RENEWSTART

Title: **ANALYSIS OF THE POTENTIAL FOR DEVELOPMENT OF THE HYDROGEN ECONOMY IN BULGARIA**

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INTRODUCTION - SUSTAINABLE ENERGY PATHWAYS AND THE PROMISE OF THE HYDROGEN ECONOMY

In the recent years, numerous innovative paths towards sustainable energy have emerged, with the "hydrogen economy" garnering significant attention. A hydrogen-based energy system presents multiple advantages. It provides clean and safe energy without producing pollutants at the point of use, thereby supporting environmental conservation. Additionally, hydrogen is adaptable, suitable for powering vehicles, generating electricity, heating homes, and serving industrial processes. Furthermore, it is considered cost-efficient, although the actual economic feasibility depends on factors like production methods and infrastructure investments. This approach aligns well with broader sustainability objectives, such as those outlined in the European Green Deal, which seeks to achieve climate neutrality in Europe by 2050. Hydrogen's versatility is another notable benefit; it can be derived from various primary sources, including both fossil and non-fossil resources. This adaptability enables the establishment of localized supply infrastructures, bolstering energy security.

Hydrogen's Impact on the Industrial Sector

The industrial sector plays a pivotal role in driving the global economy but is also a substantial contributor to greenhouse gas (GHG) emissions. These emissions largely stem from fuel combustion for heating purposes, with additional emissions arising from process activities and electricity generation. Emissions from industry and transport are increasing, driven by higher activity levels and slower adoption of cleaner technologies. Conversely, the power sector sees declining emissions due to the rise of renewable energy, improved energy efficiency, and carbon capture technologies. This results in a broad plateau in total emissions through to 2050. Distinct variations in CO2 emission trends emerge. Advanced economies, comprising about 30% of global emissions, see a yearly decline of around 1%, mirroring the past decade's average. By 2050, CO2 emissions in the EU drop by 60%, and in North America by 10%. China, responsible for another third of global emissions, shows a marginal increase until 2030, then starts a gradual decline. The rest of the world, accounting for nearly 40% of emissions, raises CO2 emissions by 1% annually, contributing to over half of total emissions by 2050. In 2050, per capita emissions in emerging markets and developing economies (excluding China) are around 2.7 t CO2, much lower than the 5.7 t CO2 in advanced economies and 7.5 t CO2 in China[1].

Here, hydrogen emerges as a promising solution to fully decarbonize medium- and high-temperature industrial heating systems. Beyond heating, hydrogen serves as a critical feedstock in the chemical and refining industries. It is used to produce fundamental chemicals like ammonia and methanol, as well as in various refining operations. Currently, grey hydrogen, particularly that derived from natural gas, remains the most practical option for ammonia and methanol production due to its availability and cost-effectiveness.

However, the shift towards green hydrogen holds immense potential for reducing emissions in this sector. By facilitating the production of ammonia through electrolysis powered by renewable energy, green hydrogen can enable the transportation of energy from regions rich in renewable resources to areas with high energy demand. This transition could significantly contribute to achieving global sustainability goals.

[1] IEA (2025), *World Energy Outlook 2025*, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2025, Licence: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)

Hydrogen in Power Generation: A Transformative Shift

The landscape for utilizing hydrogen in power generation has experienced a significant transformation recently. Driven by the rapid expansion of wind and solar installations, the power generation sector now has access to multiple technologies capable of delivering low-, zero-, or even negative-carbon dioxide (CO2) emissions.[2] This positions hydrogen as a central component in this evolving energy landscape. Consequently, hydrogen is poised to play a crucial role in power generation, offering specialized services that ensure grid stability during periods of peak consumption. Moreover, it addresses the challenge of seasonal energy storage, effectively bridging the gap between peak renewable energy production in summer and peak demand in winter.

Building a Robust Hydrogen Infrastructure

Creating a robust hydrogen infrastructure presents considerable challenges. Such an infrastructure must facilitate the conveyance of hydrogen (H2) from production sites to end-users, which include industrial facilities, power generators, and fueling stations. Key components of this infrastructure encompass pipelines, liquefaction plants, ground transport vehicles, storage facilities, compressors, and dispensing units necessary for the fuel delivery process. To meet the growing demand for hydrogen, there is a need for regional infrastructure expansion, economically viable solutions, and technological advancements. These advancements include developing chemical carriers for high-density hydrogen transport and improving high-performance fuel cell technologies for heavy-duty transportation.

European Initiatives and Bulgaria's Strategic Position

Recent developments underscore the EU's REPowerEU strategy, which aims to reduce energy dependence on Russia. This strategy proposes leveraging existing European gas infrastructure for long-distance hydrogen transport. In addition to the established gas transmission system, new intra-European pipelines need to be built for inland hydrogen transport. The European Hydrogen Backbone (EHB) project, launched in alignment with the REPowerEU strategy, envisions a European hydrogen network comprising approximately 53,000 km of pipelines by 2040.

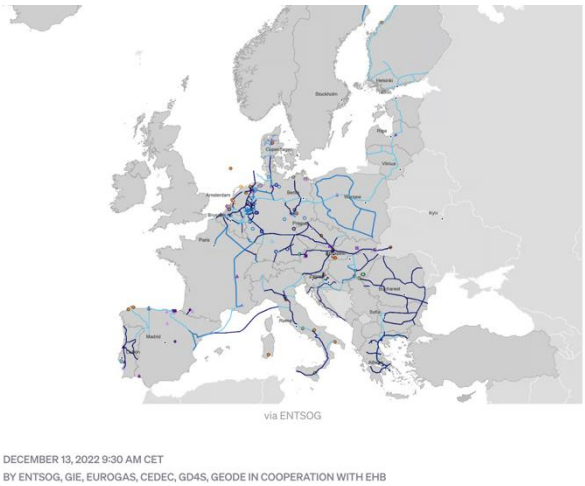


Figure 1 European hydrogen infrastructure map[3]

This network is to connect to European green hydrogen production hubs and facilitate hydrogen transport from import terminals. While the proposed networks will require repurposing a significant portion of existing natural gas pipelines for hydrogen mixtures (or pure hydrogen), new import terminals will necessitate new pipeline infrastructure. The Hydrogen Infrastructure map

[2] Dang Viet Quang, Dia Milani, Mohammad Abu Zahra, A review of potential routes to zero and negative emission technologies via the integration of renewable energies with CO2 capture processes, International Journal of Greenhouse Gas Control, Volume 124, 2023, 103862, ISSN 1750-5836, https://doi.org/10.1016/j.ijggc.2023.103862

[3] Hydrogen Infrastructure Map, https://www.h2inframap.eu/

includes over 220 hydrogen projects, with more than 120 TSO and DSO projects, 40 storage and 10 for terminals and ports.

Figure 2 Where to Fuel?

Bulgaria holds a strategically advantageous geographical location and boasts a well-developed gas infrastructure. Managed by Bulgartransgaz EAD, the gas transmission system features interconnections with all neighboring countries—Greece, North Macedonia, Romania, Serbia, and Turkey.

