

# Introduction



Rainer Quitzow  and Yana Zabanova 

**Abstract** This introductory chapter places Europe’s hydrogen ambition in the broader context of the evolving geopolitics of the transition to net zero. It highlights the growing geoeconomic rivalry among the world’s leading economies, such as the European Union, the United States, and China. This process is marked by the resurgence of state intervention in markets and industries as well as by the increasing attention paid by governments to supply chain resilience and asymmetric dependencies. Clean hydrogen has been part and parcel of these developments. The EU and many of its Member States view hydrogen as essential to their climate goals, industrial competitiveness, and energy security. As a result, Europe has played an active role in promoting a European hydrogen economy and an international hydrogen market. The chapter frames EU hydrogen policy as the interplay of interests at EU- and Member State level, which can be a source of both tensions and synergies. It also discusses how this is manifested in the EU’s external climate and energy policy and international partnerships. Finally, the chapter presents the structure of the edited volume, introduces the case studies and summarises the key analytical dimensions applied in individual chapters to examine the domestic and international components of European hydrogen policy.

## 1 Geopolitics of the Energy Transition

The transition to net zero involves a profound structural transformation of all economic sectors, going far beyond its initial focus on decarbonising the power sector. This transformation goes hand-in-hand with major changes in how access and control over energy resources influence the distribution of power in the global economy. While the spatial distribution of fossil fuels played a pivotal role in shaping

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R. Quitzow (✉) · Y. Zabanova  
Research Institute for Sustainability (RIFS), Helmholtz Centre Potsdam, Berliner Str. 130, 14467  
Potsdam, Germany  
e-mail: [rainer.quitzow@rifs-potsdam.de](mailto:rainer.quitzow@rifs-potsdam.de)

R. Quitzow  
Technische Universität Berlin, Berlin, Germany

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R. Quitzow and Y. Zabanova (eds.), *The Geopolitics of Hydrogen*, Studies in Energy,  
Resource and Environmental Economics, [https://doi.org/10.1007/978-3-031-59515-8\\_1](https://doi.org/10.1007/978-3-031-59515-8_1)

power dynamics and inter-state relations during the twentieth century, the decarbonisation of the global economy is unleashing a shift to renewable energy resources as the new backbone of the energy system, with significant geopolitical and geo-economic implications (Siddi, 2023; Vakulchuk et al., 2020). For countries and regions dependent on hydrocarbon rents, these developments represent a direct challenge not only to their economic model but also to the social and political model underpinning the distribution of power and influence in their societies (Goldthau & Westphal, 2019; Tagliapietra, 2019; Van de Graaf, 2023). Hence, this transition is also hotly contested with incumbent actors resisting change at different levels of governance (Geels, 2014), ranging from local protests against coal mine closures to intense international negotiations over the future role of fossil fuels in a carbon-neutral world economy.

But this transition not only implies a shift in the resource base that powers the global economy. Rather, it is a far-reaching transformation of socio-technical systems as climate-friendly technologies begin to replace carbon-intensive technologies and supply chains (Rohracher, 2018). This transition unlocks new opportunities for industrial development and value creation with countries and economic blocs vying for technological leadership (Goldthau, 2021). It opens up the potential for capturing early mover advantages in an emerging carbon-neutral economy and for positioning local industries in related value chains (Lema et al., 2020). In particular, China and other leading emerging economies have seen the rise of green industries as a window of opportunity for pursuing strategies to secure industrial leadership. Indeed, the rise of renewable energy technologies, the most prominent success story to date, has been accompanied by the rapid growth of Chinese renewable energy industries, challenging Western dominance of the global economy (Quitizow, 2015).

China's increasing success in dominating a growing number of emerging green industries is closely related to a deterioration of the relationship between China and Western market economies, with geopolitical considerations progressively overshadowing the principles of economic efficiency and market liberalisation. The US increasingly views China's growing industrial capabilities as a challenge to the existing economic order and US hegemony (Lippert & Perthes, 2020). China and the US have engaged in ever more hostile trade-related disputes, and multilateral fora for engagement are under strain (Kwan, 2019). More generally, the rise of Chinese state-centred capitalism and its growing influence around the world has raised concerns among OECD countries of asymmetric dependencies and waning industrial competitiveness (Gertz & Evers, 2020). Specifically, frontrunners in the development of renewable energy technologies, including the US and Europe, are increasingly disillusioned by the shrinking market shares of Western firms in the sector.

