REPORT

Geopolitics of Europe's Hydrogen Aspirations

Creating Sustainable Equilibrium or a Combustible Mix?

| Tomas Jermalavičius | Tomas Janeliūnas | Andrian Prokip | Iliya Kusa
| Alan Riley | Pier Paolo Raimondi | Andrei Belyi | Miguel Sainz de Vicuña

May 2022

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International Centre for Defence and Security

Tallinn, 2022

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This report was prepared with the support of the ICDS research partner in energy and climate security, Elering AS

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Title: Geopolitics of Europe's Hydrogen Aspirations: Creating Sustainable Equilibrium or a Combustible Mix?

Authors: Jermalavičius, Tomas; Janeliūnas, Tomas; Prokip, Andrian; Kusa, Iliya; Riley, Alan; Raimondi, Pier Paolo; Belyi, Andrei; Sainz de Vicuña, Miguel

Publication date: May 2022

Category: report

Cover page photo: Energy Observer, the first hydrogen vessel in the Seaplane Harbour in Tallinn, Estonia (Mihkel Maripuu/Eesti Meedia/Scanpix).

Keywords: hydrogen, energy security, energy sovereignty, climate policy, renewable energy, geopolitics, European Union, Ukraine, Middle East and Africa, Estonia, Finland, Latvia, Lithuania, Ida-Virumaa, Russia

ISSN 2228-0529

ISBN 978-9916-9699-6-0 (print)

978-9916-9699-7-7 (pdf)

63/4 Narva Road
10120 Tallinn, Estonia
info@icds.ee, www.icds.ee

Content

About the Authors

Andrei Belyi

Dr. Andrei Belyi is Adjunct Professor at the Centre for Climate Change, Energy and Environmental Law of the University of Eastern Finland (UEF) and owner of an energy consultancy firm Balesene OÜ, based in Tallinn, Estonia. At UEF, he participated in a research project for the Academy of Finland about the implications of US LNG exports for EU energy law and policy. Before joining UEF, he was based at the University of Tartu (2012-15) where he co-directed EU-funded Jean Monnet modules on EU energy and climate policies. Prior to that, he acted as a Deputy Head of Department on Energy and Commodity Markets at the Higher School of Economics in Moscow (2006-12), worked for the Energy Charter Secretariat (2005) and provided consultancy services for MVV Consulting GmbH in Brussels (2000-04).

Tomas Janeliūnas

Dr. Tomas Janeliūnas is Professor at the Institute of International Relations and Political Science (IIRPS) at Vilnius University, and also Director of Research at the Eastern Europe Studies Centre – a think-tank in Vilnius, Lithuania. He has been lecturing at the IIRPS since 2003 on subjects including strategic studies, national security, and foreign policy of Lithuania, as well as foreign policy of the great powers. From 2013 to 2018 he served as the Head of the Department of International Relations at the IIRPS. From 2009 to 2020 he was the Editor-in-Chief of the main Lithuanian academic quarterly of political science, *Politologija*. From 2007 to 2014 he served as the Editor-in-Chief of *Lithuanian Foreign Policy Review*.

Tomas Jermalavičius

Tomas Jermalavičius is Head of Studies and Research Fellow at the International Centre for Defence and Security (ICDS). Prior to joining ICDS, he worked at the Baltic Defence College (BALTDEFCOL) in Tartu, Estonia, and Lithuanian Ministry of National Defence. Since 2017, he also has been a visiting professor at the Natolin Campus of the College of Europe in Warsaw. He holds a BA in political science from the University of Vilnius, an MA in war studies from King's College London and an MBA degree from the University of Liverpool.

Iliya Kusa

Iliya Kusa is a Kyiv-based author and analyst of international relations with the Ukrainian Institute for the Future. For the past six years he has been writing about Middle East, Ukrainian foreign policy after 2014, and European politics. A special focus of his expertise is dedicated to the Middle East and North Africa.

Andrian Prokip

Dr Andrian Prokip is the Director of Energy Programme at the Ukrainian Institute for the Future, an independent think tank in Kyiv, and is also serving as a Senior Associate at the Kennan Institute (Woodrow Wilson Center, Washington DC). He regularly publishes op-eds in the US and the EU on changes and reforms in Ukraine and the energy developments in the region.

Pier Paolo Raimondi

Pier Paolo Raimondi is Researcher in the "Energy, climate and resources" programme at IAI (Italian Institute of International Affairs). His main research activity is related to energy geopolitics and geoeconomics in different geographical areas, mainly Europe, Africa, MENA region and former Soviet Union area. He is also Researcher at the Fondazione Eni Enrico Mattei (FEEM). He holds a Master's in International Relations and a Bachelor's degree in Political Science from the University of Milan.

Alan Riley

Dr. Alan Riley is Senor Fellow of the Atlantic Council (USA) and one of the leading competition law scholars in the UK. He co-founded and chairs the Europe-wide Competition Law Scholars Forum and is co-editor of Competition Law Review. He also specialises in energy law, particularly in relation to the market and strategic questions associated with pipeline gas and LNG. In the energy field, he is researching a number of questions concerning market liberalisation and market regulation in both the Russian and EU gas markets.

Miguel Sainz de Vicuña

Miguel Sainz de Vicuña is currently pursuing an Erasmus Mundus Master's in Security, Intelligence and Strategic Studies (IMSISS). He holds a Double Bachelor's Degree in Law & International Relations from Nebrija University in Madrid. His previous studies have concentrated on China, EU-Russia relations, energy security and maritime security. In summer 2021, as part of the IMSISS programme, he was a research assistant at the ICDS in Tallinn and worked on the projects related to energy security, energy policies in the EU related to hydrogen and nuclear power, and migration.

List of Abbreviations, Acronyms and Units of Measurement

bcm	billion cubic metres
CBAM	Carbon Border Adjustment Mechanism
CO_2	carbon dioxide
COP	Conference of the Parties
COVID-19	coronavirus disease
CCS	carbon capture and storage
DSO	Distribution System Operator
EBRD	European Bank of Reconstruction and Development
EFSD+	European Fund for Sustainable Development Plus
EHB	European Hydrogen Backbone
EIB	European Investment Bank
EKRE	*Eesti Konservatiivne Rahvaerakond* (Conservative People's Party of Estonia)
EU	European Union
FCH JU	Fuel Cells and Hydrogen Joint Undertaking
FOB	free on board
GIPL	Gas Interconnector Poland Lithuania
GO	guarantee of origin
GW	gigawatt
ITC	Inter-Transmission System Operator Compensation
kWh	kilowatt-hour
LNG	liquified natural gas
MENA	Middle East and North Africa
MoU	memorandum of understanding
Mt	megaton
NB4	Nordic-Baltic Four
NDICI	Neighbourhood, Development and International Cooperation Instrument
NECP	National Energy and Climate Plans
NGO	non-governmental organisation
Nm^3	normal cubic metres [of air]
NS2	Nord Stream 2
RES	renewable energy sources
RGC	Regional Gas Company
SMR	1) small modular reactor, 2) steam methane reforming
TREC	Trans-Mediterranean Renewable Energy Cooperation
TSO	Transmission System Operator
TWh	terawatt-hour
UAE	United Arab Emirates
UGS	underground gas storage
UN	United Nations

Executive Summary

Discussions about hydrogen's role in the transition to carbon-neutral economies and the EU's Green Deal seldom include consideration of geopolitical aspects and/or national security imperatives. However, given the importance of energy as a factor in global and regional geopolitical trends and national security, hydrogen development will reshape not only energy relations between countries but will also alter the broader geopolitical picture. While elevating new aspects of geopolitical interplays, such as the importance of technology and regional clusters, hydrogen development might also unwittingly transplant present-day challenges—such as excessive dependence on the energy supply from hostile powers—into the carbon-neutral future. Since Europe's energy sovereignty and geopolitical role in its neighbourhood could be at stake, the nexus of geopolitics, energy security and hydrogen development should be given serious attention. At the same time, the transformative socioeconomic impact of energy transition will create winners and losers within and between nations, which in some cases will have national security implications; hydrogen development could offer ways to mitigate this.

This report focuses on exploring the impact that the European Union's ambitions and plans for hydrogen development—including an expansion of its infrastructure in the form of the European Hydrogen Backbone—on its geopolitical position up to 2040. It first looks into the greater detail of the EU Hydrogen Strategy and how it links with the Energy Union, as well as with European strategic autonomy and energy sovereignty issues. It finds that hydrogen development—alongside the growth of the renewable energy sector—offers a great opportunity to reduce the current exposure to hostile actors, such as Russia, through the energy sector that hampers Europe's ability to act as a geopolitical force in its neighbourhood. However, it also warns that the lack of unity and coherence currently afflicting the Energy Union, and manifest in such controversies as the Nord Stream 2 undersea gas pipeline from Russia to Germany before Russia's invasion of Ukraine in 2022, could potentially weaken such a positive geopolitical impact of hydrogen.

The EU and its member states will have to exercise particular caution when it comes to Russia. Moscow has already shown its willingness to use energy as a geopolitical weapon and the determination to maintain its position in the energy supply to Europe. Although Russia's war against Ukraine triggered substantial shifts in the EU's attitude towards energy imports from Russia, Moscow could still seek to restore some role in the European economy already in the hydrogen era, dressing it up as a major opportunity for the EU to combat climate change. In particular, Russia's nuclear energy sector could be seen by some industrial and political players in Europe as a major source to draw upon—through the production of pink hydrogen from electricity generated by nuclear power—should it face a deficit of hydrogen. The opportunity comes with significant risk that Russia's role in European hydrogen supply chains will be again leveraged for geopolitical purposes in the future, much the same as natural gas is leveraged at present.

Still, although hydrogen development requires Europe to draw upon external suppliers, the fact that this supply can come from many other countries provides a significant opportunity for diversification and reducing the impact of energy supply as a geopolitical weapon. In this regard, two directions stand out in the EU's neighbourhood—Ukraine in the east, and the Mediterranean along with the Middle East and North Africa (MENA) to the south. Both have huge potential for playing major roles in the European hydrogen supply chains, and their cultivation by the EU would provide many opportunities both to strengthen the EU's influence in its neighbourhood and to build new partnerships. Certainly, neither of those directions comes without risks and downsides: political instability and armed conflicts, poor governance, unstable investment environment, water scarcity, and in some cases dependence on the hydrocarbons industry for income will be significant factors hampering the efforts to unlock their potential. Ukraine in particular will require sustained reconstruction efforts to tackle the massive devastation caused by Russia's war. This will divert resources and attention, but transforming its energy sector and developing its hydrogen production base could still be important strands of these efforts.

Europe's own potential for domestic hydrogen production is another direction that this report looks into as a way to disentangle from the present-day geopolitically toxic dependencies and enhance its energy sovereignty. The Baltic states and Finland represent an interesting case study on how hydrogen could underpin a regional cooperation cluster with a high degree of integration—one of the new characteristics of the hydrogen era that will have geopolitical implications. The report, however, finds that different national perspectives on hydrogen, lack of coordination, and certain issues of trust arising from recent failures of solidarity and unity when tackling the regional nexus of energy security and geopolitics might hamper future regional cooperation in hydrogen.

The hydrogen economy also offers some important benefits in managing national security challenges at the national level. In Estonia, the loss of the fossil fuel-based industry in the highly sensitive north-eastern region of Ida-Virumaa will be a socioeconomic blow to the local population. This report highlights how the vulnerability of the region, dominated by the Russian-speaking ethnic minorities who are already highly exposed to Russia's malignant influence activities, could imperil Estonia's energy transition and its national security. Creating a national hydrogen cluster in this region, drawing upon its industrial infrastructure and human capital, could mitigate the consequences of decarbonisation and energy transition. However, these considerations do not seem to receive sufficient attention from the government and energy businesses when drawing Estonia's hydrogen map of the future.

The report recommends that various stakeholders in the EU—including those behind the European Hydrogen Backbone—continuously monitor and assess the geopolitical risks, especially in terms of their impact on European energy sovereignty, when creating and managing new hydrogen-related interdependencies with the regions and countries outside the EU. The report urges the EU to support energy transition and necessary market and governance reforms in post-war Ukraine and the MENA countries to facilitate their emergence as crucial and reliable partners in hydrogen value chains. The report also recommends closer coordination and common planning between hydrogen stakeholders of the Baltic states and Finland when forming a regional cluster of hydrogen supply that would contribute to European energy sovereignty. Last but not least, it suggests that, for national security and resilience reasons, Estonia should focus more attention on the Ida-Virumaa region when developing its national hydrogen roadmap.

Introduction

In 2020, the European Union (EU) adopted its Hydrogen Strategy. The strategy outlines ways in which clean hydrogen will help to replace fossil fuels in electricity generation, decarbonise some industries along with transport and serve as a means of output storage for renewable energy sources (RES).[1] This will contribute to the EU's climate neutrality ambitions as well as, potentially, to Europe's greater energy independence. Member states are expected to develop their own national strategies and plans that will establish a clear role for hydrogen in their energy, transport and industrial sectors and will facilitate necessary investments in technology, innovation, production, infrastructure and market development.

This push for greater use of hydrogen in the economies of the EU has triggered debates among various stakeholders in and between the member states—how the vision outlined in the EU Hydrogen Strategy could be implemented and what implications it would have for national energy sectors and economies, as well as for European cooperation and further integration. Most of the debate, however, is focused primarily on the technological, economic, infrastructural and climate aspects and eludes broader geopolitical issues or regional and national security dimensions. But transition towards carbon neutrality that will, to a significant degree, rely on clean (green) hydrogen (i.e. hydrogen produced using electricity generated by RES) should consider several interlocking international relations, regional security and national resilience aspects such as:

- in the broadest sense, pursuing greater European energy independence versus forging new or reshaping the existing energy relationships with non-EU partners that depend on trade with the Union;
- balancing different national priorities and interests of the member states in engaging countries in the southern and eastern neighbourhoods of the EU;
- reducing or even eliminating energy dependence on Russia due to it being a geopolitical threat to the EU versus allowing the return of Russia to some role in the European energy system and the attendant political leverage;
- using hydrogen-related opportunities to review and reconfigure regional energy security relations in the Nordic-Baltic area versus pursuing those opportunities through the existing formats and mechanisms; and
- exploiting hydrogen ambitions to transform national regions dominated by the fossil fuel industry (e.g. in north-eastern Estonia) to offset socioeconomic (and, by extension, national security) repercussions of decarbonisation versus bringing economic development to economically underdeveloped regions.

This report aims to explore the above aspects in order to inform and shape the debate between various political and economic stakeholders about the future Europe-wide, Baltic Sea regional and Estonian national hydrogen landscape. It will inject geopolitical and security considerations into this debate and will help to ensure that these considerations are taken into account when addressing various economic, infrastructural and technological issues. The main policy problem to be addressed in this study is how Estonia and other EU member states should, in its approach to hydrogen, incorporate and reflect various foreign and security policy imperatives and national interests and, conversely, how those imperatives and interests could be framed to support the emerging national and European visions for the role of clean hydrogen in Estonia's climate-neutral economy and that of the EU.

This report is structured as follows:

- Chapter 1 "European Hydrogen Dreams" looks into the greater detail of the Hydrogen Strategy and how it links with the Energy Union, as well as European strategic autonomy and sovereignty issues.
- Chapter 2 "Barriers to Hydrogen and Russia's Siren Song, 2030-40" highlights some key barriers for large-scale zero-carbon production of hydrogen in Europe and argues that Russia could potentially use the resulting deficit of hydrogen and growing climate concerns to regain some role in the decarbonised energy supply chains of the EU.
- Chapter 3 "The Ukrainian Promise" analyses the challenges and opportunities related

1 European Commission, "Hydrogen strategy for a climate-neutral Europe," COM(2020) 301 final, 8 July 2020.

to building a hydrogen partnership with post-war Ukraine, as part of the economic reconstruction and of the country and transformation of its energy sector.

- Chapter 4 "The MENA's Allure" looks into how various countries in the Mediterranean, North Africa and the Middle East approach hydrogen and whether the southern direction represents a geopolitical opportunity for Europe.
- Chapter 5 "Finno-Baltic Realities" analyses the state of play and future plans drawn by the Baltic states and Finland and examines how the hydrogen cooperation in the region will interact with the existing dynamic of energy relations between these countries.
- Chapter 6 "Woes and Hopes of Ida-Virumaa" zooms into Estonia's north-east as the region most exposed to hybrid threats from Russia and poised to become the biggest economic loser in energy transition, and considers whether hydrogen holds at least some potential to revive the prospects of this region.

The final chapter draws overall conclusions and recommendations to be taken into account when developing the European Hydrogen Backbone—the initiative that seeks to find ways of repurposing the extensive European natural gas transmission infrastructure for transportation of hydrogen—as well as implementing the EU's overall hydrogen strategy.

1. European Hydrogen Dreams

Tomas Jermalavičius
Tomas Janeliūnas
Miguel Sainz de Vicuña
with contribution by Pier Paolo Raimondi

The global energy transition has become one of the most pressing political issues. Governments have increasingly pledged to drastically reduce their greenhouse gas emissions by mid-century. In 2020–21, there has been a significant increase in climate actions, culminating in a number of pledges made in the run-up to the UN Climate Change Conference, in November 2021 in Glasgow (COP26).[2] Although those pledges are still regarded by many observers as insufficient in preventing the worst-case scenarios of global warming,[3] it is a sign of change in the overall sentiment that many countries, including the EU member states, have decided to devote a significant portion of post-pandemic economic recovery plans and funding to the green and clean energy transition. The ultimate result of these commitments should be the transformation of the energy systems and economies, reduced fossil fuel consumption, expanded electrification, and extensive use of clean energy sources.

The European Union has sought to significantly accelerate the process of energy transformation and decarbonisation. In November 2018, the European Commission (EC) set out its vision for a climate-neutral EU to be achieved by 2050.[4] The European Green Deal, endorsed by the European Parliament in March 2019 and approved by the European Council in December 2019, outlines the EU's new growth strategy for a carbon-free EU economy to make Europe the first climate-neutral continent in the world.[5] In June 2021, the European Council adopted the European Climate Law, presented by the Commission in March 2020, which wrote into the legislation the objective of a climate-neutral EU by 2050. As an intermediate step towards climate neutrality, the EU raised its 2030 climate ambition, committing to cutting emissions by at least 55% by 2030 compared with 1990 levels.[6] The Climate Law includes measures to keep track of progress and adjust the EU's actions if needed. And following on from that, a number of sectoral strategies have been drafted to facilitate the massive process of

The European Union has sought to significantly accelerate the process of energy transformation and decarbonisation

2 Noah Garfinkel, "The major climate pledges made at COP26 so far," *Axios,* 4 November 2021.

3 Climate Action Tracker, "Warming Projections Global Update: Glasgow's 2030 credibility gap," November 2021.

4 European Commission, "A Clean Planet for All: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy," COM(2018) 773 final, 28 November 2018.

5 European Commission, "Committing to climate-neutrality by 2050: Commission proposes European Climate Law and consults on the European Climate Pact," 4 March, 2020.

6 "Fit for 55," Policies, European Council, last updated 22 December 2021.

energy and economic transformation involved in achieving a climate-neutral economy.

This chapter aims to discuss Europe's hydrogen ambitions in the context of its strategic autonomy and energy sovereignty aspirations and how this will interconnect with the geopolitical challenges and opportunities. It first describes the EU's plans for hydrogen development at home and within its neighbourhood, then considers how European energy dependency on hostile geopolitical actors impedes its energy sovereignty agenda and whether energy transition—particularly hydrogen development—offers an opportunity to diminish exposure to such actors. Finally, the chapter discusses how some of the old geopolitical risks might continue afflicting Europe's energy security in the hydrogen era, and highlights some new aspects of geopolitical competition as well as cooperation that will become more salient due to the nature of the hydrogen economy.

The EU expressed one of the strongest political commitments, thus far, to lead in hydrogen, as it considers it a key element in its pursuit of climate neutrality by 2050

1.1. Dawn of the hydrogen era?

In the quest for technological solutions to achieve a net zero scenario, hydrogen has drawn enthusiasm from the private as well as the public sector, particularly in pursuing sustainable and climate-friendly growth in the aftermath of COVID-19 and the ensuing economic crisis. Governments and companies have announced numerous ambitious hydrogen plans, considering hydrogen to be a useful tool to achieve both national climate targets, especially in hard-to-abate sectors, and a key driver for economic recovery.[7]

In July 2020, the EU Strategy for Energy System Integration and the EU Hydrogen Strategy were adopted to pave the way towards a fully decarbonised, more efficient, and interconnected energy sector.[8] The EU expressed one of the strongest political commitments, thus far, to lead in hydrogen, as it considers it a key element in its pursuit of climate neutrality by 2050 and, at the same time, a sector in which to enhance and sustain its technological leadership (particularly bearing in mind its experience in solar photovoltaic manufacturing, which was developed in Europe at a high cost only to be eventually moved to China).

The EU Hydrogen Strategy stipulates that "renewable electricity is expected to decarbonise a large share of the EU energy consumption by 2050, but not all of it. Hydrogen has a strong potential to bridge some of this gap, as a vector for renewable energy storage, alongside batteries, and transport, ensuring back up for seasonal variations and connecting production locations to more distant demand centres".[9] It also points out that "hydrogen can replace fossil fuels in some carbon-intensive industrial processes, such as in the steel or chemical sectors, lowering greenhouse gas emissions and further strengthening global competitiveness for those industries".[10] In other words, hydrogen is recognised as a "golden ingredient" necessary to fully achieve the goal of zero-emissions by 2050.

The Hydrogen Strategy envisages that the share of hydrogen in Europe's energy mix will grow from the current figure set at below 2% up to 13–14% by 2050, and cumulative investments in renewable hydrogen, or green hydrogen, i.e. hydrogen produced purely from renewable electricity, in Europe could be up to 180–470 billion euros by 2050. Meanwhile investments in blue hydrogen, i.e. hydrogen produced from natural gas while applying carbon capture and storage (CCS) technology, which is relegated to an intermediate target alone, would amount to some 3–18 billion euros.[11] At the national level, France, Germany and the Netherlands have announced public funding of around 17 billion euros for hydrogen development, while Italy, Portugal and Spain have announced plans for investments totalling another 25.9

7 Michel Noussan, Pier Paolo Raimondi, Rossana Scita, and Manfred Hafner, "The Role of Green and Blue Hydrogen in the Energy Transition – A Technological and Geopolitical Perspective," *Sustainability*, 2021, 13(1), 298.

8 European Commission, "Powering a climate-neutral economy: An EU Strategy for Energy System Integration," COM(2020) 299 final, 8 July 2020; European Commission, "Hydrogen strategy for a climate-neutral Europe," COM(2020) 301 final, 8 July 2020.