Source: https://h2-stations.eu/

In line with European and national climate neutrality targets and the widespread adoption of hydrogen, the company is developing several hydrogen (H2) transmission projects. These include a hydrogen pipeline in the Maritsa East coal mining region in Bulgaria and the conversion of the existing gas connection between Greece and Bulgaria.

The groundbreaking hydrogen refueling station in Bulgaria and the region has recently become operational in Sofia. This milestone heralds the commencement of the Central Research Center "HITMOBILE's" ambitious research program scheduled for 2024. The core aim of this program is to produce hydrogen through the electrolytic dissociation of water, harnessing electricity generated from renewable energy sources. The resulting hydrogen will be incorporated into the transportation sector, advancing sustainable mobility initiatives. By forging strategic alliances with diverse industries, the research team endeavors to demonstrate the efficacy of hydrogen technology, thereby expediting its broad adoption nationwide.

H2 CONTEXT IN BULGARIA – THE PROS AND CONS

Political instability poses a formidable obstacle to Bulgaria's progress in the energy sector and its broader efforts to achieve sustainable development. Overcoming these challenges requires a multifaceted approach that addresses both the immediate political uncertainties and the structural impediments hindering effective policymaking.

By prioritizing stability, transparency, and long-term planning, Bulgaria can pave the way for a more resilient and prosperous future in the realm of energy and beyond.

Navigating Political Instability: Bulgaria's Path Towards Sustainable Energy Reforms

Bulgaria is striving for energy climate neutrality by 2050, with a goal of cutting GHG emissions by 55% by 2030. Major focuses include boosting the renewable energy proportion to 34.96%, enhancing energy efficiency, securing energy supply, and championing clean technologies such as hydrogen and electric vehicles. Initiatives involve modernizing buildings, refining energy systems, diversifying energy sources, and driving innovation[4].

Over the past few years, the country has faced significant political instability, marked by frequent parliamentary elections and a lack of sustained, long-term policies. This situation poses

[4] World Energy Outlook, https://www.iea.org/

considerable challenges for sectors like energy, where the capacity to implement and sustain critical reforms and strategies is often hindered.

Despite these obstacles, there is growing recognition of the importance of a meaningful progress in energy transition and decarbonization. The National Recovery and Resilience Plan incorporates essential measures aimed at decarbonization, which are vital for aligning Bulgaria with broader European Union (EU) objectives. Several studies highlight the significance of political support for reforms associated with the plan. They underscore the overall need to mitigate risks and maintain a stable policy framework conducive to sustainable development. Many stakeholders recognize that without a stable eco-soc environment, it becomes increasingly difficult to implement comprehensive energy policies and regulatory frameworks that are essential for fostering innovation, attracting investment, and ensuring a smooth transition towards cleaner energy sources. Efforts to foster cross-party consensus on key energy and environmental issues, strengthen institutional capacities, and promote transparency and accountability in governance were underway. These initiatives aimed to create a more favorable environment for sustainable development and energy transition.

In the special report "Assessment of the Potential for the Development of Hydrogen Technologies in the Republic of Bulgaria, 2022", key operational objectives to support hydrogen economy have been defined:

1. Promote the consistent and effective introduction of technologies for the production, transport, and use of green hydrogen in industry, energy, and transport.
2. Strengthen scientific research and innovation in the field of hydrogen technologies.
3. Create conditions for education and training that support new professions and jobs, as well as an informed consumer base and administrative environment related to hydrogen technologies.
4. Stimulate European and international cooperation to advance hydrogen development.

In 2023 the Ministry of Economic Development updated the Innovation Strategy for Smart Specialization of Bulgaria in the Thematic Area "Clean Technologies, Circular and Low-Carbon Economy", where the production of hydrogen with an emphasis on green hydrogen, and the use of hydrogen in industry, energy, transport and everyday life are envisaged as sub-areas. It was expected that a total of over 30 million euros would be invested in the overall construction of the planned hydrogen infrastructure. The same year the published Hydrogen Roadmap was set as a reform in the National Recovery and Resilience Plan (NRRP)[5]. The Council of Ministers adopted the National Roadmap for improving the conditions necessary to unlock the potential of hydrogen technologies, as well as mechanisms for hydrogen production and supply. The document is referred to as part of the implementation of Reform C4.R7, "Unlocking the potential of hydrogen technologies and hydrogen production and supply," under the National Recovery and Resilience Plan (NRRP), and also in accordance with the National Development Program BULGARIA 2030, the Long-Term Strategy for Climate Change Mitigation until 2050 of the Republic of Bulgaria, the Integrated Energy and Climate Plan of the Republic of Bulgaria/IPEC, the Strategy for Transition to a Circular Economy of the Republic of Bulgaria for the period 2022-2027, the Strategic Vision for the Electricity Sector of the Republic of Bulgaria 2023-2053, the Innovation Strategy for Smart Specialisation (ISIS) 2021-2027.

The National Roadmap outlines the pathway for developing a hydrogen industry. Its goal is to establish a coordinated framework for the effective, smooth, and consistent introduction of

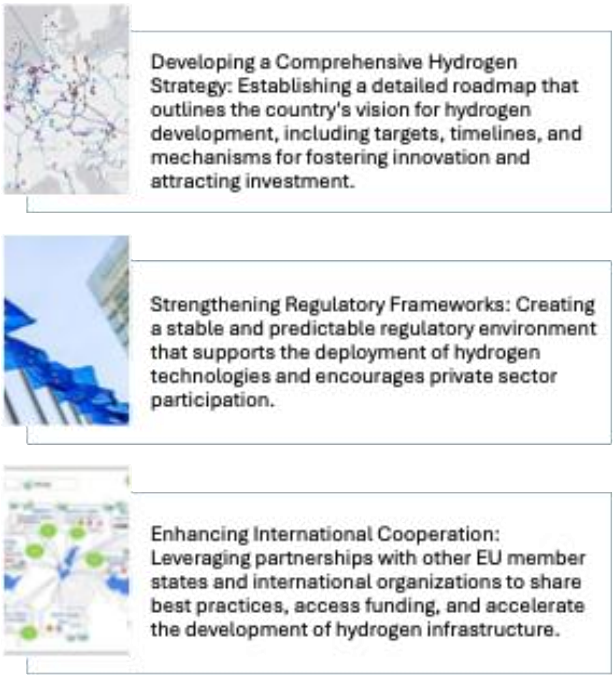
[5] https://strategy.bg/bg

hydrogen production, transport, and use across industry, energy, transport, and households—creating favorable conditions for innovation and investment. It identifies the sectors and stages needed to maximize contributions to a climate-neutral economy, develop new hydrogen value chains, and strengthen partnerships at national, regional, and European levels.

