downstream segments of the hydrocarbon industry maintain intimate and strong linkages optimised for oil and natural gas. Consequently, infrastructure operators will argue for the least

change possible, so their ability to capitalise on existing resources is least affected. Biogas and green hydrogen jeopardise their existing models, since energy may be produced and consumed in a much more decentralised manner in comparison to the *status quo*. Soft infrastructure and the way it is designed also underpins fossil capital's lock-in. For instance, ENTSO-G functions as an advisory body for the European Commission in drafting codes, regulations, and policy. Green hydrogen faces a clear disadvantage in this domain, since professionals drafting the regulatory framework governing power-to-gas facilities have only begun to clarify and develop the conceptual and legal definitions and tools necessary to integrate these facilities into the grid. The natural gas industry has developed a relatively united front and strategy to ensure the industry's survival, while renewables and green hydrogen producers are both fairly small and convey fragmented interests.

Political dimensions of a lock-in surface through the hydrocarbon industry's ability to shape government policy and its role in maintaining social stability. The fossil fuel industry is an immensely powerful political bloc shaping the actions of the state (Johnstone and Newell 2018), carrying the ability to influence policy via lobbying, shaping agendas (e.g. the Madrid Forum), drafting studies that will form the basis of policy, and so on. Simultaneously, fossil capitalism has maintained established consumer-producer relations, which has entrenched certain domestic (e.g. by providing jobs) and international links (e.g. through EU-Russia relations) that fortify lock-ins. Lastly, fossil capitalism provides an ideology that has normalised human practices pertaining to the widescale use of natural resources for gain, irrespective of the environmental and social impacts. An industrial capitalist regime that places capital accumulation on the back of labour and resource exploitation has been constantly reproduced by society, especially since the industrial revolution. The shock of climate change may force society to introduce technofixes that mitigate emissions, but buds of systemic transformation are not (yet) in sight. Fossil capitalism has proved to be an extremely flexible system that promulgates the desirability of fossil fuel-based practices irrespective of their sustainability. Hydrogen is the perfect energy carrier that enables fossil fuel-based relations of production and consumption to remain in place. The natural gas industry has taken the opportunity to offer the convenient solution of substituting a gas for another gas. Natural gas may be swapped for hydrogen, but apart from the technocrats directly involved with this undertaking, broader society will barely notice the change.

Final Thoughts

This paper proposed to reflect on the hypothesis that power relations of fossil capitalism will allow the natural gas industry to appropriate the notion of a hydrogen utopia and substitute a natural gas-based vision for one based on

renewables. This ultimately allows natural gas interests to dominate (future) hydrogen markets. Green and blue hydrogen only offer techno-fixes to climate change, but the latter carries the potential to perpetuate current capital accumulation practices that rely on the exploitation of our natural resources in an unsustainable manner. In doing so, fossil capitalism is set to prevail in a slightly altered form. The carbon lock-in based on economic, infrastructural, political, and ideological elements is sustained through blue hydrogen. Even if green hydrogen does not offer an opportunity to supersede capital accumulation as the governing principle of our society, the more equitable distribution of renewable energy resources, as well as the potential to decentralise and ensure a sustainable form of energy production, introduces significant change to social power relations. However, hydrocarbon interests will deploy all means at their disposal to limit the extent of this change, a move society seems willing to accept. To rephrase Jameson (2003) quoting *someone*, *it is easier to imagine an end to the world than to end fossil capitalism*.

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