9 European Commission, "Hydrogen strategy."

10 Ibid.

11 Produced from natural gas through the process of steam methane reforming (SMR) combined with carbon capture and storage (CCS).

billion euros.[12] Adapting end-use sectors to hydrogen consumption and hydrogen-based fuels will also require significant investments: it takes some 160–200 million euros to convert a typical EU steel installation coming to end-of-life to hydrogen. In the road transport sector, rolling out an additional 400 small-scale hydrogen refuelling stations (compared to 100 in 2020) could require investments from 850 million to 1 billion euros.[13] The EU's financial instruments to support the transition for hydrogen are referred to in the Hydrogen Strategy, in particular the EU Innovation Fund, which will pool together around 10 billion euros to support low-carbon technologies over the period of 2020–30 and, as part of the Commission's recovery plan, the Strategic European Investment Window of InvestEU.[14]

Combined with the Strategy for Energy System Integration, the Hydrogen Strategy highlights the EU's clear ambition to stimulate the scale-up of hydrogen before 2030. The ambition is to install at least 6 GW of renewable hydrogen electrolysers in the EU by 2024, thus enabling production of up to one million tons of renewable hydrogen, approximately six times more than at the beginning of 2021.[15] It is intended to install 40 GW of electrolysers and to produce 10 million tons of renewable hydrogen by 2030. By 2050, according to the Hydrogen Strategy, renewable hydrogen technologies should reach maturity and be deployed at a large scale to reach all hard-to-decarbonise sectors.[16]

The EU also set the framework for the development of the hydrogen sector into one of the backbones of the European energy industry. With the Hydrogen Strategy, the EU has launched the European Clean Hydrogen Alliance—a collaboration between public authorities, industry, and civil society—which should develop an investment agenda and a pipeline of concrete projects. This initiative resulted in a European hydrogen infrastructure vision "Extending the European Hydrogen Backbone" published in April 2021 (the first version, covering a much smaller number of European states and gas companies, was prepared in 2020). This study covered 23 gas infrastructure companies within 21 EU countries and elaborated on a dedicated hydrogen network across the EU.[17] The 2022 iteration of the study further positions the European Hydrogen Backbone, an expanded and accelerated vision of which already covers 28 countries and 53 000 km of pipelines, within the discourse of greater energy independence and resilience of Europe.[18]

The EU also set the framework for the development of the hydrogen sector into one of the backbones of the European energy industry

In December 2021, the European Commission adopted a set of legislative proposals aimed to create a framework for the decarbonisation of gas markets, promote hydrogen and low-carbon gases (e.g. biomethane), and ensure the resilience of gas networks and security of supply. Among the manifold aims of this package, the proposed changes to the Gas Directive and Gas Regulation of 2009 will "make it easier for renewable and low-carbon gases to access the existing gas grid, by removing tariffs for cross-border interconnections and lowering tariffs at injection points."[19] It furthermore creates a certification system for renewable gas in order to provide a level playing field in determining the carbon footprint of various gases and seeks to ensure that the EU does not remain dependent on fossil natural gases by proposing that none of its long-term contracts for supply is extended beyond 2049.[20]

These efforts are bound to have geopolitical implications, especially if they end up reshaping relations with the dominant fossil fuel suppliers

12 Gonzalo Escribano, "H_2 Med: hydrogen's geo-economic and geopolitical drivers and barriers in the Mediterranean," Elcano Policy Paper, Real Instituto Elcano, May 2021.

13 European Commission, "Hydrogen strategy," 8.

14 Ibid., 18.

15 Maximilian Boemke, "The European Hydrogen Strategy," Watson Farley& Williams, 8 February 2021.

16 European Commission, "Hydrogen strategy."

17 Creos, DESFA, Elering, Enagás, Energinet, Eustream, FGSZ, Fluxys Belgium, Gasgrid Finland, Gasunie, GAZ-SYSTEM, GCA, GNI, GRTgaz, National Grid, NET4GAS, Nordion Energi, OGE, ONTRAS, Plinovodi, Snam, TAG, and Teréga, *Extending the European Hydrogen Backbone* (Utrecht: Guidehouse, April 2021).

18 Gas for Climate, "European Hydrogen Backbone grows to meet REPowerEU's 2030 hydrogen targets and develops 28,000 km in 2030 and 53,000 km in 2040, now covering 28 European countries," news, 5 April 2022.

19 European Commission, "Commission proposes new EU framework to decarbonise gas markets, promote hydrogen and reduce methane emissions," press release, 15 December 2021.

20 For the initial assessment, see James Kneebone, "A first look at the EU Hydrogen and Decarbonised Gas Markets Package," The Florence School of Regulation, 16 December 2021.

to Europe and facilitating or obstructing what is referred to as European strategic autonomy, or "the capacity to act autonomously when and where necessary and with partners wherever possible."[21] While this concept was initially confined to the defence domain, the current discourse and thinking—often under the related label of "European sovereignty"—already extends into digital, space, health and other domains, including energy. This is because, as Mark Leonard and Jeremy Shapiro point out, "Various powers are instrumentalising asymmetric interdependencies in healthcare, economic relations, digital technology, security, and climate issues in a way that reduces Europe's capacity to act autonomously and to protect the interests and values of its citizens."[22]

1.2. Energy sovereignty on a horizon?

The EU has already recognised the importance of achieving a reliable and diversified energy supply, especially after the 2009 disagreement between Ukraine and Russia, which resulted in the disruption of gas transit to Europe. According to Eurostat, in 2019 the EU imported 61% of the energy it consumed, with Russia as the main oil and natural gas supplier.[23] The energy dependency of each EU member varies greatly, but not one would be able to function without relying on external suppliers. This landscape makes EU members vulnerable to temporary disruptions to energy supplies and, in some cases, potentially weakens the EU's position as an international actor.[24] The fact that the EU relies on imports of energy sources such as natural gas and oil calls into question whether the EU can truly exercise much-coveted strategic autonomy without getting its lights turned off by external hostile powers and/or because of regional conflicts.[25] As Eloïse Ryon points out, "Such asymmetric dependencies in such a strategic sector as energy create a potentially damaging situation for our European strategic autonomy, weakening our capacity to freely take political decisions and act on them."[26]

> *The fact that the EU relies on imports of energy sources such as natural gas and oil calls into question whether the EU can truly exercise much-coveted strategic autonomy without getting its lights turned off by external hostile powers*

Indeed, the degree of Europe's asymmetric energy dependency on Russia in particular came back into sharp focus in 2021–22, when the situation in the global liquified natural gas (LNG) markets led to supplies being diverted to Asia due to the growing demand and higher prices there.[27] By only minimally resupplying the depleted natural gas storages (some of them owned by Gazprom, Russia's main gas export company) in Europe during the summer of 2021, Russia aggravated the resulting shortages and increased the price pressure.[28] It then further substantially reduced natural gas deliveries through the Ukrainian gas transmission system and Yamal-Europe pipelines and refused to provide additional gas for the "spot" markets, thus putting Europe in a tight squeeze at the time of growing winter demand.[29] This, combined with other factors such as weather conditions that reduced the output of renewable energy sources in Europe, led to an unprecedented rise in gas prices across the EU. This episode prompted the head of the International Energy Agency, Fatih Birol, to finger point Russia's actions in the European gas markets as one of the drivers of the energy crisis that also coincided with a major

21 Council of the EU, "Council conclusions on progress in implementing the EU Global Strategy in the area of Security and Defence," press release, 6 March 2017.

22 Mark Leonard and Jeremy Shapiro, "Sovereign Europe, Dangerous World: Five Agendas to Protect Europe's Capacity to Act," European Council on Foreign Relations Policy Brief, November 2020, 4.

23 "Where does our energy come from?," Infographs, Eurostat.

24 Fatih Birol, "Europe and the world need to draw the right lessons from today's natural gas crisis," IAE Commentary, 13 January 2022.

25 Humeyra Pamuk and Steve Holland, "U.S. in talks with energy producers to supply Europe if Russia invades Ukraine," *Reuters*, 25 January 2022.

26 Eloïse Ryon, "European strategic autonomy: Energy at the heart of European security?," *European View,* Vol. 19(2), 2020: 241.

27 Jason Bordoff, "Why This Energy Crisis Is Different," *Foreign Policy,* 24 September 2021.

28 David Sheppard, Mehreen Khan, and Guy Chazan, "Gazprom's low gas storage levels fuel questions over Russia's supply to Europe," *The Financial Times,* 27 October 2021.

29 "Russia's Gazprom Declines To Book Extra Capacity On Ukraine, Poland Pipelines," *RFE/RL*, 2 November 2021.

geopolitical crisis on the continent—Russia's preparations for a full-fledged invasion of Ukraine (which eventually, despite Moscow's vehement denials of its aggressive plans, took place on 24 February 2022).[30] Meanwhile, the admission by the Italian Prime Minister Mario Draghi, made in December 2021, highlighted the limits of the EU's power, which became even more apparent in this crisis: commenting on Russia's military build-up near Ukraine in the second half of 2021 and concerns that the Kremlin was planning overt use of military force, he argued that Europe was not able to deter Russia's aggression even through the threat of severe economic sanctions, because it was not yet in a position to give up Russian gas.[31] During the first weeks and months of the war, similar reasoning represented mostly by Germany prevented the EU from enacting full-scale oil and gas embargo against Russia in order to compel it to halt its military aggression.[32] Some recent assessments, however, suggest that various emergency alternatives could be found to replace Russian supply cut-offs, and efforts have been underway to secure those alternatives.[33]

Europe's vulnerability to strategic coercion applied against the energy sector is what the EU sought to prevent through its long-term strategies and policies even before the strategic autonomy debate emerged

Europe's vulnerability to strategic coercion applied against the energy sector is what the EU sought to prevent through its long-term strategies and policies even before the strategic autonomy debate emerged. The EU brought energy security into the framework of the Energy Union as one of its central pillars. Launched by the European Commission in order to provide "EU consumers—households and businesses—secure, sustainable, competitive and affordable energy" aligned with the climate objectives, it seeks to diversify external suppliers, increase domestic green energy production and improve the interconnectivity of the market.[34] The Energy Union is thus one of the main organising frameworks for enhancing energy security in the EU for its member states and their societies, thus eventually giving more freedom and flexibility to act externally as a geopolitical actor in the realm of its foreign, security and defence policies.

The EU officials talk about the EU being capable of achieving energy sovereignty through the concerted European action.[35] For fulfilling this aspiration, they are betting heavily on the very same Green Deal, particularly on the growth of RES and on achieving a leading position in the production of green hydrogen, which would reduce external dependency and boost self-sufficiency. The EU has also categorised, as part of its so-called "green taxonomy," nuclear energy and natural gas as sustainable sources in the medium term.[36] The debate on the future role of nuclear energy, however, is still playing out. A few member states are fiercely opposed to its inclusion in the "green taxonomy" and seek to challenge the decision in the EU Court of Justice while at least ten nations have strongly insisted on this inclusion.[37] This debate indicates that

Energy sovereignty, however, will not be achieved overnight due to the technological, political, economic and other complexities it entails

30 David Sheppard, James Politi, and Max Seddon, "IEA chief accuses Russia of worsening Europe's gas crisis," *The Financial Times,* 12 January 2022, .

31 Silvia Sciorilli Borrelli, "Draghi says Europe lacks means to deter Russia over Ukraine," *The Financial Times,* 22 December 2021.

32 "Germany warns against ban on energy imports from Russia," Deutsche Welle, 3 March 2022.

33 "How will Europe cope if Russia cuts off its gas?," *The Economist,* 29 January 2022; David E. Sanger, "U.S. to Bolster Europe's Fuel Supply to Blunt Threat of Russian Cutoff," *The New York Times*, 25 January 2022.

34 "Energy Union," Topics, European Commission, last updated 26 October 2021.

35 Thierry Breton, "Europe: The Keys to Sovereignty," European Commission, 11 September 2020.

36 European Commission, "Commission Delegated Regulation (EU) of 9.3.2022 amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities," C(2022) 631 final, Brussels, 9 March 2022.

37 Nikolaus J. Kurmayer, " Austria, Luxembourg to take green label for nuclear and gas to EU courts," *Euractiv*, 3 February 2022; Frédéric Simon, "10 EU countries back nuclear power in EU green finance taxonomy," *Euractiv*, 12 October 2021.

nuclear power is likely to remain pivotal to Europe's energy security and form an important part of the hydrogen economy due to the limitations of the RES (see Chapter 2).

Energy sovereignty, however, will not be achieved overnight due to the technological, political, economic and other complexities it entails. In addition, despite the aspirations of enhanced self-sufficiency, the EU may not be able to produce all renewable energy domestically due to various constraints, such as the continent's limited land availability, high population density, environmental footprint, and issues of public acceptance of the related infrastructure. From an energy efficiency point of view, it makes more sense to use the limited renewable energy potential to fully decarbonise the power sector first, while at the same time importing green (i.e. renewable energy-based) or pink (i.e. nuclear energy-based) hydrogen from more enriched regions. Thus, it may still need to turn to hydrogen imports from other regions. In its Hydrogen Strategy, the EU envisaged the role for green hydrogen imports through the 2x40 GW idea by 2030 (40 GW in Europe and 40 GW in southern and eastern neighbouring countries)—supported by a European industry alliance.[38]

Moreover, the EU may need to import blue hydrogen in the medium term due to competitive costs compared to green hydrogen (even though blue hydrogen poses significant challenges too—see Chapter 2). Indeed, according to some reports, even if European carbon prices reached 200 euros per tonne, green hydrogen would still struggle to compete with fossil fuels without further government support.[39] Some European countries have already been considering investments aimed

> *The global clean energy transition is likely to reshape the global and regional geopolitical landscape*

at ensuring cost-competitive supply from abroad. For example, Germany allocated 2 billion euros of its 9-billion-euros hydrogen investment plan for overseas production. Thus, the Green Deal and the hydrogen role in it are expected to drastically reduce the EU's fossil fuel consumption and imports; however, it will not eliminate its energy interdependence to meet its climate targets. European decarbonisation will not transform the EU into an isolated energy island. As Kirsten Westphal argues, "To maintain and expand the strategic ability to act, dependence must be reduced in instances where it leads to vulnerability. Autonomy, however, should in no way be confused with autarchy. On the contrary, strategic partnerships and mutual relations may well help to widen the range and scope of available actions."[40] The EU Green Deal and the energy transition will thus create new external (inter)dependencies for the EU, with all the attendant geopolitical complexities and nuances when it comes to European energy sovereignty aspirations. Some countries with more potential land or sea wind installations or solar energy are already aiming at such new possibilities to become energy suppliers for EU industry centres such as Germany. Therefore, huge infrastructure networks are planned, which may significantly redraw the European energy map in the future—the Nordic countries, the Baltic states, Ukraine, and the Mediterranean, as well as the MENA regions, may become important suppliers of renewable energy and hydrogen.

1.3. New landscape, new dynamics?

The global clean energy transition is likely to reshape the global and regional geopolitical landscape. As new cleaner energy sources are deployed, old players such as oil-producing countries could see their geopolitical influence shrink, while new players will emerge.[41] Hydrogen is likely to play an important role in these shifts, as highlighted in a major report by the International Renewable Energy Agency (IRENA), which argues that its "geopolitical impact might follow the patterns of steam power, electricity, or the internal combustion engine".[42] According to the report, "Countries with an abundance of low-cost renewable power could become producers of green hydrogen, with commensurate geo-economic and geopolitical consequences."[43]

38 Ad vam Wijk and Jorgo Chatzimarkakis, "Green Hydrogen for a European Green Deal A 2x40 GW Initiative," Dii Desert Energy, April 2020.

39 Agora Energiewende and Guidehouse, "Making renewable hydrogen cost-competitive: Policy instruments for supporting green H_2," July 2021.

40 Kirsten Westphal, "Strategic Sovereignty in Energy Affairs," SWP Comment, No. 7, January 2021, 2.

41 Indra Øverland and Roman Vakulchuk, *The Geopolitics of Renewable Energy* (Oslo: NUPI, June 2017).

42 IRENA, *Geopolitics of the Energy Transformation: The Hydrogen Factor* (Abu Dhabi, UAE: International Renewable Energy Agency, January 2022), 21.

43 Ibid., 10.

If this is indeed the case, Europe will be well positioned—given its strong emphasis on hydrogen development—to capitalise on the trend in consolidating itself as a coherent geopolitical actor that could exercise its power without undermining its energy security.

Some of the negative dynamics related to the disunited approach by the EU member states that hampers the Energy Union, and absence of cohesion in conducting relations with those established geopolitical players that use energy supply as a tool of coercion, could be transplanted into the hydrogen era

This perspective, however, needs to be tempered by a certainty that oil and gas—especially oil and gas derived from countries with low production costs—will continue to have an important role in the energy mix by 2040 or even 2050, thus giving those countries an opportunity to retain some of their geopolitical clout in world affairs. According to Meghan O'Sullivan and Jason Bordoff, "In the next 10 to 20 years, the energy transition will make opportunities for petrostates to wield significant geopolitical and economic power."[44] In some cases, those states will also seek to carve out a role for themselves in the hydrogen value chains and thus continue exercising a degree of influence over European decision-making in energy security and foreign affairs.

There is also a risk that some of the negative dynamics related to the disunited approach by the EU member states that hampers the Energy Union, and absence of cohesion in conducting relations with those established geopolitical players that use energy supply as a tool of coercion, could be transplanted into the hydrogen era. The clearest example of this negative dynamics in the past was the case of the Nord Stream 2 (NS2) gas pipeline running directly from Russia to Germany across the Baltic Sea. Despite public opposition and heavy criticism of the project by some fellow EU member states, and even the US sanctions imposed on the companies involved (that were lifted by the administration of President Joe Biden after reaching a deal with Berlin in mid-2021), the gas pipeline was expected to enter service by mid-2022 at the latest.[45] The pipeline could well become part of the European Hydrogen Backbone after its repurposing, but its certification was eventually halted by the German authorities only on the very eve of Russia's war against Ukraine.[46] However, until that very moment, it had a negative effect on transatlantic relations, European cohesion in the energy sector, the EU's ability to withstand Russia's geopolitical blackmail, and German political will to extend into the energy sector the efforts necessary to compel Moscow stop its aggression against Ukraine.[47]

Ostensibly, the lack of strategic foresight and geopolitical perspective in managing energy policy risks (acknowledged by the German foreign minister Annalena Baerbock[48]), as well as European-level incoherence characterising the NS2 saga do not bode well for the future when imports of hydrogen and other climate-friendly energy sources and vectors replace imports of fossil fuels. On the other hand, the exposure to malignant geopolitical actors such as Russia would have naturally diminished in the coming years, as natural gas takes on a smaller role in the European energy mix, and the new trade geography of green hydrogen supply will provide greater diversification. Even if those actors manage find their place in the EU's hydrogen supply chains, they are unlikely to enjoy the same degree of dominance in energy supply and influence in Europe as in the hydrocarbon era.

Also, as demonstrated by the gradually toughening responses, both at EU level and by the individual member states, to Russia's actions in the European gas markets and its

44 Meghan O'Sullivan and Jason Bordoff, "Russia Isn't a Dead Petrostate, and Putin Isn't Going Anywhere," *The New York Times,* 27 January 2022.

45 Karin Matussek, Birgit Jennen and Dina Khrennikova, "What Nord Stream 2 Needs Before Gas Can Start Flowing," *Bloomberg* & *The Washington Post*, 19 November 2021; Guy Chazan, Henry Foy, and Max Seddon, "Germany eyes Nord Stream 2 sanctions if Russia invades Ukraine," *The Financial Times*, 8 December 2021.

46 Zia Weise, "Germany shelves Nord Stream 2 pipeline," *Politico*, 22 February 2022.

47 Martin Russell, "The Nord Stream 2 pipeline: Economic, environmental and geopolitical issues," European Parliamentary Research Service Briefing, July 2021; Jana Puglierin, "Sanctions in the pipeline: Germany's troubles over Russia and Nord Stream 2," European Council on Foreign Relations, 19 January 2022.

48 Hans von der Burchard, "Annalena Baerbock: Germany knew about Russian energy risks — and did nothing," *Politico*, 29 March 2022.

aggression against Ukraine in early 2022, energy relations are clearly no longer seen just from a commercial or security of supply perspective (as previously insisted by some governments), but also from a geopolitical point of view. If the recent European Commission proposals, REPowerEU, are successfully implemented, the scope of energy relations with Russia in particular will drastically shrink as a result of the Kremlin's war against Ukraine.[49] Most individual member states such as Poland and the Netherlands go even further and plan to halt all energy imports from Russia as early as the end of 2022. Germany is envisaging the same deadline for ending imports of oil and coal, but ending its dependence on Russian natural gas is not seen as feasible until 2024 at the earliest.[50]

Still, it is not unimaginable that under the right political conditions the import of hydrogen from Russia might have become an attractive opportunity for some European industrial or energy sector stakeholders by 2040. Thus, the risk of repeating the same strategic mistakes of the 2000s and 2010s may arise again. Lessons learned from the multifaceted crisis caused by Russia's attack on Ukraine in 2022 should continue informing and shaping Europe's judgement not only about the already well-recognised danger of the energy dependence on Russia, but also about the risks of forming long-lasting hydrogen relations with any assertive authoritarian regime in the future. These risks could potentially be managed (at least when it comes to protecting the EU member states) through the application of anti-coercive measures proposed by the European Commission in December 2021 (which are still subject to endorsement by the European Parliament and member states at the time of the writing of this report).[51] Overall, however, energy security policy and coherent action coordinated at the EU-level will be paramount in addressing such risks.

Along with the continuing, if less pronounced, traditional geopolitical issues related to the hydrocarbon era, energy transition also brings along new aspects of geopolitical competition and cooperation, such as a quest for technological mastery and leadership (often collectively labelled as "geotech"). As many countries are considering pathways towards becoming technology makers rather than being technology takers, the dynamics of hydrogen technology development is being brought into sharp focus. In this regard, the geopolitics of hydrogen will be about the political value of, and power derived from, leveraging knowledge and innovation networks and access to hydrogen technology; about the ability to protect those technologies from geopolitical adversaries; and about statecraft in management of geopolitical risks in ensuring security of supply of key raw materials and components for those technologies.[52]

Technological dimension is not an entirely new factor in causing geopolitical disruption (as was the case with, for instance, fracking technology that turned the US into a major producer of shale gas and consequently diminished the importance of the Middle East in its foreign policy),[53] but the nature of this disruption will be somewhat different due to hydrogen being an energy vector, meaning that it is a conversion business rather than an extraction one and requires tighter integration of cross-border regional supply chains. This will put a premium on strategic foresight and long-term planning when it comes to creating favourable preconditions for regional hydrogen clusters and infrastructure development. This in turn will require a high degree of geopolitical stability and resilience to adverse changes in the security environment of those particular regions that will play a major role in hydrogen supply chains within and to the EU.

In many ways, hydrogen-related cooperation will resemble the functioning of regional gas markets

In many ways, hydrogen-related cooperation will resemble the functioning of regional gas markets—such as the one that was formed on

49 European Commission, "REPowerEU: Joint European action for more affordable, secure and sustainable energy," press release, 8 March 2022.

50 Zosia Wanat, "Poland to EU: Follow our lead on scrapping Russian energy," *Politico,* 30 March 2022; Joshua Posaner, "Germany aims to be nearly free of Russian oil and coal by year's end," *Politico,* 25 March 2022.

51 European Commission, "Proposal for a regulation of the European Parliament and of the Council on the protection of the Union and its Member States from economic coercion by third countries," COM(2021) 775 final, Brussels, 8 December 2021.