Major crises and shocks like the Covid-19 pandemic and the war in Ukraine have further reinforced these concerns. They have led to severe disruptions in critical supply chains, with the result that leading economies around the world are now paying far greater attention to geopolitical risks (Cui et al., 2023; Pujawan & Bah, 2022). Raising the resilience of critical supply chains—through reshoring, friend-shoring and the diversification of suppliers—is becoming a priority for many governments

(Maihold, 2022). This in turn is beginning to erode the principles of free trade and open markets that have dominated global discourse over the past decades.

More generally, this rise of geoeconomic rivalry coupled with the need to rapidly decarbonise the economy is leading to a re-emergence of state intervention in markets and industries (Bulfone, 2022). Governments are setting decarbonisation targets and designing support schemes to promote new, climate-friendly technologies. They are initiating policies to phase-out carbon-intensive industries, while cushioning the related socio-economic impacts. Moreover, these policies are increasingly combined with techno-nationalist discourses in the West, concerned with securing industrial value creation and maintaining control over key technologies and value chains to confront the rise of China (Van Manen et al., 2021). Western economic governance is partially adopting elements that have long characterised China's industrial policy regime, such as the strategic development of emerging industries and supply chains with large-scale investment subsidies and domestic content requirements (Lewis, 2015).

However, there are also differences in the Western response to the perceived threat of China. The US has taken a very vocal and at times belligerent stance towards its rival. It has framed the relationship as one dominated by systemic confrontation and aims at decoupling global supply chains and curtailing China's access to critical technologies (Mearsheimer, 2021). The European Union has taken a more measured approach, formulating a vision of strategic open autonomy (Miró, 2023) and de-risking—rather than decoupling—of economic interdependencies. Similarly, with the adoption of the Inflation Reduction Act (IRA) in 2022, the US government has launched an extensive subsidy scheme to counterbalance China's state-driven economic model and unleash large-scale investments across clean energy value chains. The EU, though formulating similar ambitions, remains constrained not only by the rules of its single market but also by diverging interests across different Member States and their constituencies (Prontera & Quitzow, 2021, 2022). Correspondingly, the EU's proposed Net-Zero Industry Act, widely considered a response to the US IRA, has largely fallen short of the European Commission's initial ambition to match US investment incentives.

## **2 The Emerging Role of Hydrogen in the Geopolitics of the Global Energy Transition**

It is against the background of the global trends outlined above that hydrogen has emerged as a new arena of competition in a global energy transition, increasingly characterised by geopolitical contestation. Following the formulation of carbon-neutrality targets following the Paris Agreement in 2015, governments around the world have acknowledged the crucial importance of this energy carrier for addressing a range of decarbonisation challenges that renewable electricity alone cannot solve. Most prominently, hydrogen can help decarbonise hard-to-abate industrial sectors,

like steel and cement, as well as parts of heavy transport, most notably aviation and long-distance shipping. It also has a role to play as a storage medium in a carbon-neutral energy system.

Indeed, the properties of hydrogen and derivatives like ammonia and methanol as a medium for storing and transporting energy may give it a role in a future energy system that exhibits similarities to that currently held by fossil fuels (Van de Graaf et al., 2020). Thus, it raises similar energy security questions as traditional energy commodities, pertaining to the supply and trade within a global trading system (Dejonghe et al., 2023). The development of infrastructure for the production and transport of hydrogen comes with important implications for the control over future energy flows. That said, the relative difficulty of storing and transporting hydrogen compared to fossil fuels make it unlikely that it will rise to the same prominence as today's hydrocarbons (Ansari et al., 2022).

Moreover, as an energy carrier—rather than a source of energy—hydrogen is not intrinsically linked to a natural geography of supply. There are a number of different production pathways that could play a role, at least temporarily, in the transition to carbon neutrality. These differing options represent another point of contention in the emerging geopolitics of hydrogen. Most prominently, hydrogen can be produced from natural gas in a carbon-intensive process known as steam methane reforming. If combined with carbon capture and storage technologies, the carbon footprint of this process can be reduced though not eliminated entirely. Upstream emissions of methane during extraction and transport of the natural gas feedstock as well as residual emissions from the capture and storage of CO<sub>2</sub> cannot be avoided entirely (Howarth & Jacobson, 2021). It also remains uncertain how cost-effective this is at levels of carbon capture approaching 100 percent. Nevertheless, incumbents from the natural gas industry are promoting this as an important option for accelerating hydrogen use on the way to a carbon-neutral future (Szabo, 2020). Opponents are warning of further exacerbating fossil-fuel lock-ins in the energy system.