The roadmap outlines several operational objectives aimed at harnessing the potential of hydrogen technologies:

1. **Consistent and Effective Introduction**: Promoting the systematic integration of technologies for producing, transporting, and utilizing green hydrogen across various sectors such as industry, energy, and transportation. This ensures that hydrogen technologies become a reliable and efficient part of the broader energy landscape.
2. **Research and Innovation**: Intensifying efforts in research and development to advance hydrogen technologies. This includes exploring new methods for hydrogen production, improving storage and distribution systems, and enhancing end-use applications.
3. **Education and Training**: Creating an environment conducive to education and training programs focused on emerging professions and job roles related to hydrogen technologies. Additionally, fostering an informed consumer base and supportive administrative framework to facilitate the adoption and utilization of hydrogen solutions.
4. **European and International Cooperation**: Encouraging collaboration at both European and global levels to share knowledge, best practices, and resources. This cooperative approach accelerates the development and deployment of hydrogen technologies worldwide.

Figure 3 The concept of the National roadmap for developing a hydrogen Energy



However, at the beginning of 2025, it was announced that water supply, green hydrogen, and geothermal energy projects would be dropped from the Recovery Plan due to their early-stage implementation status. These projects were deemed unlikely to be completed by the August 2026 deadline[6]. Among these are:

- Green hydrogen production projects (planned over BGN 64 million);
- Project for the production of heat and electricity from geothermal sources (BGN 343 million);
- Integrating the ecosystem approach and implementing nature-friendly solutions in the protection of protected areas from the Natura 2000 network (BGN 30 million);
- On-board equipment for the European Train Management System (BGN 63 million);
- Program for the construction of water supply and sewage systems, including treatment plants, for settlements with between 5,000 and 10,000 inhabitants (BGN 300 million);
- Modernization of the Aerospace Observation Center (BGN 110 million);
- Digitization of information arrays in the administration (nearly BGN 62 million);
- Improving the National Emergency Communications System at number 112 (nearly BGN 47 million).

The amended in 2025 Law amending and supplementing the Renewable Energy Sources Act[7] explicitly recognizes "green hydrogen" (alongside biogas) as a renewable energy source. Accordingly, the national framework for renewable energy is expanded to include not only electricity from wind/solar/biomass, but also energy from green hydrogen (and biogas) — including its production, transport, distribution and use.

The amendments introduce a number of concrete enabling measures facilitating green hydrogen deployment, among others:

- Producers of green hydrogen get guaranteed access to transmission and distribution networks — subject to network security criteria set by the operators.
- Network charges (for transmission or distribution) must not discriminate against green hydrogen or biogas compared to other forms of energy.
- Operators must publish tariffs for connection of green-hydrogen production sites, enabling transparent grid access.
- There is a mandatory purchase requirement: green hydrogen (with defined quality and pressure standards) must be accepted under contract either by the public supplier or end-suppliers — effectively ensuring a market for hydrogen produced.

While the law does not treat green hydrogen in isolation, the reforms to RES aim to align Bulgarian legislation with broader EU climate and energy goals:

- Simplified and accelerated administrative procedures for construction and grid-connection of renewable energy facilities, which lowers barriers also for hydrogen and other renewable infrastructure.
- Legal support for long-term contracts for renewable energy (e.g. "power purchase agreements"), which may provide investors in hydrogen-based energy systems greater certainty and stability.

[6] https://nextgeneration.bg/14

[7] Renewable Energy Sources Act (published in State Gazette No. 35 of 2011; amended in Nos. 29 and 54 of 2012, Nos. 15, 59, 68, and 109 of 2013, No. 33 of 2014; Decision No. 13 of the Constitutional Court of 2014 – No. 65 of 2014; amended, Nos. 14, 17, 35, 56, and 100 of 2015, No. 58 of 2017, Nos. 38 and 91 of 2018, No. 41 and 65 of 2020, No. 9 and 21 of 2021, No. 42 and 102 of 2022, No. 11, 54, 86 and 106 of 2023 and No. 14 of 2025)

- Inclusion of renewable energy (and implicitly hydrogen) among the priority sources for the sectors of energy, possibly industry, transport and buildings — setting the regulatory groundwork for hydrogen to play a role in the green transition.

The amendments to the Bulgarian Renewable Energy Act introduce green hydrogen explicitly into the legal framework for renewable energy, establishing the basis for regulating its production, transport, grid integration, and use across sectors. They create the legal preconditions for future support schemes, certification mechanisms, and streamlined administrative procedures, thus opening the way for investment and development of hydrogen value chains in Bulgaria.

Table 1 BEFORE vs. AFTER — Focus on Green Hydrogen

Area	*Before the amendments*	*After the amendments (2025)*
Legal status of green hydrogen	Green hydrogen was not explicitly defined or treated as a distinct renewable energy carrier.	Green hydrogen is explicitly recognized as a renewable energy source and incorporated into the scope of the Act.
Regulatory framework	No dedicated regulatory provisions for hydrogen production, transport, or use.	A specific regulatory basis is established for hydrogen-related activities (production, transport, integration into energy systems).
Grid access	Grid access rules focused primarily on electricity from RES (solar, wind, biomass).	Green-hydrogen producers fall under clarified grid-access and connection procedures, aligned with other RES.
Support measures	Incentive schemes did not explicitly include green hydrogen.	Hydrogen projects become eligible for RES-related support mechanisms, depending on secondary legislation (e.g., future schemes, guarantees of origin, investment support).
Planning & permitting	Hydrogen projects lacked defined administrative or planning rules.	Administrative processes begin to include hydrogen facilities, enabling more predictable development and permitting paths.
Sector integration (industry, transport, energy)	Hydrogen was referenced only indirectly through EU-level strategies and national planning documents.	The Act now enables cross-sector integration of green hydrogen (industry decarbonization, transport fuels, storage, blending, etc.), pending implementing regulations.
Guarantees of origin / certification	No national guarantees-of-origin scheme for hydrogen.	Legal grounds are created for a future certification system for renewable hydrogen (aligned with EU rules).
Investment conditions	No explicit investor certainty for hydrogen projects.	Hydrogen gains a clearer investment environment, as it is formally included in RES legislation and long-term planning.

Taking decisive action now can accelerate progress toward a greener and more sustainable future. By aligning with EU objectives and leveraging the opportunities presented by hydrogen technology, Bulgaria can ensure compliance and avoid potential penalties and sanctions.

Target areas are generalised in the following:

1. *Key Changes Relevant to Green Hydrogen*

✓ Formal Recognition - Green hydrogen is officially classified as a renewable energy source within legal framework, which ensures hydrogen is treated on equal footing with wind, solar, hydro, and biomass.

✓ Regulatory Framework for Production and Use covers hydrogen production, transport, and use across sectors; and hydrogen infrastructure is included within national renewable energy planning and reporting.

✓ Grid Access and Connection - Hydrogen production facilities benefit from clarified and harmonized procedures for grid access. The operators must apply non-discriminatory rules comparable to those for other renewable producers.

✓ Enabling Support Mechanisms - Legal grounds are established for future incentives, guarantees of origin, and certification schemes for renewable hydrogen, aligned with EU methodology. Hydrogen projects may become eligible for renewable energy support programs once secondary legislation is adopted.

✓ Streamlined Permitting and Administrative Processes - Hydrogen installations can follow simplified RES procedures, improving predictability for investors. This supports faster project initiation and reduces administrative uncertainty.

✓ Cross-Sector Integration - The amendments allow green hydrogen to be integrated into industry, transport, and energy systems, enabling decarbonization pathways beyond electricity generation.