52 For more on the critical raw materials in hydrogen supply chains, see European Commission, *Critical materials for strategic technologies and sectors in the EU - a foresight study* (Luxembourg: Publications Office of the European Union, 2020), 24-28.

53 Robert A. Manning, *The Shale Revolution and the New Geopolitics of Energy* (Washington, DC: Atlantic Council, 2014).

the eastern shores of the Baltic Sea and includes Finland, Estonia and Latvia (with Lithuania poised to join soon), with their reliance on detailed rules, regulations, standards, and arbitration mechanisms, as well as a high degree of coordination and trust-building (see Chapter 5). According to the IRENA report, as a result of hydrogen development, "energy relations are likely to be regionalised, thereby transforming the geopolitical map".[54] The existing templates for analysing the nexus of energy and geopolitics will have to be adjusted to reflect this important characteristic.

In these circumstances—facing the possibility of the old geopolitical risks currently driven by natural gas trade resurfacing in the hydrogen era and then supplemented with the dynamics of regional gas markets as well as technological competition—choosing partners carefully and building effective energy cooperation frameworks to exploit new opportunities related to hydrogen, while being prepared to mitigate exposure to various risks connected to those partners, will remain important considerations when managing the overall nexus of geopolitics, energy security and hydrogen economy. The next chapter of this report investigates whether Russia could still play a certain role in hydrogen supply chains during the post-fossil fuel age, even though it would come with a caveat due to Russia's political animosity towards the EU and by Europe's need to enhance its energy sovereignty.

2. Barriers to Hydrogen and Russia's Siren Song, 2030-40

Alan Riley

with contribution by Tomas Jermalavičius

The EU's efforts to decarbonise the economy and diminish energy dependency on unreliable suppliers will continue in the coming decades, with hydrogen expected to play an important role (as highlighted in the previous chapter). Technological and economic factors that are likely to influence hydrogen production and consumption, however, will shape not only the success of achieving the EU Green Deal goals, but also the extent to which firm geopolitical posture vis-à-vis those unreliable suppliers can be sustained in the long-term.

With "irreducible minimum" of demand, especially for fertiliser and the hard-to-decarbonise market, comes a geopolitical risk of Russia seeking to exploit the deficit of green hydrogen supply to stage a return to the European energy markets between 2030 and 2040

With "irreducible minimum" of demand, especially for fertiliser and the hard-to-decarbonise market, comes a geopolitical risk of Russia seeking to exploit the deficit of green hydrogen supply to stage a return to the European energy markets between 2030 and 2040. For the EU in particular, it will be difficult to produce all the green hydrogen it requires, even for just the hard-to-decarbonise sectors, given the existing low utilisation of renewables and the limited capacity of other sources of non-carbon power generation (principally nuclear). However, Russia has under-used nuclear power capacity and one of the world's most developed nuclear industries. And it has the ability to ramp up its nuclear fleet to help provide for European demand for green hydrogen that might come to be seen as an opportunity by some industrial stakeholders in Europe.

2.1. A hydrogen opportunity or illusion?

At first sight the prospects for hydrogen to obtain a central role in the energy transition appear to be clear. Hydrogen, when combusted, produces no greenhouse gas emissions. It can be used to generate electricity; it can be deployed for direct heating; it can be used for storage; and potentially can be transported either by pipeline or by ship. In addition, it can be deployed in the transport sector as a source of fuel via fuel cells for lighter vehicles and heavy-duty trucks and lorries. Furthermore, there is the potential of using the existing natural gas infrastructure to carry and store hydrogen across the European gas networks. It is not surprising, therefore, that hydrogen has been referred to as the "Swiss Army knife" of the energy transition.[55] Nor is it

54 IRENA, 71.

55 Emily Pontecorvo, "Why the 'Swiss Army Knife' of climate solutions is so controversial," *Grist*, 27 September 2021.

surprising that both the EU Green Deal and the European Recovery Programme have focused on developing the hydrogen economy with ambitious 2030 and 2050 production targets.[56]

The expansive vision of a hydrogen dominated economy is difficult to sustain without addressing some key technological, financial, and geopolitical issues. The first major issue is that almost all hydrogen in the world created today is produced with fossil fuels, either natural gas (grey hydrogen) or coal (brown hydrogen). In addition to harmful climate effects, this still empowers and entrenches in the supply chain countries extracting hydrocarbons. Advocates of using natural gas to generate hydrogen in the energy transition have argued that it is possible to generate blue hydrogen, i.e. hydrogen generated from natural gas but where the greenhouse gas emissions are either eliminated from the supply chain or sequestered via CCS. In the EU's thinking, the short- to medium-term basis for using hydrogen is indeed to use blue hydrogen, thus ostensibly dealing with the emissions problem.

The expansive vision of a hydrogen dominated economy is difficult to sustain without addressing some key technological, financial, and geopolitical issues

However, on closer examination it appears conversely that the principal barrier to the large-scale deployment of blue hydrogen is that it delivers unacceptable levels of greenhouse gas emissions. Recent academic research, in particular a paper by Howarth and Jacobson, provides compelling evidence that the actual generation of CO_2 emissions from blue hydrogen across the supply chain is in fact greater than the emissions generated using only natural gas.[57] A fundamental problem with blue hydrogen is the initial production of natural gas, which requires the methane leaks to be taken into account, the use of natural gas to produce the hydrogen, and then the use of further natural gas to take the measures necessary to sequester the greenhouse gas emissions via CCS. The leaks from the initial production process plus the scale of natural gas use make it impossible for blue hydrogen to have lower levels of greenhouse gas emissions than the direct use of natural gas to produce hydrogen. This is the case even if a lower level of methane leaks during initial production is factored in instead of the standard measures used by Howarth and Jacobson.[58]

There are also significant cost issues arising from the blue hydrogen model. Hydrogen is not a primary energy source. It has to be generated via another energy resource such as natural gas or renewables. Hence there are always energy losses from generating hydrogen. These may be reduced with new processes and technology. However, with blue hydrogen, those losses are significantly increased by the need to undertake a sequestration process, and then for the CO_2 to be transported and stored. There are also additional questions as to the availability of storage capacity for CCS sites at scale.[59]

If hydrogen is to play a major role in the energy transition, it has to reduce greenhouse gas emissions to zero and be cost-efficient. The key transition alternative therefore is to generate hydrogen directly from renewables: the green hydrogen option. There are, however, two difficulties here. First, green hydrogen generation is approximately two to three times

If hydrogen is to play a major role in the energy transition, it has to reduce greenhouse gas emissions to zero and be cost-efficient

56 European Commission, "Hydrogen strategy."

57 Robert W. Howarth and Mark Z. Jacobson, "How Green is Blue Hydrogen?," *Energy Science and Engineering,* Vol. 9, Issue 10 (2021), 1676.

58 Howarth and Jacobson, "How Green is Blue Hydrogen?". The central emission rate used by Howarth and Jacobson for methane leaks from gas production is 3.5%. However, even when the authors use a more conservative emission rate of 1.54% it is still the case that blue hydrogen still emits more greenhouse gases than just burning natural gas.

59 A further concern not discussed in this paper due to its technical complexity is the question of hydrogen embrittlement, i.e. the capacity of hydrogen within a gas pipeline to undermine the physical integrity of that pipeline. At lower levels of blending of hydrogen with natural gas in a pipeline, it appears unlikely that there is much of a threat of embrittlement. However, this appears not to be the case at much higher levels of hydrogen concentration within the pipeline or with pure hydrogen. At the very least there appears to be a significant additional cost factor to upgrade the existing natural gas pipeline to carry heavy or pure hydrogen.

as expensive as blue hydrogen.[60] No doubt, over time these costs could be reduced, but high costs nevertheless remain a barrier to market entry and will require public support. Second, and perhaps most crucially, the utilisation rate (or in the technical jargon, the capacity factor) of renewables in Europe remains quite low. Offshore wind power can obtain over 40% utilisation, but onshore wind power has lower utilisation rates, and solar energy, even in the most propitious circumstances, has even lower utilisation rates.[61] The issue of utilisation rates is compounded by the fact that while the most recent EU/UK renewables fleet has higher utilisation rates, older parts have significantly lower rates. This point underpins Samuele Fufari's observation that the total EU/UK wind and solar capacity of 258 GW in 2019 had an overall utilisation factor of just 19%.[62]

Clearly, over time, utilisation rates will rise as more modern and effective wind and solar farms are rolled out and more sophisticated and cheaper large-scale batteries and other battery-like solutions become available. In other words, the loss of renewable generation when there is over-production of wind and solar energy will be solved, as we will eventually be able to store the power generated and use it later. In addition, "excess" power generation not immediately used but stored in large-scale batteries is likely to prove an extremely low-priced competitor against other sources of power.[63]

Even with large-scale battery solutions (which do not yet exist at scale), utilisation rates are still going to limit the ability of renewables to generate hydrogen to permit it to take up a dominant role in the energy transition. That view is reinforced by the reality that the process of generating the necessary hydrogen involves significant power losses. Currently they are of the order of 20–40%. Again, over time, with new technology, processes and know-how, they can be reduced. However, given the existence of low utilisation rates for wind and solar power, does one really want to factor in, on top of the low utilisation rates, significant energy losses from generating the power to make hydrogen? For at least the short to medium term, it makes more sense to use renewable power to generate electricity and use renewable power as part of the decarbonisation and electrification process of the transition with none of the energy losses that would arise from generating hydrogen.

These difficulties do not mean that hydrogen has no future. Hydrogen cannot easily be replaced in the fertiliser and chemical sectors. For instance, it is used in oil refining (by assisting in the removal of sulphur from oil), non-agricultural ammonia production, methanol production and steel-making.[64] A major continuing vital use of hydrogen is as the basic ingredient in fertilisers, which underpins agricultural production. So far, almost all current hydrogen production deployed to produce fertiliser depends on natural gas and coal—as part of the energy transition, at the very least, the fertiliser market will have to be decarbonised and some form of green hydrogen deployed. In addition, hydrogen can potentially play a major role in sectors where electrification cannot easily be applied, for instance, in heavy-duty lorry and trucking sector. Hence, there is significant irreducible demand for green hydrogen, which *The Economist* estimates as amounting to sectors that generate 10% of greenhouse gas emissions.[65]

It is difficult to see how there could be sufficient green power generation to deliver green hydrogen in the quantities that Europeans need. The only other major potential source of zero carbon for hydrogen is nuclear power

2.2. Russia's Trojan horse back into Europe?

It is difficult to see how there could be sufficient green power generation to deliver green hydrogen in the quantities that Europeans need. The only other major potential source of zero carbon for hydrogen is nuclear power,

60 Jim Magill, "Blue vs Green Hydrogen: Which will the Market Choose?," *Forbes*, 22 February 2021.

61 Nick Ash, Alec Davies, and Claire Newton, *Renewable Electricity Requirements to Decarbonise Transport in Europe with Electric Vehicles, Hydrogen and Electrofuels* (London: Transport & Environment and Ricardo Energy & Environment, December 2020).

62 Samuele Furfari, *The Hydrogen Illusion* (Independently published, 2020), 96.

63 Energinet, Fingrid, Statnett, and Svenska Kraftnät, *Nordic grid development perspective 2021* (Oslo: Energinet et al, 2021).

64 Jose M Bermudez and Ilkka Hannula, "Hydrogen: More Efforts Needed," IAE Tracking Report, November 2021.

65 "Hydrogen's Moment is Here at Last," *The Economist*, 9 October 2021.

the advantage being that nuclear energy has high utilisation rates and there is no need for additional power to enable CCS. So, it could play a significant role in generating zero-carbon hydrogen in vital sectors such as agricultural related fertiliser processing, core chemical requirements, steel-making and fuel for heavy-duty trucks. However, with the EU Green Deal, all zero-carbon sources are in demand, and it will be difficult for the EU to solely depend on its own nuclear power sources to generate sufficient hydrogen in vital economic sectors.

Moscow could build upon the growing concerns over the fate of the planet to divert the attention from its geopolitical behaviour and re-fashion itself as an indispensable partner in ensuring success of energy transition in Europe. Hydrogen could potentially play an important role in these efforts

Clearly, there is an environmental issue with the prospect of making more use of nuclear power to generate zero -carbon hydrogen. However, one must consider the balance of risks. We have a potentially uncontrollable risk of rapidly advancing climate change against a known and much more manageable risk from the use of nuclear power. Given the circumstances, we are deploying one manageable risk against one uncontrollable risk, which may, if it continues, undermine planet earth and in the process, the survival of humanity.

This is where Russia might try to create cracks in Western sanctions regime as well as to offset the impact of the EU efforts to eliminate its dependence on the imports of hydrocarbons, and consequently re-assert itself as a major player of the European energy market in the post-hydrocarbons era. Over time, Moscow could build upon the growing concerns over the fate of the planet to divert the attention from its geopolitical behaviour and re-fashion itself as an indispensable partner in ensuring success of energy transition in Europe. Hydrogen could potentially play an important role in these efforts.

So far, Russia's nascent hydrogen plans are heavily dependent on the prospects for blue hydrogen. However, as explained above, given the problem with greenhouse gas emissions from blue hydrogen being greater than just using natural gas, blue hydrogen is not a credible option. It also flies in the face of the European determination to cut its dependence on natural gas supplied by Russia. However, Russia has just short of 30 GW of installed gross nuclear power capacity some of which is not currently fully utilised. Further, through Rosatom (an entity not sanctioned by the US or the EU yet, at the time of this report's writing), Russia has a significant nuclear technological base, which could be deployed to increase capacity.

Given the scale of that resource, and its capacity to be expanded, one can see the potential for Russia to play a significant role in helping Europe and the world to decarbonise various hard-to-decarbonise sectors and maintaining fuel supplies. In the future, once the shock of Russia's attack on Ukraine has subsided and pressure to restore some of the economic relations with Moscow begins building up in traditionally Russia-friendly EU member states, this technological base could be used by Russia to entice some of the EU energy players seeking to significantly reduce the costs of producing hydrogen by using nuclear power. By showing reluctance to support development of nuclear energy beyond 2045 (the proposed time horizon for the inclusion of new generation nuclear energy in the "green taxonomy"), the EU is putting itself in a position where building a positive green future might inadvertently open the doors for Russia back into the European economy and restore some of those dependencies that the EU is trying to shed at the moment.

In the long term, there will be various pressures arising from within the EU to seek new opportunities, in the name of climate security and future of humanity, to engage Russia again

In the short and medium term, this is not a major concern. Russia's aggression against Ukraine and use of energy as a tool of coercion vis-à-vis Europe has made it clear to many that Moscow is not a trustworthy commercial or political partner and helped to build momentum in the EU towards cutting energy ties with Russia. But, in the long term, there will be various pressures arising from within the EU to seek new opportunities, in the name of climate security and future of humanity, to engage Russia again. The shifts in the European energy system caused by Russia's war against Ukraine will not completely remove the desire of some political and economic players in Europe to go back to the "business of usual" with Russia in the post-hydrocarbons era. In order to reduce the potential scale and impact of such pressures, the extent of European hydrogen partnerships with other regions as well as its own progress in building domestic green and pink hydrogen capacity will be of pivotal importance. Making Ukraine a major thrust of this effort will be not only a moral imperative, but also a strategic one.

3. The Ukrainian Promise

Andrian Prokip
Iliya Kusa

For decades Ukraine has been a key corridor for the transit of Russian gas to other European states. When the Soviet Union collapsed, the movement of Russian gas became dependent on Ukrainian transit. This in time has become one of the reasons why Europe has supported Ukraine, which in turn transformed this dependency into an interdependence between Ukraine and the EU.

Ukraine has benefitted significantly from this situation, not only from transit gas fees, but also in terms of European financial support and political protection. For instance, gas transit interdependence was the major driver behind Europe's support for Ukraine during the Russian-Ukrainian "gas wars" in the early 1990s, 2005–06, 2009–10 and 2014–15. European officials played a key role in mediating and coordinating Russia-Ukraine negotiations to settle these disputes.

A huge blow was dealt to this interdependence in 2015, when a Nord Stream 2 agreement was signed, just a year after Russia launched its military aggression against Ukraine. Many in Ukraine feared that Russia's attempts to develop gas transit capacities bypassing Ukraine would alter the energy balance in the region, and therefore weaken Ukraine's security position, allowing Russia a free hand to promote instability and even unleash a full-scale war without the need to worry about damaging the gas transit infrastructure. These fears only intensified when a few years later the Turk Stream pipeline went under construction, to be finished in just four years.

The EU Hydrogen Strategy gave Ukraine a chance to further integrate with the EU, building new ties in the field of energy and giving Kyiv a new direction for reconstructing mutually beneficial energy interdependence

In the late 2010s, following the gradual ascension of the hydrogen topic to the top of the world agenda, it also came under discussion in Ukraine. However, many were sceptical about its potential in Ukrainian energy development, particularly because of uncertain perspectives and doubts about whether Ukrainian infrastructure was technically ready to embrace it.

The adoption of the EU Hydrogen Strategy in June 2020 was a turning point, as it singled out a specific role for Ukraine, which in turn changed the common attitude and persuaded energy companies to declare their interest in hydrogen energy projects. According to the strategy, "the Eastern Neighbourhood, in particular Ukraine, and the Southern Neighbourhood countries should be priority partners."[66]

The EU Hydrogen Strategy gave Ukraine a chance to further integrate with the EU, building new ties in the field of energy and giving Kyiv a new direction for reconstructing mutually beneficial energy interdependence. For these reasons, the topic was recently promoted to the top of the national energy agenda. It will be an important part of Ukraine's path towards EU membership—a bid that was launched by the Ukrainian government and acknowledged by the EU in the early days of the war in February 2022 (although it is yet to be endorsed by the EU member states, and some are already voicing their objection[67]).

66 European Commission, "Hydrogen strategy," 19.

67 Peter McLaren-Kennedy, "Ukraine's hopes of joining EU dented by Austria," *EuroWeekly News,* 25 April 2022.

Ukraine also has good opportunities to develop hydrogen for its own needs. While the outcome of the war with Russia is still uncertain, its impact on Ukraine's economy and infrastructure has already been massive.[68] The post-war economic reconstruction of sovereign and independent Ukraine will entail major investments in its energy sector, including renewables and hydrogen. However, the pre-war period suggests that there will also be some obstacles and threats to the success of these endeavours if various elements of pre-war energy policy, governance practice and the business environment remain in place. This chapter aims to highlight those elements while also underscoring the major opportunities related to Ukraine's hydrogen potential.

3.1. Resource base for hydrogen production

Because of its vast territory and favourable natural conditions, Ukraine has excellent potential for developing renewables that can be used to produce green hydrogen for both domestic needs and export. According to assessments conducted by the Institute for Renewable Energy at the National Academy of Sciences of Ukraine, the technically accessible potential for renewables in Ukraine amounts to 874 GW, allowing for the production of 2,717 billion kWh of electricity or 515 billion normal cubic metres of hydrogen annually.[69] In comparison, the annual electricity production in Ukraine in recent years has varied between 150 and 155 billion kWh.

However, technically feasible potential is not the same as economically feasible production. The economic feasibility of hydrogen production will depend on its comparative competitiveness relative to other energy resources, taxing and subsidising policies, and the cost of capital and price of technologies to produce renewable energy and hydrogen (which will decrease in the future). But these figures are important in understanding Ukraine's hydrogen production potential in the long term—up to 2040–50—if other necessary preconditions exist and requirements are fulfilled.

Even now, low-carbon power capacities are available, including in the renewable sector, to start the production of hydrogen on pilot or small commercial industrial levels. The installed capacities of nuclear power plants, which are traditionally responsible for half the electricity produced in the country, amount to 13.8 GW. The installed capacities of hydropower plants amount to 4.8 GW, or 4% of power production in 2020, and those of solar and wind amount to 5.9 and 1.4 GW respectively, which, with other renewables, contributed 7.3% of power production in 2020.[70]

3.2. Potential demand side

In future, the key directions of hydrogen usage in Ukraine may be gas substitution and using methane-hydrogen mixes, energy storage to balance production and demand, fuelling hydrogen transport, and export to other states.

Because of technical restrictions, a lack of balancing capacities and an inability to meet the demand curve with all capacities working, nuclear and renewable are not used to full extent. If these unexploited capacities were used for hydrogen production, this would not only mean a better utilisation rate of energy assets and improved performance but the manufactured hydrogen could also be used for energy storage. Surplus electricity generation capacities offer a good opportunity to start pilot projects for hydrogen production and usage. For instance, with 13.8 GW of currently installed nuclear capacities, only 7 GW were operating in June 2020 and 10.5 GW in February 2021.[71] According to the assessments of the transmission system operator (TSO) NPC Ukrenergo, by 2025 the Ukrainian power system will need 2 GW of electricity storage capacities in operation.

Gas import dependency also opens opportunities for hydrogen usage. Considering that in recent years Ukraine's gas consumption has been 30–33 bcm, and 10–12 bcm has been covered by imports, the country will need to produce 20–36 billion Nm^3 of hydrogen annually to enhance self-sufficiency.[72] Reducing gas import dependence must become a priority for Ukraine, since its current transit contract expires at the end of 2024, and this will affect virtual reverse flows. So, combined with efforts

68 "Ukraine's war losses amount to $565B," *Ukrinform*, 28 March 2022.

69 Stepan Kudrya (ed.), *Atlas of Energy Potential of Renewable Energy Sources of Ukraine* (in Ukrainian), 2nd ed. (Kyiv, Ukraine: Institute of Renewable Energy, NASU, 2020).

70 Capacity data as of August 2021 by transmission system operator (TSO) – National Power Company Ukrenergo. They do not account for the temporary loss of capacity due to Russia's occupation of various production facilities such as Zaporizhzhia Nuclear Power Plant that was attacked and captured by the Russian troops.

71 TSO data.

72 Depending on the future infrastructure's readiness for gas-hydrogen mixes.

to increase domestic gas production and energy efficiency enhancing, hydrogen may be helpful. But the problem is that by 2025 the country will not be ready for hydrogen production and usage to substitute imported gas, neither in terms of production capacities nor in terms of the pipelines' readiness.

In early 2021, electrolysers, used to produce renewable hydrogen, were the weakest link in the chain, as there was no industrial-scale production

To cover this demand and to produce additional volumes of hydrogen for potential exports, much more power regeneration capacities are needed, as well as electrolysers.

3.3. Production side and infrastructure readiness

It is clear that the current size of renewables' capacities installed in Ukraine can produce relatively small volumes of hydrogen—about 0.35 Mt or 3.9 billion Nm^3 annually, which equals 3.5% of the EU's hydrogen consumption and is far from covering even potential demand in Ukraine, not to mention its export to the EU.[73] Still, these capacities are enough to start pilot projects of hydrogen production right now.

It is unclear how many renewable energy producers will be interested in hydrogen production until 2030, the period when the payment of feed-in tariffs for renewable electricity is guaranteed by law. Since late 2019, the state has not been able to fully disburse these payments, which has led to huge debts.[74] So, if the situation is not improved, it may push some of the renewable energy producers to consider hydrogen projects, to enter the new emerging market.