The main alternative to this is the production of renewable hydrogen. Produced from water molecules via a process known as electrolysis, this can reduce emissions to zero. However, in a power system that still includes other forms of power generation, this raises points of contention regarding alternative uses of renewable energy as well as the role that nuclear power should play as a low-carbon option for powering hydrogen production. The latter has sparked intense debates in the European context, while the former raises important concerns regarding equity and justice within an emerging global hydrogen economy. Among other things, it has triggered discussions regarding possible trade-offs between the export of renewable hydrogen to industrial centres in the Global North, on the one hand, and the expansion of energy access in the Global South, on the other (Müller et al., 2022).

More broadly, it raises questions regarding the distribution of costs and benefits from the production of hydrogen across actors along the value chain, pointing to another important spatial dimension in the development of a global hydrogen economy. While renewable hydrogen can be produced anywhere using local renewable energy resources, the relative cost of renewables constitutes a critical factor in determining the final production cost. However, as alluded to above, relative to the

fossil-fuel economy, the geography of hydrogen production is less determined by natural resource endowments. While it is likely that the costs of hydrogen will play a key role in the formation of regional centres of hydrogen supply, the production of hydrogen close to the sites of its use also comes with important benefits. Potential buyers have to consider not only the additional cost of hydrogen transport but also questions of energy security and other geopolitical considerations when making sourcing decisions (Quitow, Mewes et al., 2023; Quitow, Triki et al., 2023).

Moreover, the question of spatial distribution extends beyond the narrow sphere of hydrogen *production*. As producers of industrial goods consider investments in new, climate-friendly production facilities, they may also consider co-locating industrial production at sites where they have ready access to a low-cost renewable hydrogen supply. In this vein, scholars have entertained the idea of a “renewables pull effect” where the availability of low-cost renewables drives locational investment decisions in future decarbonised industrial production (Samadi et al., 2023). This raises the prospect that regions that are well-endowed with renewable energy resources might out-compete existing centres of industrial production with a less favourable resource endowment (Eicke & De Blasio, 2022). However, again, this is far more than just a question of economic efficiency. Rather, it is a subject of political negotiation as stakeholders from the private and public sector explore the development of international hydrogen value chains. Countries with favourable resource endowments have an incentive to leverage their assets to ensure industrial value creation and local socio-economic benefits, while existing centres of industrial production are keen to secure a reliable and low-cost supply of hydrogen to retain current levels of value creation.

Finally, hydrogen—like other clean energy technologies—represents an important sphere of technological competition, both between rival technologies and between the major economic blocs vying for technological leadership (Van de Graaf et al., 2020). While Europe has traditionally held a leading position in the field of hydrogen technologies, competition has increased markedly in the past years, with China rapidly emerging as a low-cost competitor in electrolyser technologies. Linked to this are considerations of critical minerals, like nickel and platinum, that play an important role in the production of hydrogen-related technologies (Ansari et al., 2022; Pepe et al., 2023). Concerns over asymmetric dependencies are driving efforts to secure technological sovereignty and to diversify the emerging supply chain relationships.

### **3 The Case of Europe in the Emerging Geopolitics of Hydrogen**

The European Union as a self-identified global climate power has been at the forefront of the global energy transition and the development of a climate-friendly hydrogen economy. With its landmark European Green Deal (2019), the EU became the first major economic player to set a carbon neutrality target, which has been legally

enshrined in the European Climate Law adopted in 2021 (Knodt, 2023). In addition to relying on carbon pricing as a key mechanism to promote emissions reductions, the EU has also been bolstering its green industrial policy. It has long promoted innovation in climate-friendly technologies by funding R&D and their early industrial deployment. In this context, it has strengthened its support for public–private partnerships and industrial alliances to bolster the competitiveness of European producers (Veugelers & Tagliapietra, 2023). More recently, the bloc has tried to broaden the scope of its industrial policy to include measures to retain and expand its manufacturing capacity for net-zero technologies deemed strategically important. These include electrolyzers and fuel cells, wind and solar power components, batteries, heat pumps, carbon capture and storage (CCS), as well as biogas/biomethane and grid technologies (European Commission, 2023).