2. *Expected Impact*

✓ Investor certainty increases, enabling planning of electrolyzer projects, hydrogen hubs, and industrial uses.

✓ Energy system flexibility improves, supporting storage and sector coupling.

✓ Alignment with EU hydrogen strategies positions Bulgaria to access EU funding, cooperation mechanisms, and cross-border projects.

✓ New economic opportunities emerge: domestic production, logistics, and green-tech workforce development.

3. *Remaining Gaps and Next Steps*

✓ Secondary legislation is needed to define - guarantees of origin and hydrogen certification rules; technical standards for infrastructure and quality; support schemes and market incentives; integration rules for gas grid operators.

✓ Strategic planning (national hydrogen strategy, hydrogen valleys) will be key to fully applying the law.

Devil in the Details: Is Our Economy Ready for the Hydrogen Revolution?

As Europe embraces the ambitious goals of the European Hydrogen Strategy, aiming for a carbon-neutral economy through deep decarbonization across multiple sectors, the demand for hydrogen is poised to surge. With the EU setting long-term targets, interest in hydrogen as an alternative energy source is skyrocketing, opening up new avenues for economic growth and innovation. However, **one of the most pressing issues facing our nation's economy is the persistent problem of low energy efficiency**. Outdated energy infrastructure leads to substantial losses during transmission, hampering our ability to compete effectively on the global stage. Moreover, the energy sector remains heavily reliant on imported resources, with escalating energy prices adding further strain.

To address these challenges and capitalize on the growing demand for hydrogen, Bulgaria must take several key steps. First, **modernize the energy infrastructure** to reduce transmission losses and improve overall efficiency. This involves investing in upgrading and modernizing power grids, enhancing storage capabilities, and integrating renewable energy sources. Second, **promote hydrogen technologies** across various sectors by developing and implementing policies that encourage their adoption. This includes supporting research and development, providing financial incentives, and creating a favorable regulatory environment for hydrogen projects. Third, **diversify the energy mix** to reduce dependence on imported energy resources. This entails increasing the share of domestically produced renewable energy sources, such as solar, wind, and biomass, and exploring the potential of hydrogen as a clean energy carrier. Lastly, **enhance energy efficiency** across all sectors of the economy by implementing measures to improve energy efficiency. This includes promoting energy-efficient technologies, encouraging energy conservation, and raising public awareness about the benefits of sustainable energy practices.

By the end of 2026, the National Plan for the Renovation of the Building Stock in Bulgaria will be prepared. The document represents a significant step towards improving energy efficiency and sustainability in the country's residential sector. By allocating BGN 2.5 billion until 2029, the Bulgarian government demonstrates its commitment to addressing climate change and reducing energy consumption through targeted investments in building renovations. In addition to environmental benefits, these efforts are expected to create jobs, improve living conditions, and reduce energy poverty among Bulgarian citizens.

Over BGN 1.58 billion will be allocated for energy efficiency in public buildings, photovoltaic systems for small and medium-sized enterprises, and the transformation of mining sites in Stara Zagora, Kyustendil, and Pernik. In Stara Zagora, programmes for innovation in defence technologies and hydrogen power are planned. The funds are provided by the Ministry of Regional Development and Public Works under the Fair Transition programme.

Currently, programs worth over BGN 1.17 billion are being implemented in the three regions, including the renovation of multi-family residential buildings and the diversification of small and medium-sized enterprises. An agreement with the Ministry of Labor and Social Policy to map the skills of the affected persons is financed with BGN 3 million.

By the end of 2025, three new procedures will be opened: for the socio-economic transformation of mining areas (budget of BGN 475 million), pilot initiatives for energy communities and energy efficiency in public buildings (BGN 300 million), and for small and medium-sized businesses to build photovoltaic systems (BGN 142 million). Measures are also planned for innovation in defense technologies (BGN 85 million) and for a hydrogen value chain in Stara Zagora (over BGN 263 million).

The hydrogen economy offers significant opportunities for Bulgaria, particularly in enhancing energy efficiency and independence. Although Bulgaria is relatively lacking in fossil fuel reserves, it possesses abundant natural resources suitable for renewable energy sources (RES). Unfortunately, these resources remain largely untapped due to unclear regulatory frameworks and complex administrative procedures. Nevertheless, Bulgaria stands out as one of the 11 European Union member states that have either surpassed or met their 2020 renewable energy targets. By 2012, the country had successfully achieved its national mandatory goal of a 16% share of renewable energy in gross final energy consumption by 2020. This accomplishment was facilitated by a diverse mix of renewable energy installations, including 3.2 GW of hydroelectric power plants, 1.1 GW of solar photovoltaic systems, and 0.7 GW of wind power capacity.

The forecast for the development of Bulgaria's production capacity until 2034, in the Plan for the development of the transmission electricity transmission network of Bulgaria for the period 2025-2034 is based on the investment intentions expressed by the production companies[8].

Table 2 Planned connection of RES and CHP to the electricity transmission and distribution networks

Type RES	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Wind power plants	204	350	7	7	115	274	7	7	7	7
Photovoltaic power plants	4681	3621	1449	649	646	1271	446	250	360	240
Hydroelectric power plants	5	0	0	0	0	0	0	5	800	800
Bio-power plants	1	2	2	5	5	5	2	2	2	2
Battery energy storage facilities	1	4564	62	86	72	137	87	112	112	62
Total	4892	8537	1520	747	838	1687	542	376	1281	1111

Source: Plan for the development of the transmission electricity transmission network of Bulgaria for the period 2025-2034, (updated on 03.11.2025), https://www.eso.bg/doc?93

Bulgaria's potential for renewable energy development extends far beyond its current utilization levels. Geographically, it lies within the so-called "solar belt," which indicates favorable conditions for harnessing solar energy. However, the country also holds considerable promise for wind energy, with increasing interest in offshore wind power projects in the Black Sea. According to data from Hydrogen Europe, Bulgaria has immense potential for generating energy from renewable sources, utilizing only approximately 4% of its total capacity at present.

These factors create substantial opportunities for advancing green hydrogen production in Bulgaria, with significant potential for export. Consequently, Bulgaria could emerge as a key player in the global green hydrogen market. The proposed reforms and investments in the REPowerEU chapter aim to achieve several key objectives: improving the energy efficiency of buildings and critical energy infrastructure, decarbonizing industry, increasing the production and uptake of sustainable biomethane and hydrogen from renewable or non-fossil sources, and increasing the share and accelerating the uptake of energy from renewable sources.

One significant contribution towards these goals is Investment 5 (C13.I5): Installation of photovoltaic systems in existing social service buildings and provision of electric vehicles and

[8] Plan for the development of the transmission electricity transmission network of Bulgaria for the period 2025-2034, (updated on 03.11.2025), https://www.eso.bg/doc?93

related charging stations for the provision of social services. This initiative is proposed and should be implemented by the Ministry of Labor and Social Policy (MLSP).