In early 2021, electrolysers, used to produce renewable hydrogen, were the weakest link in the chain, as there was no industrial-scale production (due to it being an innovative industry, especially for Ukraine). But this should not be a problem going forward due to the predicted direction of government policy, real investors' interest (foreign in particular), and the fact that several companies have already developed feasibility evaluations and proposals for investors to build electrolysers to produce renewable hydrogen.

The best progress achieved in 2021 was in the distribution section. Studies have been commissioned on the impact of hydrogen and hydrogen and natural gas mixes on gas distribution pipelines, metering equipment, and end-user firing equipment since early 2020.[75] Leading this research is the Regional Gas Company (RGC)—a member of the European Clean Hydrogen Alliance, uniting 20 gas distribution system operators (DSOs) covering about 70% of Ukraine's territory and 250,000 km of pipelines—who together with eight research institutions and universities will continue conducting these studies through to 2023. These investigations must be followed by redesigning gas distribution systems, which RGC estimates will last till 2030. If these plans are included in the post-war reconstruction efforts and successfully realised, from 2030 the Ukrainian gas infrastructure should be ready to carry hydrogen and natural gas mixes. But to carry pure hydrogen, some more improvements will be necessary.

Another weak link in the hydrogen chain is the system of main pipelines, operated by the state-owned company Gas Transmission System Operator of Ukraine, LLC. This TSO is only now at the stage of conducting theoretical research in hydrogen transportation; the infrastructure and the behaviour of hydrogen in the pipelines will be examined later.[76]

When Ukraine joins the European Hydrogen Backbone, it is this TSO's infrastructure that must form the basis for a system of hydrogen transmitting pipelines. In that case, it would be reasonable to split the systems: one for the delivery of pure hydrogen to the EU and another merged with DSOs, capable of carrying a hydrogen and natural gas mix used within Ukraine by that time, for shifting pure hydrogen domestically.

In September 2021, the Ukrainian TSO signed an agreement with Slovak TSO EUSTREAM,

73 Adam Balogh, "13th OIL FORUM," in *Hydrogen Potential in the Contracting Parties… with Reality Check* (Energy Community Secretariat, 2021).

74 Steven P. Finizio and Charlie Caher, "Escalation of Ukraine's Renewable Energy Crisis: A Year in Review," JD Supra, 4 October 2021.

75 "For the First Time, the Gas Equipment of Ukrainian Production Passed the Hydrogen Testing Program," Regional Gas Company, 7 October 2021; Maksym Bielawski, "The First Practical Project in the Hydrogen Energy Sector of Ukraine," Razumkov Centre, 4 March 2021.

76 "The GTS of Ukraine is studying the issue of hydrogen transportation" (in Ukrainian), *Ukrinform*, 1 October 2021.

Czech NET4GAS and German OGE on future collaboration in creating a hydrogen corridor for supply from Ukraine to Germany.[77] But the TSO's officials seem to have little understanding about the cost of modernisation, only assuming it to be billions of US dollars.[78] And so sufficiency and sourcing of the financing is another weakside of hydrogen energy in Ukraine and defined by the energy policy the country conducts.

> *Among the key challenges in Ukraine's energy sector before the war of 2022 was the attitude common among Ukrainians that the government was supposed to protect the consumers from the dynamics of free-market economy*

3.4. Institutional and regulatory environment

Among the key challenges in Ukraine's energy sector before the war of 2022 was the attitude common among Ukrainians that the government was supposed to protect the consumers from the dynamics of free-market economy, which regularly makes the government enact populist decisions aimed at maintaining low energy prices, primarily for households.[79]

This has led to the overregulation of energy markets, inefficiency and the neglect of market-oriented policies. As a result, there are not enough resources for energy companies to reinvest, even making some of them unprofitable. Corruption in the judicial system and law enforcement agencies has led to a low level of foreign investor interest in the Ukrainian energy sector. Decades of such populist and ineffective policies has resulted in high levels of depreciation of energy assets and, correspondingly, huge financial losses in the energy sector, making the overall economy inefficient.

Now, most of the infrastructure requires modernisation or redesign as well as reconstruction in the wake of the war. Old equipment needs replacing to undertake energy transition and the implementation of decarbonisation technologies.

Energy companies lack funding for modernisation and non-market regulations restrict investor interest and their ability to help. Just before the start of the 2022 war, because of populist short-sighted state energy policies, all sections of the potential hydrogen production chain were suffering from a lack of investment and were underfunded. Nuclear power operator Energoatom was unprofitable in 2020, partly because of supplying power to households at extra-low prices. Renewable power producers suffered from underpayment of feed-in tariffs, which also had a negative impact on investor interest in the sector. Existing price caps on electricity markets restricted the feasibility of constructing new facilities to produce profitable low-carbon electricity without subsidies.

Considering the high cost of hydrogen production, it is hard to imagine the construction of electrolysing facilities to produce this gas without private foreign investments or types of hydrogen purchase agreements that would attract national investors, and the war has upended even those plans that were in place.

> *Just before the start of the 2022 war, because of populist short-sighted state energy policies, all sections of the potential hydrogen production chain were suffering from a lack of investment and were underfunded*

The tariffs for gas distribution, approved by the energy regulator, did not cover the expenses, which resulted in the unprofitability of most DSOs and debts for the TSO.[80] If this approach remains unchanged post-war, companies will have no money to modernise and redesign those pipelines that remained untouched by war, which is essential for hydrogen-gas mix delivery. However, the redesign of DSOs'

77 Gas Transmission System Operator of Ukraine (GTSOU), "Gas Companies Present the Central European Hydrogen Corridor," news, 23 September 2021.

78 "The GTS of Ukraine" (in Ukrainian), *Ukrinform*.

79 Andrian Prokip, "Key Enemies of Energy Reforms in Ukraine," Focus Ukraine, Wilson Center, 9 September 2020.

80 Cepconsult, "Ukrainian Natural Gas Distribution Companies Incur Losses by UAH 1.2 Billion Due to Inadequate Tariff Level," news, 7 May 2020.

pipelines is necessary anyway to make them more efficient, especially taking into account the radical drop in gas consumption in the country during the last two decades—from 118 bcm in 1991 to 50 bcm in 2013 and 31 bcm in 2020—which has increased maintenance costs.[81]

The Ukrainian gas TSO was also suffering from a lack of funds to invest in any modernisation of its gas transit system. And the projected decrease of future gas transit volumes—possibly to zero if the EU eventually stops gas imports from Russia altogether in response to its aggression against Ukraine—will mean lower or even collapsed revenues for the company: the current contract stipulated 65 bcm of transit under ship-or-pay conditions in 2020 and 40 bcm annually during 2021–24. In 2021, when Europe and import-dependent Ukraine faced a gas price rally, the government obligated the TSO to transfer 1.8 billion US dollars to buy gas to cover the needs of households and utilities, even despite the fact that the company did not have the entire amount in cash. These are just a few examples demonstrating the unpredictability of regulation and the business environment impacting the companies in the hydrogen production supply chain.

The Ukrainian gas TSO was suffering from a lack of funds to invest in any modernisation of its gas transit system

Besides this, a new strategic vison framework is necessary for the development of renewables and hydrogen. In 2014, after the Russian aggression towards Ukraine started and uncertainty about the future of energy supplies to Ukraine increased, the government approved a national action plan on renewables development until 2020. However, the progress towards the goals stipulated by the plan was imbalanced, mostly because of extra-high feed-in tariffs for solar power plants: 5.36 GW of installed solar power capacity compared to 2.3 GW planned; 1.11 GW of wind power (2.28 GW planned); and 0.2 GW of bioenergy facilities (0.95 GW planned).

The energy strategy stipulated a 25% share of renewables in total primary energy supply by 2035 without any mentioning of hydrogen potential. But just a few years after being adopted in 2017, the strategy was considered to be outdated. In late 2021, the government was still discussing the development of a new action plan up to 2030, and with the support of international donors, started developing a new energy strategy and separate hydrogen strategy. These plans and strategies will have to be completely redrawn in the wake of the war with Russia and its impact on the European and Ukrainian economies, particularly the energy sector.

It is clear that green hydrogen production is not competitive right now. Even though its cost will reduce in the future, the Ukrainian government has no resources to finance such projects to their full extent, especially considering the anticipated costs of post-war reconstruction, long-term market uncertainty and prospects. Ukrainian companies do not have enough resources to prepare for energy transition, including the hydrogen economy, on their own. The unpredictable, sometimes populist regulations may undermine Ukrainian companies' efforts to raise the necessary financing.

The obvious conclusion is the necessity of attracting foreign investors to finance such projects, even though it is certain that Ukraine will also be a recipient of huge financial assistance for post-war reconstruction and EU integration. Despite its pre-war problems and the devastation wrought by the war, Ukraine will be an attractive opportunity for investment in hydrogen projects. Before the war, the country held 38th position in the ranking of the Hydrogen Investability Index.[82] Among other non-EU countries in Europe, Ukraine followed Norway, Russia and Turkey. But a reasonable question is: why should European investors and governments be interested in starting and financing hydrogen production projects in Ukraine?

Despite its pre-war problems and the devastation wrought by the war, Ukraine will be an attractive opportunity for investment in hydrogen projects

81 31 bcm gas consumption of 2020 does not include data of non-controlled parts of Donbas and Crimea prior to 24 February 2022.

82 "Emerging Hydrogen Superpowers," Hydrogen Investability Index, Cranmore Partners and Energy Estate, last accessed 20 October 2021.

3.5. What's in it for the EU?

3.5.1. Potential benefits

Decarbonisation goals aside, replacing large foreign suppliers of traditional energy sources to the EU with a wider range of small exporters of hydrogen would mean less energy dependence on a few states, such as Russia, whose geopolitical stance is openly adversarial and with whom any continued energy relations is a major risk. In these terms, the EU would benefit from having Ukraine as a significant supplier of hydrogen and probably zero-carbon electricity as well. The route of gas transportation is also familiar to the EU, which is advantageous, even if the gas transportation system requires redesigning to carry hydrogen.

The EU would benefit from having Ukraine as a significant supplier of hydrogen and probably zero-carbon electricity as well

Lower wages compared to EU countries would create competitive advantages for launching businesses in Ukraine. The country still has experienced research staff who could be deployed to work on hydrogen projects similar to the aforementioned studies conducted by the DSOs together with eight research institutions. In many cases, Ukraine could become a basis for research and pilot development projects in hydrogen production and transportation. This experience would be valuable for other Central and Eastern European states that have a similar topology of distribution gas pipelines.

As mentioned above, it is unclear how large a volume of hydrogen could be exported from Ukraine in the long term. But even if the volume is relatively small, the EU may still benefit from participating in Ukraine's energy transition and hydrogen economy development. The first key point is contribution to global climate goals. These are a part of European concerns and priorities. which Ukraine will have to subscribe to in the process of becoming a member of the EU.

Investing in Ukraine's hydrogen economy will provide impetus for additional economic growth, contributing to social and political stability in the EU's neighbourhood as well as post-accession convergence with other member states—much sought-after goals by the EU. On the other hand, the EU may be reluctant to expand energy production and export capacities in Ukraine if the outcomes of the war with Russia leave the country in geopolitical limbo that may adversely affect hydrogen's security of supply.

The diversification of the EU-Ukraine energy cooperation while maintaining it at a level not lower than in previous years will be of similar mutual benefit for both parties, as mentioned earlier in this chapter. But it also opens new dimensions of cooperation. Hydrogen exports, together with the use of the Ukrainian gas storages, exports of low-carbon electricity, production of renewable synthetic fuels and polymers, and their exports to the EU, may create a new web of interconnections enhancing the position of both parties, creating a robust energy interdependence and expediting Ukraine's full integration into the EU.

3.5.2. Potential risks and challenges

Most of the challenges and risks that the EU could face when participating in developing hydrogen projects in Ukraine relate to the institutional environment: corruption, weak rule of law, a lack of continuity in government policies, temptations to regulate prices, and a tradition of populist decision-making. These may affect the success of long-term projects with a 20–30 years lifespan and could be a risk for the EU's effort to launch hydrogen projects in Ukraine. This does not mean that the EU's participation in such projects in Ukraine would be pointless. But the forms and frameworks to make these investments efficient and protected should be researched carefully by both parties.

Investing in Ukraine's hydrogen economy will provide impetus for additional economic growth, contributing to social and political stability in the EU's neighbourhood as well as post-accession convergence with other member states

The lack of modern infrastructure is another challenge for investing in hydrogen. However, this may be balanced with some other advantages of hydrogen project development in Ukraine, which were listed above. Another potential risk for the EU-Ukraine collaboration may be the position of Russia, particularly its attempts to restore, once the war is over, its position in the EU's energy markets during and in the aftermath of energy transition and to stymie Ukraine's participation in hydrogen supply chains. Given the propensity of some policymakers in the EU to seek return to the "business as usual" with Russia once the geopolitical shocks abated, this will remain a possibilit—even though of much lesser degree than before the 2022 war and the ensuing unprecedented sanctions on Russia—to be taken into account when crafting the way ahead for Ukraine.

With hydrogen competition set to increase in the following years, Ukraine will clearly be a reliable and predictable partner for the EU in launching hydrogen projects, helping the EU to dismantle old geopolitically damaging energy dependencies and forge new partnerships

Due to these and other risks, the EU or some of its member states may seek greater self-sufficiency in terms of hydrogen, which would entail more reliance on domestic resources and less interest in supporting energy transition and hydrogen projects in neighbouring countries. However, this is not going to be an immediate mainstream policy, especially now that Ukraine's urgent bid for the EU membership could create a clear pathway towards accession. Even if accession is hampered and delayed, or derailed altogether by the war and post-war trajectory of events, the EU needs like-minded, friendly partners outside the Union, preferably not far from its borders, with comfortable logistics and infrastructure. Moreover, with hydrogen competition set to increase in the following years, Ukraine will clearly be a reliable and predictable partner for the EU in launching hydrogen projects, helping the EU to dismantle old geopolitically damaging energy dependencies (e.g. on Russia) and forge new partnerships that, in case of Ukraine, could be folded into the EU common energy market once accession has been completed.

The EU itself is interested in transforming the Baltic and Black Sea regions into one of its hydrogen hubs. In that case, Ukraine would not be the only country that has the potential, resources, will and a "green light" from Europe to develop this sphere. Similar plans are being drawn up in Romania, Georgia and Turkey, which also puts Ukraine on a path of regional competition. Turkey is an ambitious and assertive player in this regard. Although Ukraine currently enjoys a fruitful and close relationship with Ankara, Turkey is likely to behave in a competitive manner if it came to deciding who dominates the hydrogen market and takes the biggest share of supplies to Europe. After all, it was Turkey who contributed to Ukraine losing part of its gas transit potential, due to Ankara's pursuit of energy independence through such projects as the Turkish Stream pipeline.

3.6. Ukraine's potential economic losses and benefits

Under the existing trends of energy transition and falling natural gas transit through Ukraine, potential hydrogen cooperation with the EU opens a window of opportunities. It is already viewed as an opportunity for new interdependency with the EU, attracting investments to modernise energy assets and reconstruct the ageing or war-damaged distribution infrastructure—both pipelines and powerlines.

However, the biggest problem for Ukraine in terms of economic losses is that the potential benefits from cooperation—including hydrogen exports—will emerge much later, while the current losses related to pipelines bypassing Ukraine have already been occurring and the war has inflicted massive damage to the country's infrastructure. In other words, there will be a long time gap between 2021–25—when gas transit is low and Ukraine's economic and geopolitical future is uncertain—and the potential but still unknown size of benefits for the country from hydrogen cooperation with the EU in 10 to 20 years.

Potentially, a shift to renewable energy resources usage will decrease CO_2 emissions and will support the exports of goods produced in Ukraine after the introduction of the Carbon Border Adjusment Mechanism (CBAM). But again, the question is about the time lag. In terms of greater competitiveness in the context of the CBAM, the transition will affect the Ukrainian economy earlier than the benefits, which will kick in much later. In terms of economy, it is likely that hydrogen supplies will not compensate the losses from the natural gas transit and direct losses resulting from the CBAM, at least not by 2040.

It will be of the utmost importance for the EU to support Ukraine in its attempt to reshape its comprehensive strategic policy and roadmaps of energy transformation, including towards hydrogen economy

Aside from potential direct economic losses, financing both the post-war reconstruction and energy transition is also a challenge. What is clear is that Ukraine will be unable to finance all the necessary investments by itself, while the 1 billion US dollars earmarked within the Green Fund for Ukraine, which the US and Germany agreed to establish to support Ukraine's energy transition, will only amount to a small part of what is required—especially taking into account the post-war reconstruction needs. In comparison, in 2020 Ukraine's gas TSO earned more than 1.7 billion US dollars from gas transit, but these revenues will be declining.

Ukraine has great natural potential to produce hydrogen to cover its domestic needs in light of the energy transition and to export hydrogen to the EU. However, this prospect is seriously challenged by the lack of investment sources and the pre-war state's energy policy, which does not facilitate the development and modernisation of Ukraine's energy sector, first and foremost because of populism-driven efforts of overregulation. The current legal environment is also among the unfavourable conditions for investments in Ukraine and will have to undergo thorough transformation after the war.

Potentially, energy transition cooperation between the EU and Ukraine, including hydrogen transition, may bring fruitful results and real economic integration and convergence, contributing to Ukraine's economic reconstruction, stability and climate change mitigation. This, however, will require sustained efforts from both sides.

Ukraine is now fighting for its survival as a sovereign and independent nation and a viable state free to make its geopolitical and economic choices. After the war, there will have to be a period of rethinking old policies and developing new frameworks regarding hydrogen transition. Considering the EU's experience and leadership in energy transition, it will be of the utmost importance for the EU to support Ukraine in its attempt to reshape its comprehensive strategic policy and roadmaps of energy transformation, including towards hydrogen economy. In this context, priority should be given to supporting —both technologically and financially— Ukraine's economic reconstruction and energy sector's transition, not just to organising hydrogen supplies from Ukraine. This should include establishing a pilot project in Ukraine to produce low-carbon hydrogen and synthetic renewable hydrocarbons using this hydrogen.

Alongside this, it will be Ukraine's obligation to create a transparent, predictable and attractive business environment to attract and sustain investment flows, attract foreign businesses to launch commercial-scale hydrogen projects in Ukraine, and seek energy integration with the EU in a post-war and post-transition era. It must understand that competition from other regions will be tough, and some of those regions—such as MENA—might have just as strong a geopolitical, energy and climate security case for developing hydrogen cooperation with the EU as Ukraine. Next chapter of this report looks into the risks and opportunities related to hydrogen potential of MENA.

Energy transition cooperation between the EU and Ukraine, including hydrogen transition, may bring fruitful results and real economic integration and convergence, contributing to Ukraine's economic reconstruction, stability and climate change mitigation

4. The MENA's Allure

Pier Paolo Raimondi

The Mediterranean region may become one of the main hotspots for the hydrogen economy due to the complementary nature between the EU's green and technological ambitions and the great natural resource potential across the Middle East and North Africa. The MENA region is potentially well positioned to seize the opportunity of becoming a hydrogen supplier to Europe. It could produce and export both green and blue hydrogen at a competitive cost, given its great potential in renewable (i.e. solar and wind) energy as well as its large natural gas reserves and CCS potential. Hydrogen emerges as an enabler of plans to harness MENA renewable energy potential as well as gas reserves combined with CCS technology. Moreover, this could contribute to addressing socioeconomic concerns in these countries, as their economies heavily rely on oil rents.

Projects to import clean energy from the southern shore of the Mediterranean are not new in Europe. Since the early 2000s, various regional initiatives have been established to shape EuroMed energy relations with the aim to unlock the renewable energy potential in North Africa and export to Europe. With this goal, the Trans-Mediterranean Renewable Energy Cooperation (TREC) initiative was launched in 2003, which later evolved into the Desertec project between 2007 and 2009. Hydrogen adds new momentum to the idea. In supporting and investing in clean energy projects in the region, the EU could seize the opportunity to incentivise other countries to pursue decarbonisation, while enhancing its geopolitical projection in a key region that is witnessing growing influence from other countries, including China and Russia.

Hydrogen represents an opportunity for the MENA countries to renovate their geopolitical influence in the net zero-carbon future

Moreover, hydrogen represents an opportunity for the MENA countries to renovate their geopolitical influence in the net zero-carbon future. As energy transition poses an existential challenge to the current business model of oil-exporting countries, some of them are moving to find alternatives and adapt to the changing energy landscape.

For such reasons, both the hydrocarbon-rich and hydrocarbon-poor MENA countries have increasingly considered hydrogen projects. All the MENA countries hold favourable renewable energy conditions, with high solar irradiation and wind. Moreover, gas-rich countries are also considering blue hydrogen projects in order to exploit their vast gas resources. Some countries have announced major hydrogen plans: among them, three are oil exporters in the Gulf (Saudi Arabia, the United Arab Emirates and Oman) and one is a net importer in North Africa (Morocco).

The Mediterranean region may become one of the main hotspots for the hydrogen economy due to the complementary nature between the EU's green and technological ambitions and the great natural resource potential across the Middle East and North Africa

4.1. Plans and Potential

4.1.1. The Gulf

Despite being some of the largest hydrocarbon producers and exporters, the Gulf countries have started to consider plans to diversify their economies, reducing their dependence on oil rents and addressing the risks of climate change. For example, two of the main oil-producing countries made some quiet announcements a few weeks before COP26 in October 2021. The United Arab Emirates (UAE) announced its commitment to reach carbon neutrality by 2050.[83] A few days later, this was followed

83 Enerdata, "The United Arab Emirates targets carbon neutrality by 2050," Daily Energy News, 8 October 2021.

by a similar announcement by Saudi Arabia, the world's largest oil-exporting country, albeit with a little longer timeframe (2060).[84]

Saudi Arabia is working on both local production and export opportunities. In July 2020, it announced a 5-billion-dollar green hydrogen and green ammonia plant in Neom city, which should go online in 2025. The project, built by Air Products, Saudi ACWA and Neom, will be powered by over 4 GW of renewable power from solar and wind energy. Moreover, Saudi Arabia sent the world's first-ever blue ammonia shipment to Japan in September 2020. Despite the limited volume of the shipment (40 tons of blue ammonia), it certainly certified the Saudi commitment to seize the opportunity in the ongoing energy transition and not cede leadership to other players such as Australia, Chile and China. In April 2021, ENEOS and Saudi Aramco signed a memorandum of understanding (MoU) to develop a blue hydrogen and blue ammonia supply chain connecting Japan and Saudi Arabia. In the UAE, three state-run entities formed the Abu Dhabi Hydrogen Alliance to position the fossil fuel-rich emirate as a major exporter of green and blue hydrogen. Despite its green potential, the UAE also seeks to leverage its significant gas reserves to become a global key player in blue hydrogen. Oman announced the construction of a green hydrogen plant at the Duqm port, where a large export-focused refinery and petrochemicals facility are being developed. The state-owned Petroleum Development Oman is also looking to attract investments from Asian countries, notably Japan, suggesting that a portion of future output will likely be destined for exports to Asia.