With the launch of its hydrogen strategy in 2020 (European Commission, 2020), the EU also positioned itself early on in the global hydrogen race. It has identified hydrogen as a strategic field of technology and a strategic commodity for the decarbonisation of European industrial production. It has formulated ambitious plans to rapidly boost the supply of renewable hydrogen for this purpose, aiming to develop both domestic hydrogen production and large volumes of hydrogen imports. Following the invasion of Ukraine by Russia and the ensuing gas crisis, it has further increased its ambitions, identifying the transition from natural gas to hydrogen as an avenue for eliminating its reliance on Russian natural gas. To this end, the EU has drastically increased its clean hydrogen targets, aiming for 10 million tons produced domestically and the same amount in imports by 2030 (European Commission, 2022).

In this way, the EU has framed the hydrogen economy as a crucial pillar of its future energy and economic security (Pepe et al., 2023; Quitzow, Mewes et al., 2023; Quitzow, Triki et al., 2023). However, as a continent scarce in renewable energy resources (Eicke & De Blasio, 2022), the EU faces challenges in developing reliable access to renewable hydrogen. In this, the EU differs from the US and China who have the potential to produce sufficient domestic renewable energy to decarbonise their economies (Eicke, 2023; Gong et al., 2023; Quitzow & Gong, 2023).

Moreover, due to its limited financial resources and its unique nature as a supranational entity and a union of 27 Member States, the EU faces significant constraints in investing into its domestic hydrogen economy. While the US has rapidly expanded its fiscal incentives for hydrogen investments (Eicke, 2023), EU efforts remain limited by the willingness of Member States to endow the European Commission with the required mandate and the corresponding financial resources. These challenges are particularly pronounced in the field of energy policy, where the EU lacks the competence to interfere with national decision-making (Prontera & Quitzow, 2021). In this context, the interests and positions among the EU Member States are crucial to the development of the EU hydrogen policy, emerging at the interface between national and EU-level decision-making.

## 4 Europe's Domestic Hydrogen Politics

This mismatch between European hydrogen ambition and the EU's capacities to act is met by a heterogeneous mix of national hydrogen strategies among its Member States. They reveal not only differing levels of ambition (Quitow, Mewes et al., 2023; Quitow, Triki et al., 2023), but also important disagreements on some of the critical questions highlighted above. Points of contention include the shape of future hydrogen infrastructure, acceptable hydrogen production pathways, the future role of imports as well as the design of European-wide support schemes and regulations for hydrogen. Coordinating and aligning these divergent interests is a major challenge as the EU seeks to position itself as a key player in the global hydrogen economy.

These diverging approaches are a reflection of pre-existing political and economic legacies and the structural features of their national energy systems. In many cases, they replicate long-standing tensions between Member States, such as the continued contention between France and Germany over nuclear power (Szulecki et al., 2016). In other cases, differing assets and starting points within the emerging hydrogen economy, such as pre-existing industrial legacies and pipeline infrastructure or the relative availability of renewable energy, translate into differing interests across countries. Moreover, broader political agendas and priorities, such as differing positions on Europe's stance vis-à-vis Russia (Varga & Buzogány, 2020), play a role in shaping diverging visions for a hydrogen economy. Domestic climate politics play a role, too: in several countries, there is growing unease with European climate policy, which is frequently viewed as overly stringent and costly and which has been subject to a populist backlash in some cases (Huber et al., 2021).

## 5 External Dimensions of the European Green Deal and the Role of Hydrogen

The manifold geopolitical considerations outlined above also give the EU's hydrogen policy a prominent international dimension. This aligns with the development of an increasingly active climate and energy diplomacy, which the EU recently declared a "core component" of its foreign policy (Council of the EU, 2023). Europe's limited renewable energy endowment and the importance of hydrogen imports to reach EU climate targets provide it with a further impetus for integrating hydrogen-related concerns in climate and energy diplomacy. As alluded to above, this sets it apart from other large players like China and the United States whose domestic renewable energy resources provide them with the potential for developing sufficient amounts of domestic hydrogen production. For the EU, establishing a functioning international hydrogen market and developing a diversified supplier base at acceptable costs is an important component of its strategy for decarbonising its economy while maintaining its industrial competitiveness and ensuring energy security (see chapter on EU hydrogen policy in this volume).

The development of hydrogen partnerships with potential exporters in the European Neighbourhood and the Global South also has a broader geopolitical dimension. In a context where Western-dominated multilateral institutions are under strain, it offers an opportunity to strengthen economic ties, promote European values and standards and bolster the EU's leadership role on the international stage (Quitizow, Mewes et al., 2023; Quitzow, Triki et al., 2023). Another important concern is the promotion of sustainable production practices in the hydrogen sector. This is not only demanded by European consumers and civil society, but it is also seen as playing a role in establishing mutually beneficial and stable economic partnerships with the Global South. Last but not least, the economic prospects of a hydrogen economy and climate-friendly industrial production for the Global South are critical for ensuring continued support for international climate policy goals (Newell et al., 2021).