The primary objective of this investment is to enhance energy efficiency, reduce energy dependence, and improve operational sustainability in the social services sector through two complementary components: integrating solar panels into municipal social service buildings to generate clean electricity, thereby reducing reliance on traditional grid power and cutting energy costs while contributing to local energy production and lowering carbon emissions; and supplying electric vehicles for social services to reduce fuel costs and greenhouse gas emissions compared to conventional internal combustion engine vehicles, with charging stations ensuring convenient recharging. Through these efforts, Investment 5 aims to bolster energy efficiency, decrease energy dependency, and foster operational sustainability within the social services sector, aligning with the broader objectives of the REPowerEU chapter.

Table 3 Key Statistics & Targets for Green Hydrogen in Bulgaria

Indicator / Project / Target	***Value / Description***
Electrolyser capacity (pilot + near-term target)	55 MW of electrolyser capacity planned under pilot projects by 2025.[9]
Annual green hydrogen production (pilot-phase target by 2025)	7,800 tonnes of renewable hydrogen per year.[10]
Funding for national hydrogen / RES-hydrogen plan (2025)	As part of the national plan, total investment for the hydrogen roadmap (electrolysers + production + infrastructure) is indicated at ~ BGN 136.9 million (with ~ BGN 68.5 million expected as private co-financing)[11].
Major EU-funded hydrogen project: H2START	Grant of **€15 million** from the EU (under Horizon Europe) and co-financing for establishing a Centre of Excellence for renewable hydrogen in Stara Zagora.
Hydrogen production target for H2START site	The project aims to produce **500 tonnes of hydrogen annually** at the Stara Zagora site.
Planned demonstration project: ZAHYR (Zagora Sustainable Hydrogen Region)	Transport sector: a gradual transition to fully hydrogen-powered engines. Industrial processes: innovative solutions for storing ammonia and using it to produce hydrogen; hybrid infrastructure for hydrogen production that combines electrolysis and ammonia cracking technologies; industrial applications of hydrogen for heating and fertilizer production. Installation and operation of a hydrogen refueling station.
Renewables share in national energy mix (2023)	In 2023, renewables accounted for **22.55%** of Bulgaria's gross final energy consumption — a 3.51 pp increase from 2022[12].

In addition to these developments, Bulgaria is actively working on improving its regulatory environment and streamlining administrative processes to facilitate investment in renewable energy projects. This includes simplifying permitting procedures, enhancing grid infrastructure, and providing financial incentives to attract both domestic and foreign investors. Furthermore,

[9] https://gh2.org/countries/bulgaria?utm_source=chatgpt.com
[10] https://gh2.org/countries/bulgaria?utm_source=chatgpt.com
[11] Energy & Climate Change
[12] European Envirnoment Agency, https://www.eea.europa.eu/en/europe-environment-2025/countries/bulgaria/renewable-energy-sources?utm_source=chatgpt.com

ongoing research and development efforts are focused on optimizing the integration of renewable energy sources into the existing energy system, ensuring stability and reliability while maximizing the benefits of clean energy. **Moreover, Bulgaria is exploring partnerships and collaborations with other countries and organizations to leverage expertise and resources in the field of renewable energy and hydrogen technologies.** Such collaborations aim to foster innovation, knowledge sharing, and best practices, ultimately contributing to the sustainable growth of the Bulgarian energy sector.

By leveraging the opportunities presented by the growing hydrogen economy, Bulgaria can enhance its energy security, boost its competitiveness, and contribute to the EU's ambitious decarbonization goals. This will not only strengthen the country's position within the European energy market but also pave the way for a more sustainable and prosperous future.

Rising natural gas prices, coupled with disruptions in supply chains within the country, are important factors contributing to the development of green hydrogen production through renewable energy sources and its consumption. These factors highlight the vulnerability of traditional energy systems and underscore the need for diversification. One advantage of producing clean hydrogen is the limitation on financing for fossil fuels by the European Investment Bank, while simultaneously funding innovations in clean energy, energy efficiency, and renewable energy sources. This shift in investment priorities reflects the EU's commitment to achieving climate neutrality and reducing reliance on fossil fuels.

However, a **primary economic obstacle related to hydrogen is the production cost**. Producing hydrogen, especially "green" hydrogen, is expensive and therefore may not be the preferred first option for end users. The production cost of green hydrogen varies between €3 and €8 per kilogram, influenced by renewable energy prices and electrolyzer efficiency. Costs are trending downward, with projections for 2050 indicating as low as $1.50 per kg from wind and $1.92 per kg from solar, driven by decreasing renewable energy and electrolyzer costs, coupled with technological advancements. Blue hydrogen production costs around €2 per kilogram. Meanwhile, fossil fuel-based hydrogen is produced at a price of €1.50 per kilogram[13][14].

This disparity in production costs highlights the need for targeted policies and incentives to bridge the gap between the cost of green hydrogen and conventional alternatives. Possible patterns here include:

- Government Subsidies and Grants: Providing direct financial support to hydrogen producers to offset the higher production costs and make green hydrogen more competitive.
- Carbon Pricing Mechanisms: Implementing stricter carbon pricing schemes to increase the cost of fossil fuel-based hydrogen, thereby making green hydrogen more economically viable.
- Research and Development Funding: Investing in R&D to drive down the cost of green hydrogen production through technological advancements and efficiency improvements.

The cost of green hydrogen should be analyzed in the long term, considering plans for decarbonization, rising carbon dioxide emission quota prices, and the increasing costs of fossil

[13] Kotowicz, J.; Baszczeńska, O.; Niesporek, K. Cost of Green Hydrogen. *Energies* **2024**, *17*, 4651. https://doi.org/10.3390/en17184651

[14] The green hydrogen economy, Predicting the decarbonisation agenda of tomorrow, https://www.pwc.com/

fuels themselves. Over time, as the cost of fossil fuels continues to rise due to scarcity and environmental regulations, green hydrogen may become increasingly cost-competitive.

Additionally, the expenses for developing transportation and storage infrastructure also play a significant role. Adapting the existing gas network for hydrogen transmission offers a practical solution, potentially reducing the overall cost of hydrogen infrastructure development.

For producers, operators of transmission systems, and operators of distribution systems, there is a prevailing lack of security for their investments, high investment risks, and greater return on investment, partly due to the current "galloping" inflation. To address these concerns, several patterns emerge:

- Stable Regulatory Frameworks: Establishing clear and stable regulatory frameworks that provide long-term certainty for investors and operators.
- Risk Mitigation Strategies: Developing risk mitigation strategies, such as insurance schemes and hedging mechanisms, to protect against market volatility and unforeseen events.
- Public-Private Partnerships: Encouraging public-private partnerships to share the financial burden and leverage collective expertise in managing large-scale hydrogen projects.

While the production cost of green hydrogen remains a significant hurdle, the long-term benefits of transitioning to a cleaner energy system cannot be overstated. By addressing the economic obstacles through targeted policies, fostering innovation, and ensuring investment security, Bulgaria can position itself as a leader in the emerging hydrogen economy. This transition will not only contribute to the EU's decarbonization goals but also enhance the country's energy security and economic resilience.