> *Compared to the Gulf countries, North Africa holds some immediate competitive advantages to potentially export hydrogen to Europe: geographical vicinity and existing energy infrastructure*

Among these countries, Saudi Arabia and the UAE have the financial strength to boost hydrogen projects. For these countries, their significant financial resources represent a competitive advantage if coupled with low-cost gas reserves and high levels of solar irradiation. Compared to the Gulf countries, North Africa holds some immediate competitive advantages to potentially export hydrogen to Europe: geographical vicinity and existing energy infrastructure. Since transport costs can be significant with technological constraints, repurposed pipelines are the lowest-cost transport option for connecting hydrogen supply with import demand.[85]

4.1.2. North Africa

In North Africa, Morocco is commonly considered to be a hydrogen front runner. The country does not hold significant hydrocarbon reserves, but it set an ambitious renewable target of 52% of installed electricity capacity—corresponding to around 11 GW—by 2030.[86] The aim is to use its significant solar and wind potential in order to develop hydrogen. Morocco's authorities support the development of renewables as a potential way to decarbonise the country's energy mix (heavily reliant on coal), lessen its high import dependency and improve energy security (especially with regard to Algeria). Renewable energy sources could also contribute to the production and export of green hydrogen, which would allow Morocco to emerge as a relevant player in the clean energy arena. Morocco plans to devote two-thirds of its green hydrogen to exports. In June 2020, Germany signed an MoU with Morocco for the development of these hydrogen projects.

Other North African countries could evaluate hydrogen production to decarbonise domestically and become hydrogen suppliers to Europe and beyond. In this sense, two countries (Algeria and Libya) could decide to exploit some competitive advantages in order to supply hydrogen to Europe. Both of them hold significant gas reserves to produce and export blue hydrogen in the

> *Some European countries see the possibility to become a "hydrogen bridge" between the two Mediterranean shores*

84 "Saudi Arabia commits to net zero emissions by 2060," *BBC*, 23 October 2021.

85 Gniewomir Flis and Matthias Deutsch, *12 Insights on Hydrogen* (Berlin: Agorà Energiewende and Agorà Industry, November 2021).

86 "Morocco Renewable Energy Target 2030," Renewables Policies Database, IEA/IRENA, last updated 10 October 2019.

short and medium term. Algeria has already some experience with CO_2 sequestration in geological structures, especially in the In Salah project.[87] Moreover, they are also already connected to Europe through four pipelines: three from Algeria (Medgaz and GME to Spain and Enrico Mattei to Italy via Tunisia) and one from Libya (Greenstream directly to Italy). Hydrogen would allow these two countries to avoid the risk of seeing their gas reserves and infrastructure becoming stranded assets.

These energy interconnections would represent a pillar of the new European Hydrogen Backbone. Moreover, some European countries see the possibility to become a "hydrogen bridge" between the two Mediterranean shores. For example, Italy has expressed its intention to exploit its strategic position in the Mediterranean with this perspective. The country has identified hydrogen as an investment priority for its recovery plan. Moreover, it is on its way to present its hydrogen strategy, which will mobilise additional funding for hydrogen, some of which may be directed to overseas projects. Italy is willing to receive cheap hydrogen produced in low-cost RES countries in North Africa. Snam, an Italian energy infrastructure company, affirms that Italy could import hydrogen produced from solar energy in North Africa at a cost of 10–15% lower than domestic production.[88] To support potential developments in North Africa, Snam and Eni, a major Italian energy company, agreed to launch a partnership on gas pipelines between Algeria and Italy in November 2021.[89]

However, both Libya and Algeria face some challenges, albeit to a different extent. Libya has been war-torn for ten years and is currently more focused on revitalising its oil production. Algeria has experienced large protests since early 2019. Moreover, its gas export volumes are shrinking due to high domestic gas consumption and declining production.

Creating a hydrogen economy and international trade scheme requires large-scale investment and stable policy and regulatory frameworks. Thus, until the socio-political situation improves, such a major transformation, which requires significant political commitment and support as well as massive investments both from domestic and foreign entities, appears unlikely.

Other North African countries have started to investigate opportunities related to hydrogen. For example, Egypt is developing a hydrogen strategy. Due to a lack of existing pipelines, it will not be able to export hydrogen to Europe via pipeline, but it may be keener to pursue long-distance hydrogen export solutions, such as liquid hydrogen or ammonia, like those considered from the Gulf countries. Egypt can seek to produce both blue and green hydrogen thanks to its vast gas reserves and renewable potential thanks to excellent solar and wind resources in the Zaafarana region, along the western coast of the Gulf of Suez.[90] In 2021, Egypt signed a partnership with Eni to produce hydrogen.[91]

In short, the MENA countries may pursue different strategies targeting different export markets and providing different product solutions. North African countries may direct their hydrogen exports mostly to Europe due to their vicinity and existing infrastructure. However, the European preference for green hydrogen may discourage blue hydrogen exporters. The oil-rich Gulf countries may be able to export green hydrogen to Europe and blue hydrogen to Asian countries, which could accept the latter more easily—as Japan has announced.

Despite notable potential, the MENA countries' hydrogen ambitions may encounter some challenges, including water scarcity, limited renewable capacity, economic restrictions, as well as climate and environmental criteria

87 Luca Franza, *Clean Molecules across the Mediterranean: The Potential for North African Hydrogen Imports into Italy and the EU* (Rome: Istituto Affari Internazionali, April 2021).

88 Snam, "The Hydrogen Challenge: The potential of hydrogen in Italy," Position Paper, October 2019.

89 Snam, "Eni and Snam launch partnership on gas pipelines between Algeria and Italy," press release, 27 November 2021.

90 Franza, *Clean Molecules.*

91 ENI, "Eni signs an agreement to produce hydrogen in Egypt," press release, 8 July 2021.

4.2. Hydrogen as new oil

The MENA countries, especially the oil-producing countries, are looking for new sources of revenue for their socioeconomic model. As of today, they are heavily reliant on oil rents. With the expected oil demand peak, these countries face economic challenges in the long run. Hydrogen may represent one of the solutions to maintain a certain level of rents, while developing industrial capabilities and creating jobs—especially in those countries with growing and young populations. However, exporting hydrogen may not produce enough revenues for governments. For such reasons, these countries might decide to use renewable energy and hydrogen domestically for the production and export of intermediate and final carbon-intensive products, thereby creating more value.

Despite notable potential, the MENA countries' hydrogen ambitions may encounter some challenges, including water scarcity, limited renewable capacity, economic restrictions, as well as climate and environmental criteria.

The MENA countries suffer from serious water scarcity, which may penalise green hydrogen projects. Today's technology uses nine litres of water to produce 1 kg of hydrogen. To overcome it, countries could supply water through energy-intensive desalination plants. However, desalination plants are normally powered by fossil fuels in the MENA region. This would further increase energy consumption and simultaneously create higher emissions as well.

There is a growing investment gap between the northern and southern shores of the Mediterranean

Moreover, the MENA countries will need to dramatically increase their renewable energy capacity if they wish to become major green hydrogen players. To date, renewable energy has been deployed at a slow pace in the region despite the political ambition and renewable energy potential. Indeed, the deployment of RES in these countries still faces several barriers, such as fossil fuel subsidies (which contribute to negative fiscal consequences and wasteful energy consumption), regulatory barriers and limited financial resources, especially in the North African countries.

4.3. The EU's helping hand

Increasing renewable energy capacity in these countries requires massive political and financial effort. Such effort may be reduced by the negative economic and financial consequences of the COVID-19 pandemic and low oil prices, which have severely damaged these regional economies. On this issue, the EU needs to assist Mediterranean countries to develop low-carbon solutions, also in the hydrogen industry. Most of the MENA countries, excluding the Gulf monarchies, have limited financial resources.

There is a growing investment gap between the northern and southern shores of the Mediterranean. The investment gap to achieve the 2030 renewable energy targets in the southern Mediterranean area amounts to 16 billion dollars a year, about 30% more than the investment that was flowing into the region before the COVID-19 crisis.[92] The EU expressed its commitment to increase support for sustainable finance via the Neighbourhood, Development and International Cooperation Instrument (NDICI). The overall assistance to neighbouring countries has been increased by 25%, from 17 billion euros for 2014–20 to 22 billion euros for 2021–27. Over the previous period (2014–20), EU energy funding in the southern Mediterranean region was already devoted mostly to renewable energy and energy efficiency, with 15% of funding for gas infrastructure.[93] The EU's new Agenda for the Mediterranean clarified that the European Fund for Sustainable Development Plus (EFSD+), under the NDICI, will be the most important instrument of EU cooperation with its neighbours in the Mediterranean basin. All these instruments create opportunities to mobilise substantial economic resources in favour of energy and climate cooperation in the Mediterranean.[94] Moreover, the EU should also use its financial institutions and development investment banks (i.e. EIB and EBRD) to invest in the energy transformation of the MENA countries.

As Europe will need to import hydrogen, the EU needs to set regulatory standards for hydrogen

92 International Energy Agency, *Clean Energy Transitions in North Africa* (IEA Publications, October 2020).

93 Anna Herranz-Surrallés, "The Green Transition: A New and Shared Paradigm in the EU Partnership with the Southern Neighbourhood?" in *Mediterranean Yearbook 2021* (IEMed, 2021).

94 Luca Franza, "Greening the Mediterranean: Pathways for Sustainable Energy and Climate Cooperation," in *Climate Change and Sustainability: Mediterranean Perspectives* (Research Studies 6), A. Dessì, D. Fattibene, and F. Fusco (eds.) (Rome: Istituto Affari Internazionali, July 2021).

imports to conform to EU sustainability norms. The EU and MENA countries should work together to set and respect climate and sustainability standards for the new hydrogen trade.

For all these reasons, the energy transition and hydrogen could represent an opportunity for the EU to establish a new form of cooperation with the Mediterranean neighbourhood aligned with European climate ambitions. Through hydrogen, the EU and its southern neighbours can find new solutions that contribute to their clean energy transition, reduce global emissions, and foster sustainable growth and development, as highlighted by the EU Hydrogen Strategy.[95]

In the coming decade, the EU needs to set a positive environment for a new energy and climate cooperation with the MENA region, providing alternative sources of revenues for hydrocarbon-producing countries

In doing so, the EU could effectively handle and manage its transition both domestically and externally. Existing Euro-Med relations are rooted in fossil fuel energy. Without any serious and concrete plan, the EU may risk facing growing political instability in its southern neighbourhood on its way to become climate-neutral, since these countries rely heavily on hydrocarbon exports to Europe and rents.

In the coming decade, the EU needs to set a positive environment for a new energy and climate cooperation with the MENA region, providing alternative sources of revenues for hydrocarbon-producing countries. Indeed, EU natural gas imports are expected to fall significantly after 2030, decreasing by 58–67% compared to the 2015 levels.[96]

Hydrogen provides socioeconomic and energy alternatives for these countries, allowing the EU to efficiently manage the transition period and promote climate actions. Supporting low-carbon solutions (i.e. renewable and hydrogen), the EU could achieve multiple goals: achieving collectively and effectively a broader decarbonisation, ensuring cost-efficient clean energy imports, and contributing to the socioeconomic development of its neighbourhood regions, thus promoting stability and peace as well as limiting migration pressures. At the same time, the EU would also enhance its soft power and geopolitical footprint in these vital neighbourhood areas, which are strategically relevant for European countries and where other extra-EU countries are trying to increase their influence.

In pursuing new energy and climate cooperation with the MENA, the EU should avoid a regional approach, as the region is characterised by high heterogeneity. Individual EU member states, or a small group of them, should establish energy and climate ties with the MENA countries, as occurred with hydrocarbon trades.

Hydrogen is an opportunity for both shores of the Mediterranean, which might bring them even closer. The EU could enlarge its climate diplomacy in a key region while satisfying its needs for clean energy required to reach carbon neutrality. For their part, the MENA countries could seize this opportunity to position themselves on the new geopolitical map and find alternative revenue sources for their socioeconomic model. However, in order to do so, they will need to address environmental, energy and economic challenges.

Some of those challenges will be present in the Baltic area as well, just without the complications related to internal political stability and with the benefits of the regulatory environment inherent to EU member states. On the other hand, there are questions as to the extent to which the countries in this area can effectively cooperate to define and advance their common interests in hydrogen. Chapter 5 looks into the thinking, planning and actions of the three Baltic states and Finland.

Hydrogen is an opportunity for both shores of the Mediterranean, which might bring them even closer

95 European Commission, "Stepping up Europe's 2030 climate ambition: investing in a climate-neutral future for the benefit of our people," SWD/2020/176, 17 September 2020.

96 European Commission, "Stepping up Europe's 2030 climate ambition."

5. Finno-Baltic Realities

Tomas Janeliūnas

In the last couple of years, hydrogen energy has become the "new black" in terms of energy transformation and climate change. Lithuanian, Latvian and Finnish National Energy and Climate Plans 2030 (NECP 2030), prepared at the end of 2019, mention hydrogen only a few times as a very abstract future alternative. Only the Estonian NECP 2030 paid more attention to the development of hydrogen energy, stressing that "hydrogen could be one of the main options for storing renewable energy" and that "the transition to clean energy also requires the use of hydrogen from renewable energy in transport, buildings, and electricity generation, including making hydrogen also available to users".[97] Although Lithuania, Latvia, Finland and Estonia had joined the European Hydrogen Backbone Initiative already in September 2018, which has the objective of achieving the decarbonisation potential of hydrogen technology-based economic sectors, the energy system and the EU's long-term energy supply, only Estonia emphasised the importance of this initiative at the time, and in 2019 it already had a hydrogen working group set up by the Ministry of Environment.[98]

However, after the European Commission had issued its Hydrogen Strategy, things began evolving rapidly. Having in mind the EU's ambitious plans to transform and decarbonise energy systems in Europe, the Commission stated that the development of a hydrogen infrastructure is essential to reach carbon neutrality by 2050. So, firstly, the gas and electricity transmission systems operators (TSOs) in Finland and the Baltic states (hereafter this regional group is referred to as the Nordic-Baltic Four, NB4) started to look for their place in future EU hydrogen energy networks and to draft national roadmaps for hydrogen development. The Estonian TSO Elering and Finland's gas TSO Gasgrid joined the European Hydrogen Backbone (EHB) initiative, a group of European gas infrastructure companies working together to plan a pan-European dedicated hydrogen transport infrastructure.[99] In April 2021, an updated version of an EHB study was published and the proposed pan-European hydrogen pipeline transport network was significantly expanded, this time including the NB4 countries as well.[100] It was the involvement of Finland's Gasgrid and Estonia's Elering in this study that led to proposals for the development of pipelines connecting Finland and Poland via the Baltic states in the pan-European hydrogen network.

> *The experience in creating a common market for electricity or natural gas and the lingering distrust among the main energy actors in the Baltics raises doubts as to whether regional cooperation in hydrogen sector will be smooth*

Considering all the hype surrounding the transition towards hydrogen being a critical part of the decarbonised economy, it is no surprise that energy companies and governmental institutions in the Baltic states have also paid more attention to this sector. Besides the zero-emission goals that hydrogen development would help to achieve, the issue of energy security is also significant for the Baltic states. The production of hydrogen as an energy carrier could transform the existing energy dependence pattern. The Baltic states, dependent on fossil fuels for many years, would be able to bring an end to this arrangement. The envisaged role of the Baltic states as potential producers and exporters of hydrogen to the EU markets and the attraction of EU financial support also contributes to the optimism of the Baltic energy actors about this topic. However, these visions for the development of hydrogen infrastructure in the NB4 are still tentative and distant. The common gas market between the NB4 countries has still not been completed, and despite the rapid development of gas networks, various tensions are arising

97 European Commission, "Estonia's 2030 National Energy and Climate Plan (NECP 2030)," 19 December 2019.

98 Federal Ministry of Sustainability and Tourism of Austria, "The Hydrogen Initiative," 17-18 September 2018.

99 "European Hydrogen Backbone," Gas for Climate, last accessed 26 April 2022.

100 Creos, et al, *Extending the European Hydrogen Backbone*.

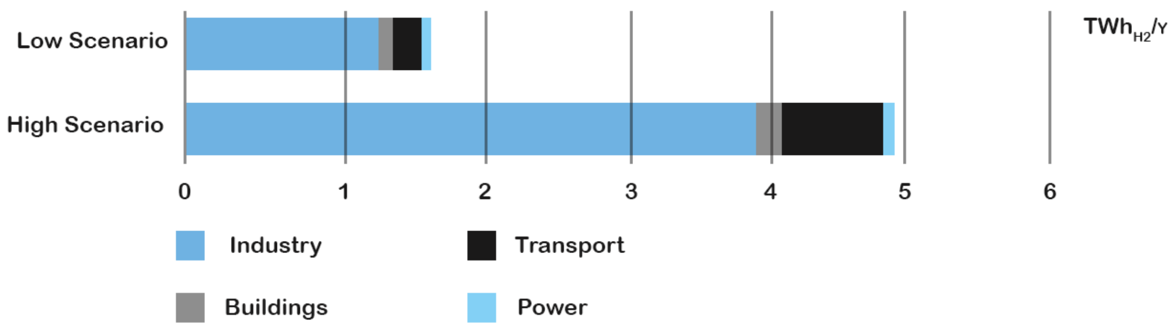

Figure 1. Estimated renewable/low-carbon* hydrogen demand for Finland by 2030
Source: Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU), Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans (Rotterdam: Trinomics B.V., 2020).
** Produced by steam methane reforming combined with CCS technology (also referred to as "blue hydrogen")*

even between Finland, Estonia and Latvia. The experience in creating a common market for electricity or natural gas and the lingering distrust among the main energy actors in the Baltics raises doubts as to whether regional cooperation in hydrogen sector will be smooth.

At the same time, the need for regional cooperation is constantly emphasised in political statements and EU-level documents. Therefore, an imperative to seek regional cooperation, and to increase the connectivity and integration of the Baltic states into EU energy markets, is generally understood. On the other hand, practical cooperation is often based on an exclusively financial argument: preferable access to EU funding for regional projects. In other cases, where there is no immediate and tangible prospect of EU funding, all countries tend to forget the long-term benefits of cooperation. This chapter will look at the factors that encourage or hinder the Baltic states and Finland as they seek to accelerate the development of a common vision for hydrogen energy in the region and beyond.

> *Finland was one of the first EU member states to set more ambitious national climate targets than the EU level and introduce a carbon tax scheme*

5.1. Visions and current progress

5.1.1. Finland

Finland was one of the first EU member states to set more ambitious national climate targets than the EU level and introduce a carbon tax scheme. Finland is also one of the regional front runners of hydrogen application in the energy system.[101] The country has a strong tradition in the industrial use of hydrogen (generated from gas), and there are some Finnish companies that already form a complete hydrogen value chain consisting of four parts: production, storage, distribution and utilisation.

The first unofficial Finnish hydrogen roadmap had already been prepared in 2013,[102] and although there is no governmental-level strategy for hydrogen, several industrial sectors have prepared their own roadmaps. The latest versions of a national roadmap, prepared by Business Finland, appeared in 2020.[103] In December 2020, Finland joined the European Clean Hydrogen Alliance, and Gasgrid joined the European Hydrogen Backbone initiative contributing to the expansion of the proposed future hydrogen network for Europe.[104]

Overall, Finland has a legal framework that reflects the integration of hydrogen into the energy system. Although Finland is not directly addressing hydrogen in its NECP, several generic targets and measures are mentioned (e.g. in transport and industry) that should indirectly stimulate the deployment and use of renewable hydrogen.[105] Unlike the NECP, the government's report

101 Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU), "Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans in Finland," 2020.

102 Pertti Kauranen et al., *Vetytiekartta - Vetyenergian mahdollisuudet Suomelle* [Hydrogen Road Map - Hydrogen Energy Opportunities for Finland] (Tampere & Espoo: VTT, 2013).

103 Business Finland, "National Hydrogen Roadmap for Finland," 2020.

104 Creos, et al, *Extending the European Hydrogen Backbone*.

105 European Commission, "Finland's Integrated Energy and Climate Plan," 2019.

on the National Energy and Climate Strategy for 2030 explicitly refers to hydrogen, though mostly in the context of renewable transport fuels and hydrogen-powered vehicles.[106]

In August 2020, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), in close cooperation with the European Commission (DG Energy), commissioned a study entitled "Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans."[107] The study is the first attempt to provide a comparative overview of all EU countries with regard to potential hydrogen needs by 2030. According to the study, renewable hydrogen in Finland could account for 1.4 TWh per year (or 0.6% of final total energy demand), in a low scenario, to 4.8 TWh per year (or 2% of final total energy demand), in a high scenario (see Figure 1).

Finland has the biggest potential demand for green hydrogen compared with the three Baltic states and is a regional front runner in planning future production, transportation and use of hydrogen in national energy

Some hydrogen-oriented initiatives and projects are being carried out already. In its Sustainable Growth Programme, the Finnish government has allocated 150 million euros in public funding to projects related to hydrogen technology and carbon capture and utilisation.[108] The projects will support the objective of the government to achieve a carbon-neutral Finland by 2035.

There is no dedicated hydrogen pipeline infrastructure in Finland, except for smaller pipelines in industrial complexes. However, as the use of natural gas in Finland has decreased by 50% during the last 15 years, part of the natural gas transmission pipelines, according to the National Hydrogen Roadmap, could be repurposed for hydrogen transport in future. With regard to the utilisation of hydrogen, the roadmap has so far singled out its use only to meet internal market demand. Low-carbon hydrogen production is not yet sufficient for export. However, if the production of hydrogen grows, there will be a significant potential for Finland to become a hydrogen exporter (assuming that domestic demand for hydrogen will increase incrementally).

By 2030, according to Gasgrid's vision, the Finnish hydrogen network could first develop hydrogen valleys in the south and south-west of Finland, and in the north-west with an interconnector to Sweden creating a Finnish-Swedish hydrogen market. At a later stage, by 2035, a possible dedicated subsea interconnector to Estonia could connect Finland to the Baltics and to potential demand markets in Central, Northern and Eastern Europe.[109] On the other hand, according to some reports and the Finnish Hydrogen Cluster White Paper, the potential of hydrogen economy has not yet been fully realised and defined appropriately in Finnish energy regulation.[110]

In late 2021, Gasgrid presented an updated vision on hydrogen development in Finland.[111] The vision suggested that Finland, possessing a green hydrogen supply potential of about 50 TWh per year by 2030 and already having 20 GW of onshore wind installation under development (with an additional 90 GW of grid applications received), could become a very competitive option to supply hydrogen for Germany. It projected that by 2030 Germany could be in a substantial hydrogen deficit reaching about 70 TWh (i.e. an approximate 4 billion euros market, assuming hydrogen's lower heating value and price of 2 euros/kg). Gasgrid concluded that Finland could meet its own hydrogen needs and potentially export to other countries already by 2030. However, a clear transfer model and new, dedicated transit pipelines are needed. In Gasgrid's current projections, only Estonia is included as a potential partner in the hydrogen export value chain.

106 Ministry of Economic Affairs and Employment of Finland, "Government's report on the National Energy and Climate Strategy for 2030," 2017.

107 Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU), *Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans* (Rotterdam: Trinomics B.V., 2020).