Finally, developing a coordinated European approach for its international hydrogen policy promises important benefits. A Europeanised purchase mechanism for imported hydrogen, for instance, could help pool demand and lower costs, compared to Member States securing their supplies individually. Indeed, this is one of the lessons from the European scramble for gas and ballooning prices after Russia's invasion of Ukraine (Kuzemko et al., 2022). Similarly, speaking with one European voice would play an important role in garnering the support of potential partner countries and catalysing investment in this new economic sector where manifold uncertainties continue to hamper decision-making. In this context, the EU is beginning to integrate hydrogen-related projects into its existing connectivity initiative, the Global Gateway (European Commission, 2021). In doing so, it seeks to promote broad-based hydrogen cooperation with partners from emerging economies and the Global South. One of the key elements of the Global Gateway is the "Team Europe" approach, which is meant to pool the resources of the European Commission, EU Member States as well as European financial institutions to promote infrastructural links and investment in hydrogen production in non-EU countries. However, despite these efforts, concerted European action remains a challenge, mirroring the tensions alluded to above (see chapter on EU hydrogen policy in this volume). Proactive Member States like Germany have moved ahead rapidly in launching their own bilateral hydrogen diplomacy efforts (see chapter on Germany in this volume). Other Member States, which do not see the immediate need for importing hydrogen, lack incentives to be involved or may even oppose such efforts.

## **6 Understanding Europe's Role in the Emerging Geopolitics of Hydrogen: The Contribution of This Volume**

This edited volume seeks to shed light on how the interplay between hydrogen policy and politics at the EU-level and in important Member States is shaping European hydrogen development as well as the role of the EU as an actor in the emerging global

hydrogen economy. While scholarly reflection on the EU and its role in global politics is frequently limited to a consideration of EU-level structures and initiatives (see for example Keukeleire & Delreux, 2022), this volume places particular emphasis on how the political economy at both the national and supranational level is shaping the EU's role as a geopolitical actor. In this vein, this book conceptualises EU policy as the combination of policies at both levels of governance. This implies that the EU as a geopolitical actor is inherently fragmented in nature, exhibiting important contradictions and tensions. The aim of the book is to provide a better understanding of what those contradictions and tensions are and how they affect EU hydrogen policy both within the EU and externally.

The volume includes ten case studies examining hydrogen policy development at the EU-level as well as in nine members of the EU and the European Economic Area: Germany, France, Poland, Hungary, Italy, Spain, the Netherlands, Sweden and Norway. The selected countries represent different geographies, and they reflect different levels of economic and political status within the EU and differing assets and starting points within the hydrogen sector. Germany and France are included as the two largest Member States, both with highly active but strongly diverging hydrogen strategies. With Poland and Hungary, the volume discusses two important Central and Eastern European countries. Despite sharing a number of similarities in their endowments and capabilities, their diverging stances on Russia have translated into notable differences in their hydrogen strategies. Italy and Spain, the largest Southern European Member States, also exhibit significant differences in their ambitions as exporters and importers in both a European and a global hydrogen economy. The Netherlands occupies a key position in Europe's emerging hydrogen economy as both an important destination and a potential trading hub for ship-based hydrogen imports. Finally, Sweden and Norway represent two key Nordic countries, both well-endowed with renewable energy resources. Yet, both have very different stances on hydrogen. Sweden is keen to pursue domestic "fossil-free" hydrogen production from both renewables and nuclear energy, mainly for the decarbonisation of local industry. Norway, in turn, is seeking to build on its natural gas resources and the prospects of carbon, capture and storage technologies to pursue an export-oriented hydrogen strategy. Though not an EU Member State, Norway's endowments in both renewable and fossil energy make it a critical player in EU hydrogen developments.

Each of these case studies provides an overview of the domestic and international hydrogen policy in the EU and the selected European countries. Moreover, policy developments are linked to key domestic political economy drivers and their role in shaping the respective policy stance. To do so, the various chapters begin with an overview of national climate and energy policy, related political priorities and key points of contention. Against this background, they provide a review of national hydrogen policy, including a discussion of how structural features and stakeholder interests in energy and industry have influenced policy-making.