Communities Rising: The Force Behind Sustainable Futures

Society holds a pivotal role in shaping the trajectory of our collective future, acting as the principal stakeholder within the value chain as an end consumer. Consequently, comprehending their apprehensions and inquiries becomes paramount.

A prevalent concern revolves around energy security. Coal and coal-derived fuels constitute 31.3% of the nation's overall energy balance. To ensure alignment with the commitment towards achieving net-zero emissions and fulfilling obligations under international accords such as the Paris Climate Agreement, Bulgaria must transition away from coal usage by 2030. The most industrialized coal mining regions encompass Pernik, Bobov Dol, and Stara Zagora. By 2024, these regions sustained employment for close to 13000 individuals in the sectors of "Extraction of Energy Products" and "Electricity Production." Looking ahead, coal-generated electricity will face mounting challenges in terms of competitiveness. Without a well-defined strategy for business transformation in these regions, job losses are inevitable. Hence, there is an urgent need to expedite the development of alternative renewable energy capacities and facilitate opportunities for workers in the industry to select between compensation packages and reassignment to other sectors, coupled with comprehensive retraining programs[15].

In addition to the above, the reliability of natural gas supplies has been significantly compromised. According to recent data, disruptions in natural gas deliveries have increased by 30% over the past year, particularly affecting regions such as Sofia, Plovdiv, and Varna, where

[15] Decarbonising the Bulgarian Power Sector, Resolving the Coal Phase-Out – Security of Supply Conundrum, © 2023, Center for the Study of Democracy

industries and households heavily rely on natural gas. This has led to heightened concerns about energy security across the country. Furthermore, the average household energy bill has surged by 15%, primarily due to the lack of competition among various gas suppliers. In regions like Burgas and Stara Zagora, where energy consumption is high, consumers are experiencing even greater financial strain, with an estimated 40% reporting difficulty in managing these increased costs[16]. This situation is expected to impact employment in the sector, as approximately 20% of current jobs may be displaced due to the gradual phase-out of natural gas. The shift towards cleaner energy sources is projected to create new opportunities, but there will likely be a transitional period during which job losses could reach up to 10%, particularly in industrial hubs like Ruse and Pleven.

A critical factor tied to social aspects in decarbonization is public awareness. Studies show that only 25% of citizens are well-informed about alternative energy production, delivery, usage, and safety measures. This knowledge gap poses a significant challenge to achieving smooth decarbonization efforts. Notably, surveys indicate that 60% of people express concern or fear regarding the adoption of hydrogen technology, highlighting the need for extensive education and outreach programs, especially in regions like Blagoevgrad and Veliko Tarnovo, where traditional energy sources still dominate[17].

To address these concerns, it is essential to implement comprehensive educational initiatives and demonstration projects focused on the transition to a hydrogen economy. These programs should aim to familiarize citizens with new gases, such as H2, and clarify how the transition will affect their daily lives, including impacts on appliances, infrastructure, and health. By investing in public awareness and understanding, we can better navigate the complexities of the energy transition and ensure a smoother path toward a sustainable future, particularly in regions undergoing rapid economic and demographic changes, such as Sofia-City and the Black Sea coast.

Societal opinions on hydrogen as a clean energy source are multifaceted and influenced by various factors. Firstly, economic concerns play a significant role, with many individuals expressing apprehension about the potential costs associated with adopting hydrogen technology. This includes worries about personal expenses, as well as broader economic implications for the nation. Secondly, technical literacy is identified as a key determinant of public sentiment. Those with a deeper understanding of hydrogen technology tend to exhibit more positive attitudes, whereas those lacking such knowledge often harbor reservations and skepticism. Additionally, regulatory uncertainties contribute to public hesitancy. Unclear policies and regulations surrounding hydrogen production, distribution, and use create ambiguity and doubt about its long-term viability. Moreover, fear of the unknown is a prevalent issue, with many citizens being unfamiliar with hydrogen technology and its applications. This lack of familiarity breeds apprehension and resistance to embracing hydrogen as a mainstream energy solution.

Effective communication and community engagement are recognized as pivotal strategies for improving public opinion. Demonstrating tangible benefits through real-world examples and involving local communities in awareness campaigns can foster trust and encourage acceptance. Finally, addressing these concerns through targeted education, community

[16] https://netzerolab-feba.bg/bg/knowledge-box/consumer-choice/

[17] Energy Sector Governance and Energy (In)security in Bulgaria, ISBN: 978-954-477-214-7 © 2014, Center for the Study of Democracy

engagement, and clear policy frameworks is essential for building public trust and support for hydrogen as a viable energy solution.

Leading the Charge: Pioneering Technology and Hydrogen Innovations

Bulgaria ratified the Paris Agreement, committing to limiting global warming to below 2°C by 2050 relative to pre-industrial levels. As one of the first 14 nations, Bulgaria embraced hydrogen as an alternative energy source through its National Policy Framework for the Development of Alternative Fuels Market in the Transport Sector and related infrastructure. Despite these efforts, Bulgaria maintains a significantly carbon-intensive economy. Thermal power plants utilizing low-calorie lignite account for approximately 36% of the nation's electricity generation. The Maritsa Iztok complex, with a capacity of 3.4 GW, contributes around 80% of this output. This reliance on fossil fuels has resulted in chronic air pollution issues, making Bulgaria one of the most polluted regions in Europe. Specifically, Bulgaria leads the European Union in "Years of Life Lost due to Air Pollution," with an average of 2400 affected individuals per 100,000 inhabitants, compared to 1500 across the EU. To address these challenges, the integration of hydrogen technologies into industrial, transportation, and domestic sectors holds significant potential for mitigating environmental impacts and fostering sustainable economic growth.[18]

The prospects for green hydrogen production largely depend on Bulgaria's capacity to generate electricity from renewable energy sources (RES) to meet the demand for clean hydrogen while accounting for domestic electricity consumption. In terms of gross electricity production, the share of RES is significantly lower than in installed capacities and amounted to 17.5%, or a total of 8,380,132 MWh in 2021. This trend is expected to continue, with projections indicating that by 2024, the share of RES in gross electricity production could rise to around 19%, reaching approximately 9,000,000 MWh.

Electricity consumption for hydrogen production from Power to X installations is expected to reach 47 GWh by 2030. However, interim projections suggest that by 2025, this consumption could already amount to about 20 GWh.[19] Hydrogen will also play a significant role in transportation, where it is projected that 3 ktoe of hydrogen will power the sector by 2030, equivalent to 34 GWh, representing 1.1% of the sector's energy consumption. By 2025, the contribution of hydrogen to the transportation sector is estimated to be around 15 GWh.[20]

To achieve these goals, additional infrastructure and new RES capacities need to be built. According to data from the Electricity System Operator (ESO), over the past two years, applications have been submitted for the construction of new RES facilities exceeding 24,000 MW, reaching the absolute limit of the electricity system, which requires urgent and adequate planning for future expansion of the electricity transmission system. When the energy system becomes saturated with RES, ensuring its sustainability and achieving seasonal and annual energy balance will be crucial.