108 Ministry of Economic Affairs and Employment of Finland, "Business Finland to accept applications on hydrogen projects as part of the Sustainable Growth Programme," Prime Minister's Office press releases and news, 16 June 2021.

109 Creos, et al, *Extending the European Hydrogen Backbone*.

110 H2 Cluster Finland, "A systemic view on the Finnish hydrogen economy today and in 2030 – Our common playbook for the way forward," Hydrogen Cluster Finland White Paper, 2021.

111 Gasgrid, "Hydrogen potential in Finland 2021," December 2021, https://gasgrid.fi/wp-content/uploads/Gasgrid_Study-on-the-Potential-of-Hydrogen-Economy-in-Finland_ENG-FINAL.pdf.

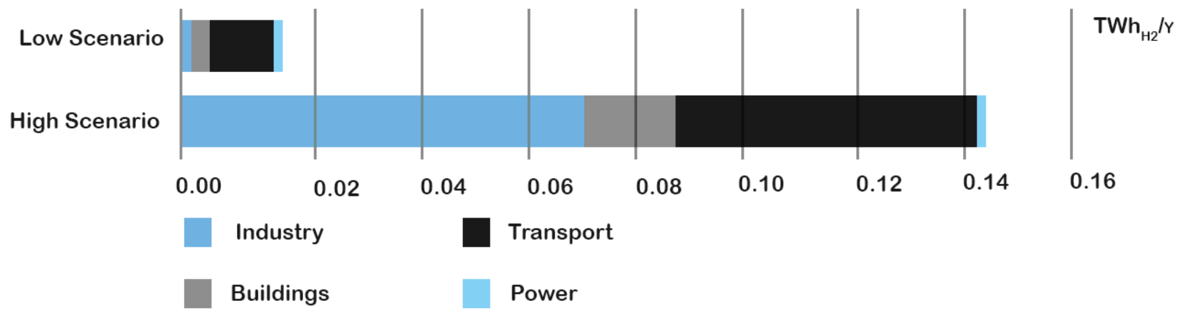

Figure 2. Estimated renewable/low-carbon hydrogen demand in Estonia by 2030

Source: Fuel Cells and Hydrogen 2 Joint Undertaking (FC J2HU), Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans (Rotterdam: Trinomics B.V., 2020).

To sum up, Finland has the biggest potential demand for green hydrogen compared with the three Baltic states and is a regional front runner in planning future production, transportation and use of hydrogen in national energy. The main driver for hydrogen production development would be an attractive German market. However, the National Hydrogen Roadmap and other analyses do not project a specific cooperation with the Baltic states in enhancing a regional hydrogen value chain or exploiting benefits of the common gas market for more effective transportation of hydrogen.

5.1.2. Estonia

Estonia has taken several strategic steps to support the use and deployment of hydrogen in recent years. There is a clear perception that "[t]he use of hydrogen in different sectors of the economy offers the most efficient possibility for moving towards a low-carbon economy" in Estonia.[112] Hydrogen is mentioned in the Estonian NECP 2030 in more detail than in the Latvian and Lithuanian NECPs. Though the Estonian NECP still does not contain any specific objectives or targets for the production or use of hydrogen, the NECP does indicate that the replacement of fossil fuels by renewable hydrogen could contribute to ensure Estonia's 2030 target for greenhouse gas emissions.[113] Estonia also joined the EHB initiative in September 2018.[114] Estonian electricity and gas TSO, Elering, actively participated in the EHB initiative and contributed to the expanded version of the hydrogen network for Europe.[115]

The legal framework that would increase and support the potential for the use of hydrogen in Estonia is still under preparation, and Estonia has just started to prepare an institutional framework, setting up a hydrogen working group within the Ministry of Environment. The main aim of the working group is to analyse the deployment of hydrogen and fuel cell applications in the Estonian energy system. Its first task is to issue a hydrogen roadmap for Estonia. The next steps will more specifically address policy and technical measures.[116]

The development of a national hydrogen strategy and pilot project is one of the priorities mentioned in the 100-day action plan approved by the Estonian government in February 2021.[117] According to the plan, 50 million euros from the EU's Recovery and Resilience Fund, directed to promote the deployment of integrated hydrogen technologies, will play an important role in accelerating the uptake of hydrogen.

Recently, there has been a significant rise in hydrogen initiatives in Estonia

Several feasibility studies have already been conducted to investigate potential hydrogen projects and the role of hydrogen in the national energy and climate plans.[118] Most of

112 European Commission, "Estonia's 2030 National Energy and Climate Plan (NEPC 2030)," 2019.

113 Ibid.

114 The Hydrogen Initiative, 2018.

115 Creos, et al, *Extending the European Hydrogen Backbone*.

116 Ain Laidoja, "Estonia's task-force for the adoption of Hydrogen Technologies," Next Generation Energy Technologies, 25 October 2019.

117 Office of Prime Minister of Estonia, "The government of Kaja Kallas approved the 100-day plan," press release, 11 February 2021.

118 For example, Fuel Cells and Hydrogen 2 Joint Undertaking, *Opportunities for Hydrogen Energy Technologies*; Civitta Eesti AS, the Tallinn Center of the Stockholm Environmental Institute (SEI), the Institute of Chemical and Biological Physics, "Analysis of the Hydrogen Resources Usage in Estonia," 2021.

these studies mainly assess Estonia's ability to produce and use hydrogen for its own needs and focus mainly on the identification of the most hydrogen-friendly sectors in Estonia. According to an analysis of the use of hydrogen resources in Estonia, the area with the greatest potential for the use of hydrogen is the transport sector, especially road and rail transport.[119]

The FCH JU study "Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans" concludes that by 2030 Estonia's green hydrogen demand could reach 0.02 TWh per year (or 0.05% of final total energy demand), in a low scenario, to 0.1 TWh per year (or 0.5% of final total energy demand), in a high scenario (see Figure 2).

In the EHB study, Elering presented a rather optimistic scenario for the development of green hydrogen and its export. This optimism stems from the potential increase of renewable energy production in Estonia by 2030. Consequently, renewable energy oversupply could open a possibility to export green hydrogen to Central Europe with an offshore pipeline by 2035.[120] Moreover, it is projected that "Estonia could also act as a transit corridor for hydrogen that would be produced in Finland."[121]

Recently, there has been a significant rise in hydrogen initiatives in Estonia. The Estonian Association of Hydrogen Technologies (established in 2016) organised a huge public event, the Estonian Hydrogen Days 2021; several municipal-level hydrogen hubs and valleys (e.g. Keila and Paldiski) are being planned and hydrogen clusters are being created. However, according to the study on hydrogen resource usage in Estonia, legislative, financial and communicative support is still needed for more effective cooperation between these actors.[122]

Latvia does not have a framework for the deployment and use of hydrogen

Looking at Estonia's legal framework, its existing energy infrastructure, as well as its projected surplus of renewable energy and the active role of Estonia's TSO in advocating hydrogen policy, Estonia looks set to become a regional hub of hydrogen production, export and transit. However, it seems that this vision is not yet clearly shared with the other Baltic partners, who are mostly oriented inwards when it comes to the development of hydrogen infrastructure. Estonia's intention to invest in hydrogen production and promote exports may be constrained if its neighbouring countries seek to develop only short hydrogen supply chains oriented towards domestic demand.

5.1.3. Latvia

The NECP of Latvia 2021–2030 describes hydrogen as a "future alternative fuel to replace petroleum products".[123] However, this brief reference to hydrogen is practically all that Latvian official documents reveal about Latvia's strategic vision on hydrogen policy. Latvia does not have a framework for the deployment and use of hydrogen and, according to some representatives of the energy sector, the Latvian government has not yet started the process of drafting a hydrogen roadmap or strategy. Its NECP refers to transport only, without specific objectives or measures. Consequently, Latvia does not yet have a clearly formulated vision on the domestic hydrogen value chain, not to mention its role in a potential regional cooperation on the issue.

The most significant opportunities for the deployment of hydrogen in Latvia are identified in the transport sector, where hydrogen could play a role in the decarbonisation of rail and road transport

This can partly be explained by a low demand for hydrogen projected for Latvia. According to the FCH JU study, by 2030 Latvia's green hydrogen demand could reach 0.05 TWh per year (or 0.1% of final total energy demand), in a low scenario, to 0.2 TWh per year (or 0.5% of final total energy demand), in a high scenario (see Figure 3).

119 Civitta Eesti AS et al, "Analysis of the Hydrogen Resources Usage in Estonia."

120 Creos, et al, *Extending the European Hydrogen Backbone*.

121 Ibid.

122 Civitta Eesti AS et al, "Analysis of the Hydrogen Resources Usage in Estonia."

123 European Commission, "The National Energy and Climate Plan of Latvia 2021-2030," 2018.

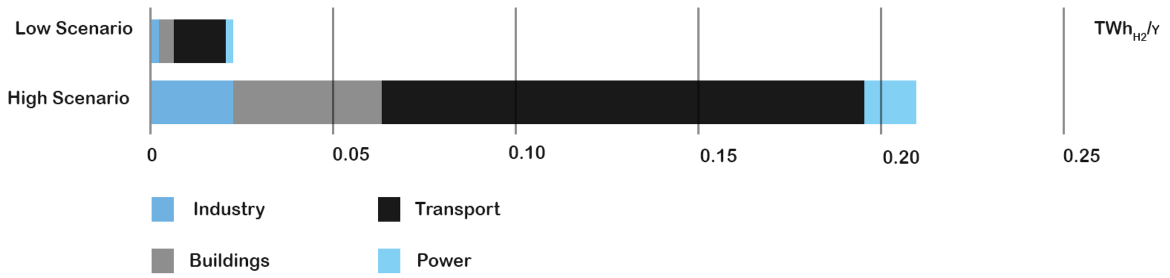

Figure 3. Estimated renewable/low-carbon hydrogen demand for Latvia by 2030
Source: Fuel Cells and Hydrogen 2 Joint Undertaking (FC J2HU), Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans (Rotterdam: Trinomics B.V., 2020).

The most significant opportunities for the deployment of hydrogen in Latvia are identified in the transport sector, where hydrogen could play a role in the decarbonisation of rail and road transport. The rail sector in Latvia is one of the most fossil fuels dependent in Europe, with fossil fuels accounting for 93% of the sector's energy use. Although less so, the Latvian road transport sector is still heavily dependent on fossil fuels. Therefore, hydrogen could play a role in the decarbonisation of this sector, especially in segments like heavy-duty transport, where electrification is challenging.[124]

Latvia has an extensive central natural gas transportation grid connected to neighbouring countries—Estonia, Lithuania and Russia, enabling additional hydrogen transportation within Latvia and the potential to export hydrogen.[125] However, the export or transit of hydrogen remains more a theoretical possibility for the moment. To enable the commercial transportation of hydrogen via gas networks in Latvia, the allowed threshold of hydrogen needs to be increased from 0.1% to 10-20% in the gas mix.[126] Therefore, a substantial part of the Latvian natural gas network would require additional investment.

It is worth mentioning that Latvia's Inčukalns underground gas storage (UGS) facility is the only functional storage in the Baltic countries, with an overall capacity of 4.47 bcm of natural gas. The Inčukalns UGS is currently being modernised, with the aim of preparing the storage functionality for higher pressure in the Baltic transmission system, enabling the extraction of compression gas with a capacity of 12–15 million cubic metres per day and injection with a capacity of 4–6 million cubic metres per day. The modernisation of the Inčukalns UGS is also directed at reducing the dependence of gas storage removal capacity on the amount of gas in storage. Research is currently underway to determine whether the Inčukalns UGS can be used for hydrogen storage in the future.[127]

Although Latvia's existing gas infrastructure could be used for hydrogen transportation and storage going forward, Latvia has made little progress in this area so far. Latvians seems to consider hydrogen applications only as a long-term perspective. There is still a lack of detailed research and studies identifying Latvia's role in the potential regional hydrogen market.

5.1.4. Lithuania

Lithuania's potential demand for hydrogen could be much higher than in Latvia or Estonia, as Lithuania has several industrial facilities that already use hydrogen, the largest of which are the fertiliser producer Achema and the only oil refinery in the Baltic states, Orlen Lietuva. However, almost all of its hydrogen is still produced from fossil fuels (natural gas or dehexanised naphtha) without carbon capture.

Lithuania's potential demand for hydrogen could be much higher than in Latvia or Estonia, as Lithuania has several industrial facilities that already use hydrogen

Achema is the largest hydrogen producing company in Lithuania, as it needs hydrogen for ammonia production, it being the major ingredient in most kinds of fertiliser. Achema

124 Fuel Cells and Hydrogen 2 Joint Undertaking, *Opportunities for Hydrogen Energy Technologies*.
125 J. Kleperis, D. Boss, A. Mezulis, L. Zemite, P. Lesnicenoks, A. Knoks, and I. Dimanta, "Analysis of the Role of the Latvian Natural Gas Network for the Use of Future Energy Systems: Hydrogen from RES," *Latvian Journal of Physics and Technical Sciences*, No 3, 2021.
126 Ibid., 217.
127 Ibid., 220-223.

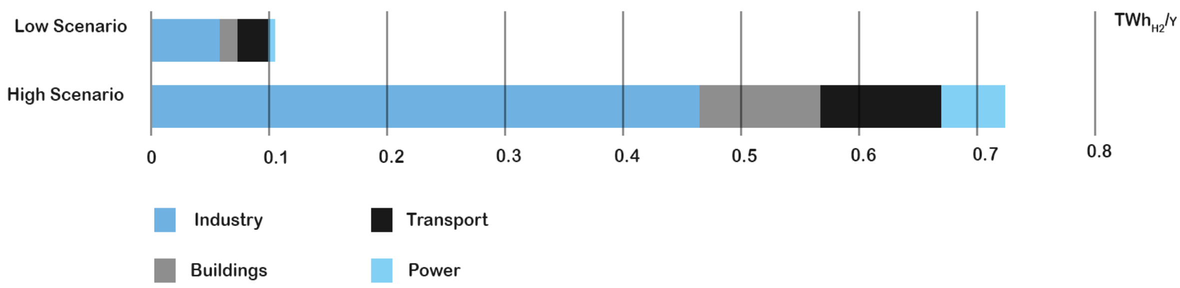

Figure 4. Estimated renewable/low-carbon hydrogen demand for Lithuania by 2030
Source: Fuel Cells and Hydrogen 2 Joint Undertaking (FC J2HU), Opportunities for Hydrogen Energy Technologies Considering the National Energy & Climate Plans (Rotterdam: Trinomics B.V., 2020).

has two steam methane reforming (SMR) facilities with an installed capacity of 275 tons of hydrogen per day. In 2020, Achema produced about 178 kt of hydrogen.[128] However, it means that Achema's hydrogen production ends up with approximately 200 kt of annual CO_2 emissions, excluding quantities dedicated to carbon utilisation.

Achema and Orlen Lietuva are the two biggest CO_2-emitting companies in Lithuania: in 2019, according to the Environmental Projects Management Agency of Lithuania, Achema's verified emissions were 2.486 Mt and Olen Lietuva's, 1.599 Mt. Emissions from these two companies alone constitute almost 70% of all industrial emissions in Lithuania (in 2019, the total emissions of Lithuanian industry were 5.853 Mt).[129] Replacing the currently produced grey hydrogen with green, hydrogen would require at least 9.35 TWh of renewable electricity (at 80% average efficiency of electrolysis) for Achema alone.[130] This is about three times Lithuania's current renewable electricity generation.

However, the current National Energy Independence Strategy and NECP do not envisage a significant surplus of renewable electricity generation that could be used for hydrogen generation. Major wind and solar power projects, including 0.7 GW offshore wind parks in the Baltic Sea, are planned to be completed by 2030. According to the current National Energy Independence Strategy, Lithuania could become self-sufficient in electricity generation only by 2050, when all electricity ought to be produced from renewables. According to the FCH JU study, by 2030 Lithuania's green hydrogen demand could reach 0.1 TWh per year (or 0.2% of final total energy demand), in a low scenario, to 0.7 TWh per year (or 1.5% of final total energy demand), in a high scenario. Both scenarios assume that in 2030 renewable hydrogen will be provided to partially substitute current conventional production and to cover additional demand, e.g. from the transport sector (see Figure 4).

Lithuania has not developed a national hydrogen roadmap yet. However, as the Minister of Energy of Lithuania Dainius Kreivys confirmed, a call has been announced to prepare a detailed study for the development of hydrogen.[131] According to Žilvinas Danys, Head of Innovations and International Cooperation Group at the Ministry of Energy, the study is expected to provide a specific roadmap for hydrogen development that could be transformed into strategic national-level programmes. The hydrogen roadmap is expected to be completed in the second quarter of 2022.[132] It is possible that in 2022 the Ministry of Energy will prepare an updated version of the National Energy Independence Strategy and will bring it to Parliament for consideration.

Until now, Lithuania has made little progress in green hydrogen production and practical development projects

Until now, Lithuania has made little progress in green hydrogen production and practical development projects. So far, there are no

128 Jurgita Šilinskaitė-Venslovienė, *Development of Hydrogen Value Chain*, Capstone Project (Kaunas: Baltic Management Institute, Vytautas Magnus University, 2021), 26.

129 APVA, "Atsiskaitymas už 2019 m. patvirtintą išmetamųjų šiltnamio efektą sukeliančių dujų kiekį [Settlement of 2019 certified greenhouse gas emissions]," 2020.

130 Šilinskaitė-Venslovienė, *Development of Hydrogen Value Chain*, 26.

131 Personal interview with Dainius Kreivys, 9 September 2021.

132 Personal interview with Žilvinas Danys, 16 September 2021.

hydrogen stations in Lithuania, only some demo-projects prepared by the Lithuanian Energy Institute. The first commercial project for the production of green hydrogen using "power to gas" (P2G) technology is expected to be finalised by 2024, when the first green hydrogen should be injected into gas pipelines.[133] There are pilot projects where public transport buses use a gas mixture to which 10% hydrogen is added.

On 30 November 2020, the Lithuanian Hydrogen Platform was established, which currently includes 36 businesses and state institutions.[134] According to Žilvinas Danys, the meetings of the Hydrogen Platform help to refine the Lithuanian hydrogen value chain and to select specific areas where Lithuania should develop its hydrogen infrastructure. As officials of the Ministry of Energy mentioned, Lithuania intends to support only the development of green hydrogen.[135] The interest of the platform participants in the development of hydrogen is growing significantly, although so far there is no clear vision of Lithuania's place in the entire EU hydrogen network. Although Lithuania has the potential to export gas, as well as hydrogen (through its LNG terminal in Klaipėda and GIPL connection with Poland from 2022), Lithuanian energy policy does not yet focus on hydrogen exports. As Žilvinas Danys pointed out, it is first necessary to build an initial hydrogen production capacity in Lithuania.[136]Lithuania seeks to use a significant part of the funds provided under the European Commission's Recovery and Resilience Facility (RRF) for green transformation. The main reforms and investment directions chosen by the Ministry of Energy are the development of renewable energy sources in the electricity generation sector and the transformation of the green transport sector. More than 30 million euros is tentatively earmarked for the development of a mechanism to promote the production of green hydrogen and its transmission to natural gas networks, as well as hydrogen technologies and applications.[137] Additionally, about 270 million euros has been requested from the EU Modernisation Fund (the EU programme intended to support ten member states to meet 2030 energy targets by helping them to modernise energy systems and improve energy efficiency).[138]

Lithuania officially supports the regional gas (and potentially hydrogen) market between the Baltic states and Finland, and welcomes cooperation in the development of hydrogen infrastructure. In September 2021, the gas TSOs of Finland and the Baltic states, including Lithuania, finally reached a compromise on the conditions for Lithuania to join the FINESTLAT gas market—according to unofficial sources, the TSOs agreed on an inter-transmission system operator compensation (ITC) mechanism whereby a discount of 75% would be applied at Klaipėda's LNG terminal entry point. Lithuania should join the market by 1 January 2023, after all the political and technical regulations have been adopted.

However, at the same time, Lithuania's politicians believe that there is much more potential in cooperation with Poland. The disagreements between the Baltic countries over the completion of the common gas market and conflicts over the methodology on electricity trade with third countries in recent years contrast sharply with the "extremely warm and friendly relations" between the officials of Lithuanian and Polish energy sectors.[139] One of the red lines for Lithuania's gas TSO to join the FINESTLAT tariff zone was that such an agreement should not hinder its future integration with the Polish gas market. It could be said that Lithuania is politically drifting fast towards Poland and also tends towards creating a common gas market with Poland. It is still unclear how this would affect the FINESTLAT+LIT gas market development.

5.2. Regional cooperation: trends and obstacles

Regional cooperation in the field of hydrogen development is directly related to the creation of a common gas market between Finland and the Baltic states. In the initial phase, hydrogen transportation would most likely take place using existing pipeline infrastructure (injecting 10–20% hydrogen into the gas mix). Therefore, the functioning of the single gas market, in terms of tariffs, regulatory and technical standards, as well as the guarantee of origin (GO) system, would significantly facilitate cooperation in the development of hydrogen at a regional level.

133 "Lietuvoje pradedamas pirmasis žaliojo vandenilio gamybos projektas [The first green hydrogen production project is launched in Lithuania]," *LRT*, 21 June 2021.

134 "Hydrogen Platform," Sectoral Policy, Ministry of Energy of Lithuania, last updated 8 December 2020.

135 Personal interview with Žilvinas Danys.

136 Personal interview with Žilvinas Danys.

137 Office of the Government of Lithuania, "Aptartos priemonės vandenilio technologijų plėtrai šalyje paspartinti [Measures to accelerate the development of hydrogen technologies in the country are discussed]," press release, 2 March 2021.

138 Interview with Žilvinas Danys.

139 Interview with Dainius Kreivys.

	Finland	Estonia	Latvia	Lithuania
National roadmap	Yes	Under preparation	No	Expected in 2022
Potential demand for hydrogen (min-max scenarios, according to FCH JU, 2020)	1.4–4.8 TWh/y	0.02–0.1 TWh/y	0.05–0.2 TWh/y	0.1–0.7 TWh/y
Main sectors of hydrogen demand	Industry	Transport	Transport	Industry
Domestic vs regional orientation	Domestic	Regional	Ambivalent	Domestic
Potential import or export demand (2030–40)	Export	Export	Ambivalent	Import
Benefits of regional infrastructure	Balticconnector	Balticconnector	Inčukalns UGS	LNG terminal, GIPL connection (2022)

Table 1. Comparing the hydrogen development visions and prospects

Since 2017, Finland and the Baltic states have been working towards integrating the gas markets of the four countries. In spring 2019, the Finnish, Estonian and Latvian TSOs signed a tariff agreement, under which Finland, Estonia

Regional cooperation in the field of hydrogen development is directly related to the creation of a common gas market between Finland and the Baltic states

and Latvia formed a regional tariff zone from the beginning of 2020. The agreement removed cross-border transmission tariffs between the countries and harmonised the entry point tariffs on the external borders, while Estonia and Latvia formed a unified balancing area.[140] Although there were some delays (the final parts of the project were finalised in June 2021), the completed Balticconnector project has physically connected the Finland and Baltic gas networks since January 2020. However, the gas market is not yet functioning smoothly. For example, the Finns were dissatisfied with the delayed launching of the Puiatu and the Paldiski compressor stations in Estonia, which prevented the smooth allocation of Balticconnector capacities in 2021. All final projects were completed only by 16 June, 2021, allowing for the utilisation of the Balticconnector's designed capacity. However, as some representatives of the sector explained, there are still no clear capacity-allocation rules for the Balticconnector.Although Lithuania actively participated in negotiations on participation in the common gas market between Finland and the Baltic states, it refused to join the common tariff zone until 2021, the main issue being that Lithuania is seeking to obtain a special clause regarding common tariffs for its LNG terminal as an entry point for the Finnish and Baltic markets. Lithuanian representatives claim that it would be unfair for Lithuania alone to bear the operating costs of the LNG terminal, although its benefits (as the only real alternative to Gazprom gas so far) would be enjoyed by all gas consumers in the region. Nevertheless, there is unofficial information that recent negotiations among regional TSOs were completed, and Lithuania should join the gas tariff zone from 1 January 2023.