The review of domestic hydrogen policy and politics provides the basis for a subsequent examination of external hydrogen policy. This part provides a systematic review of international hydrogen policy action, while placing it against the background of each country's broader climate and energy foreign policy. Each chapter provides

an overview of key dimensions of international cooperation in the hydrogen sector, covering both bilateral and multilateral engagement. The dimensions that are considered include diplomacy and political dialogue, efforts around international market and supply chain development, support for cooperation in research and development, the promotion of hydrogen-related regulations and standards, as well as capacity and skill development. Given the significant variance in scope and ambition of international hydrogen policy, each chapter provides a structure for presenting the review of activities that is tailored to the unique features of the respective case.

Each study concludes with a reflection of how national interests and priorities shape the respective country's stance vis-à-vis the EU and other key Member States, highlighting both points of tension and synergies. This includes a discussion of the evolving policy framework governing the EU hydrogen sector as well as an emerging EU hydrogen diplomacy. The chapter on the EU in turn discusses the role and constraints of EU-level policy making, both domestically and internationally.

The edited volume concludes with a chapter that synthesises the findings and key themes emerging from the individual case studies and situates them in the broader context of European and international hydrogen politics. It provides a review of how the interplay of national and EU-level politics and policies is influencing the EU's domestic and international hydrogen policy. It then highlights how the positions and interests of key Member States are shaping the EU's ambitions to become a major geopolitical player in a global hydrogen economy.

**Acknowledgements** Research for this chapter was financially supported by the German Federal Foreign Office within the framework of the project “Geopolitics of the Energy Transformation—Implications of an International Hydrogen Economy” (GET Hydrogen), funding reference number AA4521G125.

## References

- Ansari, D., Grinschgl, J., & Pepe, J. M. (2022). Electrolysers for the hydrogen revolution: Challenges, dependencies, and solutions. *Stiftung Wissenschaft und Politik (SWP)*. <https://doi.org/10.18449/2022C57>
- Bulfone, F. (2022). Industrial policy and comparative political economy: A literature review and research agenda. *Competition and Change*, 27(1), 22–43. <https://doi.org/10.1177/10245294212076225>
- Council of the EU. (2023). Council conclusions on climate and energy diplomacy. Bolstering EU Climate and Energy Diplomacy in a Critical Decade, 7248/23. <https://www.consilium.europa.eu/media/62942/st07248-en23.pdf>
- Cui, L., Yue, S., Nghiem, X.-H., & Duan, M. (2023). Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian War. *Resources Policy*, 81, 103373. <https://doi.org/10.1016/j.resourpol.2023.103373>
- Dejonghe, M., Van de Graaf, T., & Belmans, R. (2023). From natural gas to hydrogen: Navigating import risks and dependencies in Northwest Europe. *Energy Research and Social Science*, 106, 103301. <https://doi.org/10.1016/j.erss.2023.103301>
- European Commission. (2020). *Key actions of the EU hydrogen strategy*. [https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen\\_en](https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en)