By 2024, it was anticipated that the installed capacity of RES would increase substantially, potentially reaching up to 30,000 MW, which will require careful management and integration into the existing grid infrastructure[21]. These developments underscore the importance of strategic

[18] 2023 Country Report, Bulgaria, Institutional Paper 226 | June 2023, ISSN 2443-8014 (online)
[19] IEA (2025), *Electricity 2025*, IEA, Paris https://www.iea.org/reports/electricity-2025, Licence: CC BY 4.0
[20] Tenth EnerCEE Report: Hydrogen Strategies in the NECPs Of Bulgaria, Croatia, Latvia and Slovakia, https://www.enercee.net/fileadmin/user_upload/Twitter_header_enerCEE_v7_EN_0818.png
[21] European Envirnoment Agency, https://www.eea.europa.eu/en/europe-environment-2025/countries/bulgaria/renewable-energy-sources

planning and investment in both generation and transmission capabilities to support the growth of green hydrogen production and overall energy transition efforts.

Table 4 H2 industrial framework

Industry	Energy
The primary method of obtaining hydrogen for industrial use is through steam reforming of natural gas, yielding gray hydrogen. Smaller productions rely on imported bottled hydrogen from abroad or produce it via electrolysis using industrial electricity (blue hydrogen). Major consumers of hydrogen include LUKOIL Neftochim Burgas, the largest refinery in Southeast Europe, accounting for 4% of the EU's refining output, and the fertilizer industry in Devnya and Dimitrovgrad, representing 3% of European production. Currently, NEochim-Dimitrovgrad uses hydrogen for ammonia production, while Devnya imports raw materials for fertilizer manufacturing. Hydrogen can also help reduce energy intensity in various high-temperature industrial processes. According to Hydrogen Europe, the annual consumption of hydrogen (gray hydrogen) in Bulgaria is around 200,000 tons.	**For Bulgaria, the gradual restructuring of coal-fired power plants is crucial, especially for the Maritsa Iztok complex. To maintain its significance, a phased transformation into a zero-emission complex can be achieved through:** **1. Building photovoltaic parks for electricity and hydrogen production, potentially reaching 21 GW.** **2. Establishing a hydrogen hub for internal and market needs, including supplying NEochim and exporting.** **3. Introducing gas turbines using a mixture of natural gas and hydrogen, transitioning to hydrogen gas turbines later.** **This model can be replicated in other regions, starting with a pilot project for a hydrogen valley. Fuel cells will also play a role in reducing heating emissions in urban areas.**
Transport	**Storage**
Bulgaria was among the first 14 EU member states to formally recognize hydrogen as an alternative fuel through the National Policy Framework (НРП) for the development of alternative fuels in the transport sector. This framework was established in compliance with Article 3 of Directive 2014/94/EU and aims to create a favorable environment for the wider adoption of alternative fuels and propulsion systems in transportation. Member states are required to submit National Reports outlining their plans for hydrogen infrastructure deployment, introduction of hydrogen-powered vehicles, and related investments until 2030.	1. **Additional research on pipeline transport options**: Investigate the feasibility of transporting hydrogen through metal and polyethylene pipelines. 2. **Research on bottle-based battery transport**: Study the possibilities and economic efficiency of transporting hydrogen using bottle-based batteries. 3. **Pilot project for hydrogen injection into the gas distribution network**: Implement a pilot project to test the injection of hydrogen into the existing gas distribution network.

Government Support and Policy Framework: The Bulgarian government has shown increasing interest in supporting the development of hydrogen technologies. New policies and regulations are being introduced to incentivize investments in hydrogen production and infrastructure. Recent legislation aims to streamline permitting processes and provide financial incentives for hydrogen projects. Specifically, the National Hydrogen Strategy outlines plan to allocate €1 billion in funding for hydrogen projects by 2030.

Research and Development Initiatives: Several research institutions and universities in Bulgaria are actively engaged in developing innovative hydrogen technologies. Projects funded by national and European programs aim to improve efficiency and reduce costs associated with hydrogen production and storage. Notably, the Institute of Electrochemistry and Energy Systems at the Bulgarian Academy of Sciences has secured €5 million in EU funding for a project to develop high-efficiency electrolyzers.

Public-Private Partnerships: Collaborative projects between public authorities and private companies are emerging to accelerate the deployment of hydrogen solutions. These partnerships focus on building pilot plants, testing new technologies, and integrating hydrogen into existing energy systems. One notable partnership involves the establishment of a hydrogen valley in Northern Bulgaria, supported by both local and international partners, with an initial investment of €200 million.

Hydrogen Clusters and Networks: Bulgaria is part of several international hydrogen clusters and networks, such as the European Clean Hydrogen Alliance. These collaborations facilitate knowledge sharing, technology transfer, and joint projects aimed at scaling up hydrogen production and use across Europe. Bulgaria's participation in these networks enhances its visibility and attractiveness for international investment. Over the past year, Bulgaria has signed 12 Memoranda of Understanding with other European countries to collaborate on hydrogen projects.

Investment Opportunities: With the growing global interest in hydrogen, there are increasing opportunities for investment in hydrogen projects in Bulgaria. Both local and foreign investors are exploring options to participate in the development of hydrogen infrastructure and production facilities. Major multinational corporations are showing interest in establishing hydrogen hubs in Bulgaria due to its strategic location and favorable regulatory environment. Investments in hydrogen projects in Bulgaria are projected to reach €3 billion by 2030.

Education and Training Programs: Specialized training programs are being developed to equip professionals with the necessary skills to work in the hydrogen sector. This includes courses on hydrogen production, storage, distribution, and safety protocols. Universities and vocational schools are collaborating with industry partners to ensure that curricula are aligned with the latest technological advancements and industry needs. Over the next five years, it is estimated that 5,000 professionals will undergo specialized hydrogen training.

Innovation Hubs and Start-ups: Several innovation hubs and start-ups focused on hydrogen technologies are emerging in Bulgaria. These ventures are leveraging cutting-edge research and entrepreneurial spirit to develop innovative solutions for hydrogen production, storage, and utilization. Government initiatives are providing grants and incubation support to foster the growth of these start-ups. Currently, according to Green Hydrogen Association there are 25 active start-ups in the hydrogen sector in Bulgaria, with a combined valuation of €150 million. Hydrogenera is a member of the European Clean Hydrogen Alliance that is involved in large-scale deployment of clean hydrogen technologies (more than 80 projects in Bulgaria, Poland, and Turkey).

Integration with Existing Infrastructure: Efforts are underway to integrate hydrogen production and distribution with existing natural gas infrastructure. This approach leverages the extensive pipeline network and storage facilities available in Bulgaria, reducing the need for new dedicated hydrogen infrastructure and accelerating the adoption of hydrogen as a clean energy source. By

2025, it is projected that 20% of the existing natural gas pipelines will be repurposed for hydrogen transport.

These market and industry innovations highlight Bulgaria's commitment to becoming a key player in the European hydrogen economy. As the country continues to invest in research, infrastructure, and policy frameworks, it is well-positioned to contribute significantly to the growth of the hydrogen sector in the coming years.