Lithuania's importance in the regional gas market will increase even more when the Lithuanian-Polish connection GIPL starts operating in 2022. This pipeline has the potential to connect Finland and the Baltic states to the entire EU gas network and possibly allow them to become important hydrogen transit countries in the future.

Despite the uncertainties in political negotiations, the Finnish and Baltic TSOs are accelerating cooperation in the field of hydrogen

Despite the uncertainties in political negotiations, the Finnish and Baltic TSOs are accelerating cooperation in the field of hydrogen. In September 2021, the TSOs of

140 "Gas market integration," Gas Market, Gasgrid, last accessed 20 September 2021.

Finland, Estonia, Latvia and Lithuania signed a MoU on promoting the development of green gases, including renewable hydrogen. As stated in the public announcements, the TSOs intend to cooperate in joint research regarding possible gas transmission infrastructure decarbonisation solutions, the integration of green gas solutions into existing infrastructure, the development of new infrastructure (when current infrastructure cannot ensure the technical requirements of green gases), cross-sectoral integration, other technological processes, and pilot projects.[141]

The first step is to produce a regional study on hydrogen development seeking to identify required technical modifications and estimate related investments. The feasibility study is expected to be completed by 2023.[142] Also, TSOs are working on steps required for the regional recognition of GOs: on the harmonisation of rules for issuing GOs; preparing proposals for relevant national legislative changes; and starting national registries of GOs.[143]

Formally, the Lithuanian TSO Amber Grid is positive about the common Finnish-Baltic gas market: the company's latest strategy for 2030 states that a single Lithuania-Latvia-Estonia-Finland tariff area should be formed, "which at a later stage will be expanded by agreements with Poland and the development of integration solutions common to all countries".[144] Also, it is foreseen that, "in 2024, [there should be] possibilities for trade in guarantees of origin of biomethane among the aforementioned countries. In the long run, a single system guarantees [that] European origin green gas (including hydrogen) will operate".[145]

Regional cooperation in the electricity sector is far from smooth. For example, the Baltic countries have not agreed on a common test for an autonomous electricity grid. Instead, an emergency connection test of the Lithuanian electricity system to the Polish system was planned for the beginning of December 2021. This is another sign that the Lithuanian energy system is increasingly gravitating towards Poland rather than integrating with its Baltic neighbours.

On the other hand, Latvia and Estonia are accelerating bilateral cooperation in renewable electricity generation, which may also be important in planning future hydrogen production in the region. In 2020, the ministers of economy of Latvia and Estonia signed a memorandum of understanding, which foresaw the development of offshore wind parks in the Baltic Sea within the Estonian and Latvian exclusive economic zones. An offshore wind farm is planned with a total capacity of up to 1000 MW, which is envisaged to provide over 3 TWh of renewables-based energy per year. The project, called ELWIND, is expected to be completed by 2030. In September 2021, a public procurement for a pre-feasibility study, aiming to preselect suitable geographical areas for the construction of the wind farm, was completed ahead of time. Estonia and Latvia are planning to apply for co-financing for the construction of the grid from the Connecting Europe Facility of Renewable Energy funds, as the ELWIND project involves two countries and could be qualified as a regional status project.[146]

In the existing or forthcoming national hydrogen roadmaps, the regional perspective is almost ignored

Besides the incomplete regional gas market and some problematic coordination between the three Baltic countries in the electricity sector (including common rules of trade with third countries and preparations for synchronisation with the EU electricity grid), there are more obstacles to planning regional hydrogen value chain development.

First, the current cost of green hydrogen production is so high that only minimal demonstration projects are offered for investment. Most studies suggest that the cost of producing hydrogen should be equal to the cost of natural gas (plus the cost of emission permits), and only then can hydrogen become commercially attractive. Alternatively, hydrogen development would be motivated only by political goals to achieve decarbonisation targets (and therefore, sensitive to EU or national support schemes).

Second, the current development of renewable energy sources (solar and wind) in the Baltic states promises large-scale generation of green hydrogen only after 2030. Such a long-term perspective hinders the planning of

141 "Baltic, Finnish gas TSOs sign memorandum on promoting development of green gases," *The Baltic Times*, 14 September 2021.

142 Personal interview with a representative of Amber Grid, 7 October 2021.

143 Amber Grid, "Regional Gas Market Council meeting," 23 August 2021.

144 Amber Grid, "Amber Grid Strategy 2030," 11.

145 Ibid, 12.

146 "Estonian-Latvian joint offshore wind farm project kicks off," *ERR News*, 13 September 2021.

necessary investments in transportation infrastructure. Until then, only transportation by trucks within short distances is feasible.

Third, almost all NB4 countries in their hydrogen development visions so far only talk about domestic hydrogen generation and consumption—in other words, short hydrogen value chains are projected (e.g. from generation sites to transport fuels or between wind farms and industrial sites). In the existing or forthcoming national hydrogen roadmaps, the regional perspective is almost ignored (perhaps only the Estonian Elering envisages active hydrogen export potential in its vision).

Skipping the initial phase of regional coordination will make it difficult to later reconcile the nationally oriented visions and find the most effective way to coordinate hydrogen production, transport and use chain on the regional level

Finland and the Baltic countries could potentially become producers and exporters of energy carriers—natural conditions for the potential of renewable energy would allow the production of more hydrogen than is needed domestically. Western Europe, with its strong industrial need for hydrogen, would encourage Finland and the Baltic countries to become hydrogen exporters in the future. However, regional cooperation in this area is still in its infancy.

Behind the optimistic official reports, there are some grievances, mistrust and different approaches to future energy needs at the political level. Even the already functioning common gas tariff market between Finland and the Baltic states raises a number of disputes between the market participants. However, the most significant negative trend is a political quarrel between the actors of Latvian, Estonian and Lithuanian energy policy. The recent disagreements over the rules of electricity trading with third countries have significantly undermined trust between Baltic energy companies and politicians. This could potentially hamper the smooth transition to synchronisation with European electricity networks by 2025.

At the current stage, it is too early to assess the possibilities for the formation of a regional hydrogen value chain between Finland and the Baltic states. It is likely that the first roadmaps of hydrogen in the Baltic states (potentially adopted by 2022–23) will be dedicated only to projections of national needs. However, skipping the initial phase of regional coordination will make it difficult to later reconcile the nationally oriented visions and find the most effective way to coordinate hydrogen production, transport and use chain on the regional level.

Admittedly, national needs are closer to one's skin, and in the Estonian case, there is a particular aspect to be considered most carefully—the impact of energy transition on its north-eastern region of Ida-Virumaa, a traditional oil shale producer and major electricity producing area, where the urban population is heavily dominated by ethnic non-Estonians. Some characteristics of this region make it highly vulnerable in terms of national security as well as socioeconomic threats, while the hydrogen economy might bring some opportunities to mitigate those threats. The next chapter of this report focuses on whether hydrogen can be a new driver of development in Ida-Virumaa.

6. Woes and Hopes of Ida-Virumaa

Andrei Belyi

The energy transition towards climate neutrality may imply that the whole energy structure and industrial base of Ida-Virumaa will have to be transformed. According to Estonian government policy, oil shale-generated electricity will have to be phased out by 2035, while oil shale extraction is expected to be terminated by 2040. Further, in accordance with the EU Hydrogen Strategy, hydrogen needs to be considered for the decarbonisation of industries, transport and district heating.

This chapter will place the energy transition policies affecting Ida-Virumaa into the broader security context. The main specificities of the region include a difficult integration process of a Russian-speaking minority, which dominates the Ida-Virumaa area. Therefore, rising social costs of energy transition can easily be observed by the political forces of Russia. In parallel, there is a rising Estonian nationalistic and Eurosceptic political party that wishes to gain popular ground in Ida-Virumaa by opposing an oil shale phase-out. So this chapter will also address the regional economic and socio-political specificities of Ida-Virumaa in order to identify the main challenges arising from the energy transition process.

> *Apart of the Russia's attempts to induce a negative image of Europe's decarbonisation efforts, there is a parallel risk of domestic Euroscepticism*

6.1. Socio-political considerations

The Ida-Virumaa region remains very specific in the Estonian context. Urban areas are populated by Russian speakers and the cultural, linguistic and even political influence from Russia remains important. An information vacuum and distrust towards national authorities remain significant and are often underestimated in policy literature. While Ida-Virumaa has not been a successful issue for the Estonian nationalist and Eurosceptic party EKRE, the party is attempting to gain ground by opposing the shale industry phase-out plans. An alliance by default between EKRE and economically unsatisfied Russian speakers may thus become realistic in the context of higher social costs for energy transition.

6.1.1. Russian-speaking context

Since the urban areas of Ida-Virumaa are dominated by Russian speakers, the region is located in a very different informational environment compared to the rest of Estonia. A national NGO, the Estonian Roundtable for Development Cooperation, conducted a number of studies regarding building bridges between the Russian- and Estonian-speaking communities. According to the surveys conducted, since Estonia became independent, most Ida-Virumaa residents have felt excluded from the rest of the country. A partial de-industrialisation has occurred since the collapse of the Soviet centralised command economy, and the younger generation in Ida-Virumaa tends to believe that the state shows little interest in the economic development of the area.[147] Adding to that, there is deep distrust among ethnic non-Estonians in the country's ability to implement any effective social policy.

> *Russian speakers of the region focus mostly on the modernisation of the oil shale industry and on the sustainable development of this carbon-intensive sector, illustrating that the majority view oil shale positively*

This leads to difficulties in gaining sufficient public faith in the European Social Fund—a fund that the Estonian government intends to draw upon to help the region's poorer households in coping with the higher power and heating bills and temporary unemployment associated with the energy transition and oil shale phase-out.

Also, differences between Estonian- and Russian-speaking respondents have been revealed during previous opinion polls conducted by the Ministry of Finance regarding top priorities for the Ida-Virumaa region. Most Estonian-speaking respondents have pointed out the importance of energy efficiency and insulation of buildings. In turn, Russian speakers of the region focus mostly on the modernisation of the oil shale industry and on the sustainable development of this carbon-intensive sector, illustrating that the majority view oil shale positively.[148]

The context is amplified by active publications on the Russian-based Baltnews portal, which mostly focuses on socioeconomic developments in the Baltic states. The portal regularly publishes articles that explicitly criticise Estonia's plans to phase out the shale industry and point out the economic challenges of energy transition. Russian news outlets will be noting the rising unemployment among Estonia's Russian-speaking population and will likely exert external pressure on Estonian politics. Estonia's strategy in Ida-Virumaa cannot be qualified as a success—for example, compensation

147 Interview with Susanna Veevo, Policy and Advisory officer at the Estonian Roundtable for Development Cooperation, 23 September 2021.

148 Ministry of Finance of Estonia, "Ida-Virumaa õiglase üleminek arvamuskorje tulemused [Results of the opinion poll on the just transition in Ida-Virumaa]," opinion polls, n.d.

to the former engineers and workers has ignored the need for a long-term solution for the next generations of the region's residents, and the region has not enjoyed Estonia's national success in digitalisation. Numerous initiatives on the subject have proved to be greatly out of touch with social reality.[149]

6.1.2. Euroscepticism as a long-term peril

Apart of the Russia's attempts to induce a negative image of Europe's decarbonisation efforts, there is a parallel risk of domestic Euroscepticism. The nationalist party EKRE has mostly gained popularity among Estonian speakers and mostly in rural areas and small towns. While EKRE was part of the Estonian governing coalition in 2018–20, its minister of finance and current chair of the party, Martin Helme, appealed to the government to withdraw from the EU emission trading scheme in order to mitigate electricity price hikes. Although Estonia's prime minister vetoed the withdrawal back then, opposition to the EU Green Deal has persisted within EKRE. Since the party went into opposition, its vocal criticism of EU policies has increased. EKRE keeps referring to Poland as an example to follow, something that may confirm similar political trends which would affect the implementation of the Green Deal in Estonia. So far Poland is the only EU member state to openly oppose the EU climate law implementation.

> *Testing the benefits of hydrogen economy development in Ida-Virumaa will become a critical dimension of sustaining Estonia's political will to uphold its commitments to the EU Green Deal*

As the party has repeatedly held anti-Russian discourse, it has not attracted sufficient support among the Russian speakers of Estonia. But somewhat paradoxically, a pro-industrial debate is now being led by EKRE in Ida-Virumaa, and in recent months mass media has reported strong support there for EKRE—even though the recent local elections did not substantiate this claim.[150] However, it should also be noted that most of the Russian-speaking activists supporting EKRE are related to the oil shale industry.

EKRE's longer-term prospects in Ida-Virumaa remain unclear, but the party will certainly be able to take advantage of economic issues resulting from energy transition both in Ida-Virumaa and beyond. If EKRE's popularity grows, the implementation of climate neutrality objectives will become less certain, while the pressure will increase for Estonia to follow in the footsteps of Poland as an example of how to protect legacy industries generating substantial amounts of CO_2 emissions. In this regard, testing the benefits of hydrogen economy development in Ida-Virumaa will become a critical dimension of sustaining Estonia's political will to uphold its commitments to the EU Green Deal and contribute to the global efforts in addressing the unfolding climate crisis.

6.2. Hydrogen and energy transition in Ida-Virumaa

Ida-Virumaa is an old industrial region of Estonia which contains hard-to-abate sectors in terms of greenhouse gas emissions reduction. Transition from the oil shale industry is one of the main challenges resulting from the energy transition. The hundred-years-old industry is very labour-intensive. Out of the region's population of approximately 140 000 inhabitants, up to 11% (16 000) are either employed by the industry or are family members of industry workers. Adding to that, 40% of the largest employers registered in Ida-Virumaa associate their business with the oil shale industry.[151] According to the State Shared Service Centre (Riigi Tugiteenuste Keskus), the Ida-Virumaa region is potentially the most affected by the energy transition, and therefore, a specific

149 Andrei Belyi, "A New Tale, Just Without Oil Shale: Climate Neutrality and the Future of Estonia's Industrial North-East," ICDS Commentary, 9 July 2020.

150 Erik Gamzeev, "EKRE nabirayet populyarnost' v Ida-Virumaa, no sostavlenie spiskov kandidatov stanet ispytaniem [EKRE is gaining popularity in Ida-Virumaa, but drawing the lists of candidates remains a challenge]," *Severnoe Poberezhie*, 18 May 2021; "Local elections 2021: Results," *ERR News*, 18 October 2021.

151 Aleksandr Michelson, Kaupo Koppel, Kirsti Meles, Meeli Murasov, Kadri Arrak, Merilen Laurimäe, Hanna-Stella Haaristo, Jane Ester, Laura Mallene, and Gerli Paat-Ahi, *Ida-Virumaa majanduse ja tööturu kohandamine põlevkivitööstuse vähenemisega* [Adaptation of Ida-Virumaa county´s economy and labor market to the reduction of oil shale industry] (Tallinn: Praxis Think-Tank, 2020).

programme of consolidation of European funds to support the region has been set up.[152]

Following a call for proposals for industrial initiatives to support energy transition, so far only one initiative, issued by Eesti Energia, addresses hydrogen development. Eesti Energia proposes to develop green hydrogen production sites to replace natural gas with hydrogen in the pipeline networks. According to Eesti Energia's estimates, up to 20 direct and 40 indirect jobs will be created by the hydrogen economy by 2050. The number looks miniscule compared to the numbers of employment in the oil shale industry. Moreover, the question arises of the possible advantages and costs of hydrogen consumption in the region's industrial and residential sectors.[153]

There are no significant renewable energy projects related to hydrogen production involving Ida-Virumaa at this point

6.2.1. Hydrogen production

Currently, global hydrogen production amounts to 2% of natural gas market volumes, which means that hydrogen production needs drastic scaling up to be able to compete with hydrocarbon sectors. So far, an overwhelming part of hydrogen itself is produced from either coal or gas, which naturally emit carbon dioxide during processing. Hence, hydrogen as a fuel is not carbon-neutral by default. In Sillamäe, the major harbour of Ida-Virumaa, conventional hydrogen potential can be quickly expanded because of chemical facilities located in its industrial sites. However, the issue of carbon dioxide emitted during hydrogen production will remain the primary impediment for any grey hydrogen projects.

Unlike grey hydrogen, blue hydrogen involves introducing CCS for hydrogen produced from fossil fuels. These options would extend the lifetime of the oil shale industry because carbon dioxide can be captured from the industrial processes, which in turn can generate synthetic gases. However, the economic feasibility of the option remains unclear particularly because of the limited capability for CCS. The decarbonisation of hydrogen production by capturing and using carbon is still debated in a context of economic uncertainty. Overall, there are only a few active CCS facilities in Europe and it remains doubtful that Estonia can have such a facility. An intermediate solution would be hydrogen-enriched natural gas, using fossil fuels as a bridge fuel.[154] However, this solution may increase natural gas imports, which can also be politically sensitive in the current context of high prices and political vulnerabilities.

Alternatively, green hydrogen can be produced from renewable energy sources. As the innovative renewable energies, such as solar and wind, are intermittent and dependent on weather conditions, hydrogen is envisaged as an appropriate energy storage. When renewables generate an excess of energy, it can be directed to generate hydrogen. In turn, when sun and wind are scarce, hydrogen can be used as an energy source. Adding to that, dedicated offshore wind capacity either in the Gulf of Finland or on the Baltic coast can hypothetically serve hydrogen production during excess of power generation. A recent IEA report points out that offshore wind would be a good option for hydrogen because of the higher load it can offer compared to onshore wind and solar.[155] Nevertheless, the development of offshore wind still remains embryonic in the Baltic states, while costs of the green hydrogen are estimated to be about double those of blue hydrogen.[156] Besides, the oversupply of electricity from intermittent renewable energy sources occurs rather rarely, which constitutes a major impediment to scaling up green hydrogen production.[157] Even more concretely, there are no significant renewable energy projects related to hydrogen production involving Ida-Virumaa at this point.

152 The State Shared Service Centre, "Programme for 2021-2027," version of 1 October 2021.

153 The chapter represents only a brief overview of the challenges to the Estonian Hydrogen Roadmap. Ain Laidoja of the Estonian Hydrogen Union has been consulted to achieve maximal accuracy of the description.

154 Joan Ogden, Amy-Meyers Jaffe, Daniel Scheitrum, Zane McDonald, and Marshall Miller, "Natural gas as a bridge to hydrogen transportation fuel: Insights from the literature," *Energy Policy*, Vol. 115 (2018): 317-329.

155 International Energy Agency, *Future of Hydrogen: Seizing Today's Opportunities* (IEA Publications, 2019).

156 Sean McLoughlin, Edward Perry, Ashim Paun, Davey Jose, and Sarthak Sikka, "Global Hydrogen: Approaching sector tipping point – hydrogen FAQs," HSBC Global Research, 10 July 2020.

157 Samuele Furfari, "Hydrogen strategy to nowhere," *European Scientist*, 30 July 2020.

Finally, pink hydrogen implies the generation of hydrogen from electrolysis from nuclear power. Estonia still lacks a nuclear generation capacity, although one project based on small modular reactor (SMR) technology has been recently initiated. Arguably, the advantage of nuclear energy is its ability to generate steam and decarbonised heat, thereby removing the need for scaling up hydrogen production. However, nuclear power also implies other security concerns (including non-proliferation, safety and waste management), which are not part of the present analysis. Currently, Fermi Energia plans to develop an SMR in Estonia, but a link with the Ida-Virumaa region remains unclear. Fermi Energia reports that a specific study is ongoing regarding the possibility of integrating the Ida-Virumaa industrial potential into the project. Results will be known by spring 2022.

A shift to new decarbonised solutions in district heating would imply driving households' costs upwards, which may engender additional social discontent

By and large, the Ida-Virumaa region is not yet involved in hydrogen production plans other than very broad declarations and concepts. Meanwhile, the difficulty of energy transition at the level of consumption represents an even greater challenge than envisaging hydrogen production facility. After all, even if hydrogen is produced at the necessary industrial scale, it has to be consumed as well.

6.2.2. Potential consumption

In terms of the potential consumption, three sectors need to be considered: transport, district heating and energy-intensive industry. As there is no significant use of hydrogen in any of these sectors, demand-side strategy would require an in-depth understanding of technological developments alongside business models for financing each of the sectors. So far, there are no detailed roadmaps for either national or regional hydrogen development and therefore only broad estimates are available. In the decarbonised economy, the main competing model of hydrogen economy is a full electrification of transport, heating and industries. However, the full electric option involves another level of difficulties related to the costs of incremental power generation necessary to ensure the electrification of the economic sectors.[158] So far there is no clarity as to whether Estonia prefers the full electric option over hydrogen. At the national level, the Estonian rail operator Operrail announced a plan to introduce hydrogen-fuelled train locomotives, while the Hydrogen Union of Estonia claims that a shift to hydrogen would generate savings of up to 350 million euros for rail transport compared to the full electric options.[159] At the same time, there is no identified plan to develop filling stations for hydrogen-driven cars in Estonia; at present the car retail industry in Estonia prefers to focus on hybrid and electric vehicles. Thus, the development of hydrogen road transport seems to be rather premature even compared to the embryonic initiatives for railways.

District heating is an important sector in Estonia, as it provides up to 50% of the total national heat supply and constitutes the most significant source of energy in the residential sector of large urban areas in Ida-Virumaa. The current decarbonisation strategy is focusing on introducing wood pellets in combined heat and power plants. However, the use of wood is increasingly being criticised by the European Commission and environmental groups.[160]

Meanwhile, a Franco-German engineering group, Tilia A.S., estimates that the introduction of hydrogen into district heating is not an easily achievable decarbonisation option.[161] Possible energy losses from insulated district heating pipes constitute a high risk. Moreover, hydrogen-enriched natural gas leads to losses in calorific value because hydrogen in gaseous form contains less energy than methane. A shift to new decarbonised solutions in district heating would imply driving households' costs upwards, which may engender additional social discontent. The electrification option would be equally difficult, as although introducing electric heat pumps to residential areas would be more realistic than hydrogen, it would

158 Irina Kustova and Christian Egenhoffer, "The EU Electricity Sector Will Need Reform, Again," *Intereconomics*, Vol 54 (2019): 332–338.