- European Commission. (2021). Joint communication to the European parliament, the council, the European economic and social committee, the committee of the regions and the European investment bank (JOIN (2021) 30). <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021JC0030>
- European Commission. (2022). *REPowerEU: Affordable, secure and sustainable energy for Europe*. [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en)
- European Commission. (2023). *The Net-Zero Industry Act: Accelerating the Transition to Climate Neutrality*. [https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act\\_en](https://single-market-economy.ec.europa.eu/industry/sustainability/net-zero-industry-act_en)
- Eicke, L., & De Blasio, N. (2022). Green hydrogen value chains in the industrial sector: Geopolitical and market implications. *Energy Research and Social Science*, 93, 102847. <https://doi.org/10.1016/j.erss.2022.102847>
- Eicke, L. (2023). US hydrogen policy: Paving the way for energy independence, technology leadership and decarbonization. *Research Institute for Sustainability Discussion Paper*, 26.
- Geels, F. W. (2014). Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture and Society*, 31(5), 21–40. <https://doi.org/10.1177/0263276414531627>
- Gertz, G., & Evers, M. M. (2020). Geoeconomic competition: Will state capitalism win? *The Washington Quarterly*, 43(2), 117–136. <https://doi.org/10.1080/0163660X.2020.1770962>
- Goldthau, A. C. (2021). The tricky geoeconomics of going low carbon. *Joule*, 5(12), 3078–3079. <https://doi.org/10.1016/j.joule.2021.11.012>
- Goldthau, A., & Westphal, K. (2019). Why the global energy transition does not mean the end of the Petrostate. *Global Policy*, 10(2), 279–283. <https://doi.org/10.1111/1758-5899.12649>
- Gong, X., Quitzow, R., & Boute, A. (2023). China's Emerging hydrogen economy: Policies, institutions, actors. *Research Institute for Sustainability Susy*.
- Howarth, R. W., & Jacobson, M. Z. (2021). How green is blue hydrogen? *Energy Science and Engineering*, 9(10), 1676–1687. <https://doi.org/10.1002/ese3.956>
- Huber, R. A., Maltby, T., Szulecki, K., & Četković, S. (2021). Is populism a challenge to European energy and climate policy? Empirical evidence across varieties of populism. *Journal of European Public Policy*, 28(7), 998–1017. <https://doi.org/10.1080/13501763.2021.1918214>
- Keukeleire, S., & Delreux, T. (2022). *The foreign policy of the European Union* (3rd ed.). Bloomsbury Publishing. <https://www.bloomsbury.com/uk/foreign-policy-of-the-european-union-9781350930483/>
- Knodt, M. (2023). Instruments and modes of governance in EU climate and energy policy: From energy union to the European Green Deal. In *Handbook on European Union Climate Change Policy and Politics* (pp. 202–215). Edward Elgar Publishing. <https://www.elgaronline.com/edcollchap-0a/book/9781789906981/book-part-9781789906981-27.xml>
- Kuzemko, C., Blondeel, M., Dupont, C., & Brisbois, M. C. (2022). Russia's War on Ukraine, European energy policy responses and implications for sustainable transformations. *Energy Research and Social Science*, 93, 102842. <https://doi.org/10.1016/j.erss.2022.102842>
- Kwan, C. H. (2019). The China–US trade war: Deep-rooted causes, shifting focus and uncertain prospects. *Asian Economic Policy Review*, 15(1), 55–72. <https://doi.org/10.1111/aepr.12284>
- Lema, R., Fu, X., & Rabelotti, R. (2020). Green windows of opportunity: Latecomer development in the age of transformation toward sustainability. *Industrial and Corporate Change*, 29(5), 1193–1209. <https://doi.org/10.1093/icc/dtaa044>
- Lewis, J. I. (2015). *Green innovation in China: China's wind power industry and the global transition to a low-carbon economy* (p. 304). Columbia University Press.
- Lippert, B., & Perthes, V. (2020). Strategic Rivalry between United States and China: Causes, Trajectories, and Implications for Europe. *Stiftung Wissenschaft und Politik. German Institute for International and Security Affairs, SWP Research Paper 4*. <https://doi.org/10.18449/2020RP04>

- Maihold, G. (2022). *A new geopolitics of supply chains: The rise of friend-shoring*. <https://doi.org/10.18449/2022C45>
- Mearsheimer, J. J. (2021, October 19). The Inevitable Rivalry: America, China, and the Tragedy of Great-Power Politics. *Foreign Affairs*, 100(6). <https://www.foreignaffairs.com/articles/china/2021-10-19/inevitable-rivalry-cold-war>
- Miró, J. (2023). Responding to the global disorder: The EU's quest for open strategic autonomy. *Global Society*, 37(3), 315–335. <https://doi.org/10.1080/13600826.2022.2110042>
- Müller, F., Tunn, J., & Kalt, T. (2022). Hydrogen justice. *Environmental Research Letters*, 17(11), 115006. <https://doi.org/10.1088/1748-9326/ac991a>
- Newell, P., Srivastava, S., Naess, L. O., Torres Contreras, G. A., & Price, R. (2021). Toward transformative climate justice: An emerging research agenda. *Wires Climate Change*, 12(6), 733. <https://doi.org/10.1002/wcc.733>
- Pepe, J. M., Ansari, D., & Gehrung, R. M. (2023). The geopolitics of hydrogen. *Stiftung Wissenschaft und Politik (SWP)*. <https://doi.org/10.18449/2023RP13v02>
- Prontera, A., & Quitzow, R. (2022). Catalytic power Europe: blended finance in European external action. *JCMS: Journal of Common Market Studies*, 61(4), 988–1006. <https://doi.org/10.1111/jcms.13442>
- Prontera, A., & Quitzow, R. (2021). The EU as catalytic state? Rethinking European climate and energy governance. *New Political Economy*, 27(3), 517–531. <https://doi.org/10.1080/13563467.2021.1994539>
- Pujawan, I. N., & Bah, A. U. (2022). Supply chains under COVID-19 disruptions: Literature review and research agenda. *Supply Chain Forum: An International Journal*, 23(1), 81–95. <https://doi.org/10.1080/16258312.2021.1932568>
- Quitzow, R. (2015). Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany. *Environmental Innovation and Societal Transitions*, 17, 126–148. <https://doi.org/10.1016/j.eist.2014.12.002>
- Quitzow, R., & Gong, X. (2023). The geopolitics of hydrogen: The emerging role of China. *The Oxford Energy Forum*, 137. <https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/08/OEF-137.pdf>
- Quitzow, R., Mewes, C., Thielges, S., Tsoumpa, M., & Zabanova, Y. (2023). Building partnerships for an international hydrogen economy: Entry-points for European policy action. *FES Diskurs*. <https://library.fes.de/pdf-files/a-p-b/19921-20230215.pdf>
- Quitzow, R., Triki, A., Wachsmuth, J., Garcia, J. F., Kramer, N., Lux, B., & Nunez, A. (2023). HYPAT discussion paper 05/2023. Mobilizing Europe's full hydrogen potential: Entry-points for action by the EU and its Member States. *H2 Potential, HYPAT Discussion Paper*.
- Rohracher, H. (2018). Analyzing the socio-technical transformation of energy systems: The concept of “sustainability transitions.” In *Oxford Handbook of Energy and Society* (pp. 45–62). <https://doi.org/10.1093/oxfordhb/9780190633851.013.3>
- Samadi, S., Fischer, A., & Lechtenböhrer, S. (2023). The renewables pull effect: How regional differences in renewable energy costs could influence where industrial production is located in the future. *Energy Research and Social Science*, 104, 103257. <https://doi.org/10.1016/j.erss.2023.103257>
- Siddi, M. (2023). The geopolitics of energy transition: New Resources and Technologies. In J. Berghofer, A. Futter, C. Häusler, M. Hoell, & J. Nosál (Eds.), *The Implications of Emerging Technologies in the Euro-Atlantic Space* (pp. 73–85). Palgrave Macmillan, Cham. [https://doi.org/10.1007/978-3-031-24673-9\\_5](https://doi.org/10.1007/978-3-031-24673-9_5)
- Szabo, J. (2020). Fossil capitalism's lock-ins: The natural gas-hydrogen nexus. *Capitalism Nature Socialism*, 32(4), 91–110. <https://doi.org/10.1080/10455752.2020.1843186>
- Szulecki, K., Fischer, S., Gullberg, A. T., & Sartor, O. (2016). Shaping the ‘Energy Union’: Between national positions and governance innovation in EU energy and climate policy. *Climate Policy*, 16(5), 548–567. <https://doi.org/10.1080/14693062.2015.1135100>
- Tagliapietra, S. (2019). The impact of the global energy transition on MENA oil and gas producers. *Energy Strategy Reviews*, 26, 100397. <https://doi.org/10.1016/j.esr.2019.100397>

- Vakulchuk, R., Overland, I., & Scholten, D. (2020). Renewable energy and geopolitics: A review. *Renewable and Sustainable Energy Reviews*, 122, 109547. <https://doi.org/10.1016/j.rser.2019.109547>
- Van de Graaf, T., Overland, I., Scholten, D., & Westphal, K. (2020). The new oil? The geopolitics and international governance of hydrogen. *Energy Research and Social Science*, 70, 101667. <https://doi.org/10.1016/j.erss.2020.101667>
- Van de Graaf, T. (2023). Barrels, booms, and busts: The future of petrostates in a decarbonizing world. In *Handbook on the geopolitics of the energy transition* (pp. 183–196). Edward Elgar. <http://hdl.handle.net/1854/LU-01HD3CTVSS491FDM0QSQM4C4V5>
- Van Manen, H., Gehrke, T., Thompson, J., & Sweijs, T. (2021). Taming Techno-Nationalism. *The Hague Centre for Strategic Studies*.
- Varga, M., & Buzogány, A. (2020). The foreign policy of populists in power: Contesting liberalism in Poland and Hungary. *Geopolitics*, 26(5), 1442–1463. <https://doi.org/10.1080/14650045.2020.1734564>
- Veugelers, R., & Tagliapietra, S. (2023). *A green industrial policy for Europe*. <https://www.bruegel.org/book/green-industrial-policy-europe>

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