159 Ain Laidoja, "Hydrogen technologies save €350 million for rail," Estonian Hydrogen Union, 5 May 2020.

160 Andrei Belyi and Andris Piebalgs, "Towards bottom-up approach to European Green Deal: lessons learned from the Baltic gas market," Policy Brief of Florence School of Regulation, February 2020.

161 Marina Galindo Fernandez, Alexandre Bacquet, Soraya Bensadi, Paul Morisot, and Alexis Oger, *Integrating Renewable and Waste Heat and Cold Sources Into District Heating and Cooling Systems* (Luxembourg: Publications Office of the European Union, 2021).

encounter the issue of rising electricity bills. At the same time, the level of awareness about the European Social Fund remains very low, and trust in the effectiveness of national social policies has been persistently low for reasons briefly described above.

The most challenging sector is the industrial sector, which is classified as a "hard-to-abate" area for greenhouse gas emissions reduction; electrification is nearly impossible and therefore hydrogen would be the only option to consider. Among others, Ida-Virumaa contains a solid potential of chemical industry, including Viru Keemia Group. The latter focuses on producing oils from oil shale and reportedly cannot avoid CO_2 emissions. The Viru Keemia Group informed the Estonian authorities that a decarbonisation plan is not compatible with the core industrial activity of the company. The proposed solutions include CCS, which has not yet even been tested in Estonia. Moreover, a shift to CCS implies prolonging the oil shale industry, whereas the Estonian government has expressed an explicit commitment to phasing out its extraction by 2035. The question remains whether CCS would be eligible for funding from the Just Transition Fund (JTF) prior to the closure of the production sites. However, the technological testing and subsequent infrastructure development (for example, shipment of carbon dioxide to Norway, where appropriate storage sites are possible) are lengthy processes and only exist at the level of technological vectors. In response to the challenge, the Viru Keemia Group proposed that Estonia should adopt a specific climate law envisaging concrete timelines for the adaptation of the industrial sector.[162]

Without defining a clear role for Ida-Virumaa in energy transition in general and without clearly identifying the economic benefits of the hydrogen economy specifically, the Estonian national hydrogen roadmap would represent a failure in terms of addressing increasingly pressing national security imperatives

Overall, a shift to hydrogen is a challenging strategy both on the production side (e.g. finding carbon-neutral ways to produce hydrogen) and at the level of consumption in transport, district heating and industries. Solely transitioning consumption to hydrogen without stimulating carbon-neutral hydrogen production would not lead to decarbonisation. However, the consumption side remains quite challenging as well. In Estonia, only railway transport views hydrogen optimistically, whereas it appears to be more complicated in district heating and heavy industry. So far, both the Estonian state and the Ida-Virumaa region lack a comprehensive strategy involving financing models for the energy transition in general and the hydrogen economy in particular.

Economic challenges in creating a balance between the production and consumption sides of hydrogen economy also have to be considered in the regional socio-political context briefly described above. Due to regional specificities, any failure in delivering a win-win energy transition risks backfiring on the socio-political level. In fact, the argument that the long-term risks of climate change must be avoided at any price does not convince a large part of the region's public opinion. Reliance on the oil shale industry and exposure to Russian news outlets criticising the EU Green Deal will only amplify the gap between the "pro-climate" national policy narrative and public opinion in the region. The gap can further engender a fertile ground for Eurosceptic forces, who show a strong footing at the national level already.

Without defining a clear role for Ida-Virumaa in energy transition in general and without clearly identifying the economic benefits of the hydrogen economy specifically, the Estonian national hydrogen roadmap would represent a failure in terms of addressing increasingly pressing national security imperatives.

162 An interview conducted with a Viru Keemia Group representative, 15 October 2021.

Conclusions and Recommendations

Tomas Jermalavičius[163]

Hydrogen will clearly play a major role in the energy transition to a climate-neutral future for our economies and societies. As highlighted in Chapter 1, it will also be a significant component of European energy sovereignty, pursued by the EU in its efforts to enhance Europe's security, freedom of action, and influence. The EU and its various member states have made important steps in defining this role and laying the preconditions for its successful implementation. This not only encompasses the individual and collective efforts by the member states but also involves cooperative endeavours to develop hydrogen infrastructure with Europe's neighbours, many of whom are already long-standing energy partners of the EU, or could become such in the hydrogen age.

The pursuit of a European vision for hydrogen has distinctly lacked a geopolitical perspective—something that would increasingly define the EU in its relations with its neighbours and with major global players

At the same time, the pursuit of a European vision for hydrogen has distinctly lacked a geopolitical perspective—something that would increasingly define the EU in its relations with its neighbours and with major global players. This gap is manifest in the EHB studies as well as various national policies and strategies, where hydrogen is mainly seen through the lenses of economic opportunities, technology and climate security. Geopolitical considerations, however, increasingly shape energy relations between the EU and various regions in its neighbourhood. Ignoring them while crafting a strategy for the next two or three decades carries the risk that the EU might again, just as in the early 2020s, face unpalatable choices between protecting its political interests and values on the one hand and security of supply of energy resources such as hydrogen on the other. In short, the feasibility of European strategic autonomy will remain questionable without energy sovereignty, which, in turn, will be precarious if Europe's geopolitical interests as well as current and future risks and opportunities are not factored in.

From this point of view, some of the geographical directions of extending the envisaged European Hydrogen Backbone and connecting it with the neighbourhood of Europe have been more problematic than others. A perfect case in point would be Russia, which was linked to Europe by a new undersea gas pipeline, Nord Stream 2, in 2022 but certification of which was suspended indefinitely, perhaps even for good. Before Russia's full-scale military assault on Ukraine cast the project in a new light for the German government, there was already enough controversy surrounding the pipeline—and energy relations with Russia in general—to caution against any future attempts to utilise it for hydrogen deliveries. The war has made its revival highly unlikely in the short and medium term, as any continuation of energy imports from Russia has become politically toxic and an obvious geopolitical folly.

Ukraine should be a political priority. It has many prerequisites for becoming a major source of hydrogen—both of the green and pink variety—for Europe, but the key argument in favour of prioritising the development of energy relations is that Ukraine is on a Western integration course

On the other hand, as underscored in Chapter 2, Russia's nuclear energy potential to produce larger amounts of pink hydrogen is something

163 With contributions to the recommendations by Andrei Belyi, Tomas Janeliūnas, Iliya Kusa, Andrian Prokip, and Pier Paolo Raimondi.

that will potentially hold significant allure to some of the European industrial and energy stakeholders, particularly if the supply of domestic green hydrogen falls short of expectations, while the unfolding climate crisis becomes ever more pressing. Seeing Russia as a cooperation partner in addressing this crisis through the development of the hydrogen sector could hold a strong appeal: it is a country that is resourceful, competent in nuclear energy matters, well-connected through pipeline infrastructure to Europe, and has been a long-standing counterpart in ensuring energy supply. Once the psychological impact of the ongoing war wears off and if, ten or fifteen years from now, political pressure arises in some EU countries to return to "business as usual" with Russia, pink hydrogen exports could become Moscow's Trojan horse for its return to EU markets.

Such a development, unlikely as it sounds in the present geopolitical environment, would only serve to re-create a dangerous relationship with a hostile regime (unless the regime collapses or undergoes a benign transformation within the next two decades), thus laying the ground for repeating the mistakes of the 2010-20s in the hydrocarbons sector that led Europe to such an acutely vulnerable security position in 2022. However, given that the hydrogen economy will rely on a more diverse set of supply sources and regional clusters, even such a limited resurrection of Russia's role in the European energy mix would entail a much-diminished exposure to the geopolitical risks associated with Russia's foreign policy.

Ukraine, on the other hand, should be a political priority. It has many prerequisites for becoming a major source of hydrogen—both of the green and pink variety—for Europe, but the key argument in favour of prioritising the development of energy relations is that Ukraine is on a Western integration course. This stands out among the studied cases of relevance to the European Hydrogen Backbone: as a potential future member of the EU who has already signed an Association Agreement with the Union and officially applied for membership, Ukraine is poised to make a major contribution to European energy sovereignty and strengthen the EU's energy security, without an adversarial hidden geopolitical agenda that could burst out into the open at some sensitive point. Investing in hydrogen development in Ukraine would mean investing in a more secure and geopolitically stronger Europe.

Of course, as with any investment, it does not come without risks and downsides. As highlighted in Chapter 3, Ukraine must tackle many obstacles in order to realise this potential—from modernising its regulatory environment and improving governance to overcoming trust issues created by Germany's NS2 debacle, its reluctant and restrained provision of military aid in the first weeks of the war, and its outright refusal to support an immediate and comprehensive energy embargo against Russia. Also, the post-war reconstruction of Ukraine will be enormously demanding and will shape the priorities of its government for decades ahead, meaning that at different periods, various other aspects will be prioritised over the energy sector or governance reforms. The EU integration maintains its soft and normative power over the candidate countries, which gives an opportunity for the EU to shape the outcomes of Ukraine's energy sector transformation and alignment of interests (e.g. in climate policy).

Ambitions for hydrogen development in Ukraine aligned with the EU's energy and climate policy goals will face headwinds and will require strong political will, both in Ukraine and the EU, to persevere

Almost inevitably, there will be setbacks and difficult periods, as the EU has never attempted to integrate a country so devastated by a major war. But the sheer fact that the EU Commission and Ukrainian government officials continue to look into the future, beyond the current war, and discuss energy transition as well as hydrogen's role in it, indicates the importance of the topic for both sides.[164] The MoU signed between the Ukrainian gas TSO and the European Hydrogen Backbone in April 2022 that envisages close cooperation in exploiting Ukraine's green hydrogen potential is another important step towards integrating Ukraine into the emerging European hydrogen infrastructure—and a testimony to the fact that even war cannot derail this important process.[165]

164 Dmytro Kuleba (@DmytroKuleba), "Focused call with @TimmermansEU. Russia's war on Ukraine continues, but we have to think about the future," Twitter, 6 April 2022.

165 European Hydrogen Backbone, "EHB signs MoU with TSO of Ukraine on collaboration towards an integrated European hydrogen infrastructure," press release, 19 April 2022.

It also goes without saying that Russia will continue targeting Ukraine's Western integration course by all available means even after the war, including by disrupting its energy sector and its relations with the EU. Having failed to achieve its aims by the brutal use of military force, Russia will almost certainly revert to posing hybrid threats and conducing malignant influence operations instead.

There is a risk that partnership with the MENA countries on RES and hydrogen development, if it is not conditional, will perpetuate the rent-based socio-political regimes that eventually cause tensions and instability in the first place

This means that ambitions for hydrogen development in Ukraine aligned with the EU's energy and climate policy goals will face headwinds and will require strong political will, both in Ukraine and the EU, to persevere. Also, plans for this development will have to be drawn and implemented in the context of the severe financial pressure on Ukraine's energy sector as it faces the challenge of restoring basic infrastructure while experiencing shrinking income, including from steadily reducing Russian gas transit.

The EU's southern neighbourhood, on the other hand, poses a different set of geopolitical challenges, while representing a significant hydrogen cooperation opportunity, as underlined in Chapter 4. The MENA region is large, diverse and often tumultuous, while the different countries comprising it have complex and sometimes complicated relations with the EU and its member states. Developing RES and hydrogen is the region's best chance to avoid irrelevance in the post-fossil fuels world of energy and also to maintain the existing socioeconomic model of development. For Europe, it is not only an opportunity to draw on the region's renewable energy potential and help reduce its carbon footprint but also to provide the resources necessary to maintain a modicum of domestic stability in its various countries. Given that the EU's security is often seriously challenged by the instability and conflict in the MENA region, and would be even more severely undermined if this instability widened as a result of the region's failure to find its footing in the post-hydrocarbons' era, this is not a trivial argument in favour of engaging those countries in hydrogen development programmes.

Still, there is a risk that partnership with the MENA countries on RES and hydrogen development, if it is not conditional, will perpetuate the rent-based socio-political regimes that eventually cause tensions and instability in the first place. At the same time, too strict conditionality might drive those regimes into the hands of another major geopolitical rival of the West—China. Managing these challenges will be a more complex and multipronged—if perhaps less dynamic and fast-moving—undertaking than managing relations with Ukraine, while possessing less potent leverages than those that usually come with EU membership aspirations. It is also not without the risks of deliberate supply disruptions for political purposes, as some of the MENA countries may see opportunities to put pressure on the EU in case of geopolitical tensions and political disagreements. The EU may have to be as nimble and assertive in addressing those situations as in dealing with Russia.

There is the lack of a culture of closer coordination and synchronisation of national plans and ambitions in the energy sector between the NB4 countries, which often leads to disjointed approaches that reduce regional synergies and diminish their weight in the European context

Geopolitical aspects are not something that come to mind when considering how the Baltic region, particularly its eastern part, can contribute to the EU's energy sovereignty through the development of its hydrogen potential. The Baltic states and Finland, as EU member states, cooperate within the framework of the Energy Union as well as within regional arrangements such as a common regional natural gas market. As Chapter 5 demonstrates, the impediments on their cooperative endeavours in the hydrogen sector pertain more to different speeds in envisioning the role of hydrogen and drawing the contours of national roadmaps as well as the uncertainty surrounding the issues of demand, supply and technology, rather than to geopolitical factors. There is also the lack of a culture of closer coordination and synchronisation of national plans and ambitions in the energy sector between the NB4 countries, which often leads to disjointed approaches that reduce regional synergies and diminish their weight in the European context.

However, in this corner of Europe, various background political issues and trends in the broader security environment tend to assert themselves in the energy sector. Previous and still ongoing disputes over a range of questions—from the modalities of the Baltic power grids' synchronisation with Europe, through the design of the regional gas market and the issue of regional LNG terminals, to the challenge of the Astravets nuclear power plant in Belarus—contributed to a lingering lack of trust between the countries. There is also an ever-present spectre of Russia's malignant interference designed to undercut regional security and reassert Moscow's interests, which will inevitably be felt, directly or indirectly, in the energy transition of the region to a carbon-neutral future.

The government in Tallinn and the energy enterprises do not pay sufficient attention to Ida-Viruamaa's potential role in hydrogen supply chains and the wider socioeconomic and national security benefits this could deliver

At the national level, nowhere is the challenge as acute as in Estonia's north-eastern Ida-Virumaa region. As Chapter 6 explains, it is bound to be among the biggest losers of decarbonisation, due to its heavy dependence on oil shale mining and use in the energy and petrochemicals industry. As it is dominated by Russian speakers—a demographic segment most vulnerable to Russia's malignant influence strategies—the socioeconomic impact of transition to carbon-neutral economy and society will have national security implications. Hydrogen offers a pathway to mitigate this impact and attract new investments into the region's economy, while building on the region's strengths in infrastructure and human capital. Yet the government in Tallinn and the energy enterprises do not pay sufficient attention to Ida-Viruamaa's potential role in hydrogen supply chains and the wider socioeconomic and national security benefits this could deliver.

This report sought to highlight mostly the geopolitical and security aspects of the efforts to develop the European Hydrogen Backbone. It is far from comprehensive, as there are important "horizontal" issues that received cursory mentioning in this study and require further investigation to assess their implications. One set of issues is the geopolitical side of competition for cutting-edge technology in hydrogen production, transportation and use. As global technological rivalry with China intensifies, the technological dimension of European energy sovereignty will be ever more significant.

Another set of issues pertains to water security. Hydrogen production requires access to abundant reserves of fresh water, as technologies able to produce it from sea water without energy-intensive desalination are currently just at the "proof of concept" stage of development.[166] The MENA region, as pointed out in Chapter 4, is most disadvantaged in this regard: it is struggling with water security already now, and this will only worsen because of climate change. But even countries and regions that currently enjoy sufficient water security will be affected: some studies show that, for instance, Estonia and Ukraine will face higher water stress levels by 2040.[167] Water security has always had significant geopolitical repercussions in water-stressed areas, and the development of a hydrogen economy in such areas will only aggravate them. The sustainability of this economy in places where water security will become a serious concern in the future must be thoroughly assessed.

166 Le Shi, Ruggero Rossi, Moon Son, Derek M. Hall, Michael A. Hickner, Christopher A. Gorski, and Bruce E. Logan, "Using reverse osmosis membranes to control ion transport during water electrolysis," *Energy & Environmental Science*, 9 (2020): 3138-3148.

167 Andrew Maddocks, Robert Samuel Young and Paul Reig, "Ranking the World's Most Water-Stressed Countries in 2040," Commentary of World Resources Institute, 26 August 2015, https://www.wri.org/insights/ranking-worlds-most-water-stressed-countries-2040.

In addressing the geopolitical aspects of the European Hydrogen Backbone, this report recommends:

European energy security

- **Geopolitical perspective for the EU's energy security**. When creating and managing new hydrogen-related interdependencies with the regions and countries outside the EU, continuously monitor and assess the geopolitical risks (including those associated with the technological dimension of hydrogen), especially in terms of their impact on European energy security and, by extension, prospects for strategic autonomy. This should be routinely done both at the EU level and by the individual member states.

Relations with Russia, Ukraine and MENA

- **Isolation of Russia**. As long as Russia is governed by a regime hostile to the EU and its values and continues its military aggression against neighbouring countries, there should be no attempts to restore, in any form or degree, the dependence on energy supply from it. In the current and foreseeable geopolitical environment, Russia's hydrogen potential should not be treated as an opportunity to address the potential gaps in hydrogen supply related to climate neutrality objectives or as an opportunity to return to "business as usual" in relations with Moscow.

- **Support to economic reconstruction and energy transition of Ukraine**. Provide full support to Ukraine in its efforts to reshape its comprehensive strategic policy and roadmaps of energy transformation, including towards hydrogen economy. In this context, it is important to assist, both technologically and financially, Ukraine's overall post-war reconstruction, including rebuilding of its energy sector in line with the broader goals of energy transition and integration with the EU, and not just its hydrogen projects. Regarding the latter, support should also be provided to establish a pilot project in Ukraine to produce green hydrogen and synthetic renewable hydrocarbons based on it.

- **Support to reforms in Ukraine**. At the same time, the EU should support Ukraine's in its efforts to create a transparent, predictable and favourable business environment necessary to attract private sector investments from the EU and launch commercial-scale hydrogen projects in Ukraine. The most effective way to achieve this would be the accelerated accession of Ukraine to the EU, with the corresponding adaptation of Ukraine's legislation to the Union's *acquis communautaire*. The EU should also be prepared to assist Ukraine in countering Russian hybrid threats to its political governance, energy security and energy transition.

- **Support to energy transition in the MENA region**. The EU should also encourage and support hydrogen production and trade between the two shores of the Mediterranean Sea to provide valuable economic alternatives for the MENA countries and counter the growing influence of the EU's systemic rivals such as China. The EU should support the MENA countries in expanding their RES sector to decarbonise their economies and produce green hydrogen. In doing so, the EU needs to provide adequate financial support, especially for the MENA countries with more limited financial resources. The EU needs to assure them with a credible timeframe that it would import their green hydrogen and provide the incentives to disinvest from blue hydrogen in the long term.

- **Bilateralism vs regional approach**. The EU should prioritise a bilateral approach rather than a regional one due to the high heterogeneity of the MENA region. Some of the EU member states have already signed MoUs with the MENA countries aimed at boosting hydrogen production and trade. The regional approach can be applied for setting common regulatory and environmental standards of hydrogen production, as well as mitigating geopolitical risks to the energy sovereignty of the EU, related to the potential attempts to leverage hydrogen trade for the purposes of political pressure on the EU.

Nordic-Baltic Four

- **Renewal of political commitment**. Hydrogen development is a long-term commitment, and regional coordination in this field would be much needed to accelerate the region-wide transition to zero-carbon energy. Representatives of the Baltic states and Finland should reassess and confirm at a high political level the benefits of regional cooperation and their readiness to take concrete steps strengthening the integration of the region's energy markets. The signing of an MoU between these countries on regional planning and coordination would be a good step towards the development of a hydrogen market in the future.

- **Regional needs in national strategies.** The NB4 countries are currently reviewing and updating their energy needs and development strategies, and/or intend to draft hydrogen development strategies. However, in almost all cases, hydrogen development is focused only on the assessment of domestic needs and domestic production potential. The demand and feasibility for hydrogen imports and exports should be assessed as soon as possible and included in the national hydrogen strategies, as this can significantly adjust investment in local projects and encourage the development of projects at the regional level at an early stage.
- **The energy carrier of the future**. At the regional level, it is important to assess whether in the future there will be energy exchanges within the region based on electricity or hydrogen as an energy carrier. It is agreed that much less energy is lost during hydrogen transportation than through electricity transmission networks. Therefore, when planning investments in the electricity network infrastructure, it would be worthwhile always to see the integrated picture of the potential pipeline infrastructure. Finnish and Baltic TSOs for both electricity and gas networks should establish a common platform for planning and coordination, where the development of hydrogen infrastructure could be one of the regular topics.
- **Enhanced communication and consultation**. Political disagreements severely undermine trust between the countries of the region. Therefore, information on emerging issues or needs to safeguard national interests should be shared and discussed with partners as early as possible, so that differences of interest do not escalate into long-term grievances and competition. It is particularly important not only to work at the political and technical level but also to communicate with the public. Too often energy topics have been discussed in narrow groups of politicians or professionals only, while such a closed process of decision-making encourages political and commercial manipulations that are detrimental to the public interest in the region.

Estonia's north-east

- **Public support to energy transformation**. Short-term actions should include information campaigns to support energy transition with explanations of possible opportunities, including the availability of European social funds for poorer households and the economic benefits of new industries and tangible projects involving the region. The state will need to ensure the effectiveness of the social policies and of the equitable distribution of the European Social Fund. Any failure in social policy would certainly increase socioeconomic tensions at the regional level and national security threats.
- **Industrial transition**. Mid-term actions imply the transition of the oil shale industry, including the development of synthetic hydrocarbon production and CCS capabilities. The idea of an overarching Estonian Climate Act seems very relevant in this respect to differentiate between "just transition" (how to mitigate the region's socioeconomic difficulties) and decarbonisation (energy transition objectives). This separation would allow supporting the oil shale industry during the transition process, for example with the development of CCS. In addition, clear national financing plans for Ida-Virumaa's energy transition must be elaborated.
- **"Hydrogen Valley" of Estonia.** Long-term priorities should include developing technological vectors for Ida-Virumaa, required for carbon-neutral hydrogen production and consumption, including for a range of synthetic hydrocarbon products. The region would benefit from developing a hydrogen-focused cluster of technological know-how, industrial capabilities, infrastructure and entrepreneurship support entities. In the long term, even Estonia's domestic nuclear energy capacity, which is currently under consideration, could be plugged into this cluster to add pink hydrogen to the green hydrogen production and consumption. This would lead not only to a positive trajectory for the region's socioeconomic development and the prevention of its political radicalisation but also to the enhanced national security of Estonia as a whole.

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International Centre for Defence and Security
63/4 Narva Rd., 10120 Tallinn, Estonia
info@icds.ee

ISSN 2228-2076
ISBN 978-9916-9699-7-7 (PDF)
ISBN 978-9916-9699-6-0 (print)