In 2022, "Bulgartransgaz" EAD announced its 10-year network development plan, which includes retrofitting the existing infrastructure to work with up to 10% hydrogen and building new hydrogen infrastructure between Sofia and Kulata. Here are the main points from this plan:

- Retrofit of Existing Infrastructure: Modernization of existing pipelines and facilities so that they can operate with up to 10% hydrogen. This is an important step towards gradually integrating hydrogen into the energy grid without requiring large-scale new construction.
- New Hydrogen Infrastructure: Plans include building new infrastructure for hydrogen between Sofia and Kulata. This new infrastructure will enable the transportation of hydrogen from production centers to consumers and support the development of a hydrogen economy in the country.
- Strategic Importance: These measures are part of the broader strategy of the European Union for decarbonization and transition to clean energy. Hydrogen is seen as a key element in this transformation, especially in sectors where electrification is difficult or impossible.
- Collaboration and Funding: To implement these projects, collaboration with international partners and funding from European funds and programs focused on green energy and sustainable development will likely be sought.

This 10-year plan demonstrates "Bulgartransgaz" commitment to innovation and sustainable development while emphasizing the importance of hydrogen in Bulgaria's future energy system.

While the most economical way to transport large quantities of hydrogen over distances less than 1,500 km is through pipelines, the initial capital costs for building a new hydrogen pipeline network are expected to be higher than constructing a natural gas pipeline due to hydrogen embrittlement concerns. One of the obstacles arising during the low-carbon transition is the lack or limited availability of certain technologies. To achieve the outlined goals regarding hydrogen mobility in Bulgaria, it is necessary to build hydrogen charging infrastructure.

An existing technological barrier to the transformation towards a hydrogen economy is the end-user appliances that must be compatible with the new gases. In addition to production and storage, hydrogen is also included in Bulgaria's innovation policies, where research will be conducted on hydrogen-based models and technologies related to energy storage, eco-mobility, and the implementation of electrochemical energy sources. The Bulgarian government has been allocating €10 million in funding for hydrogen research and development projects between 2021 and 2027, aiming to foster innovation and support the growth of the hydrogen sector[22].

Ecology matters

Bulgaria's CO2 emissions have historically been influenced by its reliance on coal for electricity generation, heavy industry, and transportation. According to the European Environment Agency (EEA), Bulgaria's total greenhouse gas (GHG) emissions in 2020 amounted to approximately 53

[22] National Roadmap for the Hydrogen Development, 2023

million tonnes of CO2 equivalent. This figure represents a decrease compared to previous years, indicating progress in reducing emissions. Bulgaria has made strides in transitioning to cleaner energy sources, including wind, solar, and hydroelectric power. These efforts align with the country's commitments under the Paris Agreement and the EU's Green Deal, which aim to achieve climate neutrality by 2050[23][24][25].

Hydrogen is seen as a key component in Bulgaria's strategy to further reduce CO2 emissions. The country is developing a comprehensive hydrogen strategy that encompasses several key areas: First, Bulgaria is investing in the necessary infrastructure to support hydrogen production, storage, and distribution. Second, the country is supporting research and development initiatives to improve hydrogen production technologies and make them more efficient and cost-effective. Third, Bulgaria is leveraging its abundant renewable energy resources, such as solar and wind power, to produce hydrogen through electrolysis. This process involves splitting water molecules into hydrogen and oxygen using electricity generated from renewable sources, resulting in zero direct CO2 emissions. Fourth, the country is encouraging the use of hydrogen in industries such as steelmaking, chemicals, and refining, where it can replace fossil fuels and significantly reduce CO2 emissions. Finally, Bulgaria is promoting the use of hydrogen fuel cells in vehicles, which emit only water vapor as a byproduct, thereby contributing to cleaner transportation.

Despite these advancements, challenges remain. Making hydrogen production via electrolysis economically competitive with traditional methods that rely on fossil fuels is one such challenge. Additionally, building the necessary infrastructure for hydrogen production, storage, and distribution across the country poses another hurdle. Increasing public awareness and acceptance of hydrogen as a viable energy source is also crucial.

Bulgaria's efforts to reduce CO2 emissions and embrace hydrogen technologies reflect a broader trend within the European Union. By leveraging its renewable energy potential and investing in innovative technologies, Bulgaria aims to position itself as a leader in the emerging hydrogen economy. This transition will not only contribute to meeting international climate goals but also enhance the country's energy security and economic competitiveness.

It is necessary to implement a transformation towards hydrogen technologies in industry, transportation, and households. **The use of H2 does not emit carbon, but its production often does.**

In addition to environmental factors, we must consider the production processes of H2. Hydrogen can be used to power vehicles, supply electricity, and heat homes without emitting any carbon. However, most H2 is currently produced from fossil fuels. Although it contributes to decarbonization, the production of brown and blue H2 releases significant amounts of CO2. For every kilogram of H2 produced through natural gas reforming or coal gasification technology, between 11kg and 20kg of CO2 are emitted. To produce 1kg of low-carbon H2 with capture, between 4kg and 10kg of CO2 are released. This necessitates the wider use of "green" processes for producing clean H2 using renewable energy sources (RES). This, in turn, requires the necessary natural resources.

To transition to a hydrogen economy, with increased production of green H2 through electrolysis, enough water resources is required. Electrolysis requires both water and electricity.

[23] Roadmap to EU climate neutrality – Scrutiny of Member States, © European Union, 2024
[24] European Commission, 2024 Country report – Bulgaria, 2024.
[25] Republic of Bulgaria, Bulgaria – Draft updated NECP 2021-2030, 2024.

Approximately 9 liters of water are needed to produce 1 kg of H2. Bulgaria stands out with relatively significant water resources compared to other European countries, both in absolute volume and per capita. Here, territorial location plays a crucial role. Regions around the Danube River, the Black Sea, and reservoirs are expected to host more large projects related to "green" hydrogen technologies.

What is the binding legal framework

National Recovery and Sustainability Plan (NRSP):

- Period: 2021-2026
- Key Focus: Economic and social recovery from the COVID-19 pandemic, with emphasis on green transition, digital transformation, and resilience. Includes funding for renewable energy projects, energy efficiency improvements, and sustainable transport.

Integrated Energy and Climate Plan (IEECP) 2021-2030:

- Period: 2021-2030
- Key Focus: Reducing greenhouse gas emissions, increasing energy efficiency, promoting renewable energy sources, and ensuring energy security. Sets targets for hydrogen production and consumption, as well as the development of alternative fuels infrastructure.

National Framework for Policy Development of the Alternative Fuels Market in the Transport Sector:

- Period: Ongoing
- Key Focus: Promoting the use of alternative fuels like hydrogen and electricity in the transport sector. Includes plans for building hydrogen refueling stations and expanding electric vehicle charging infrastructure.

Integrated Transport Strategy up to 2030:

- Period: Up to 2030
- Key Focus: Improving transport connectivity, enhancing safety, and reducing environmental impact. Promotes the use of alternative fuels and energy-efficient transport modes.

Operational Programs for the Period 2021-2027:

- Environment Program: Supports projects related to waste management, water treatment, biodiversity conservation, and climate change adaptation.

The **Innovation Strategy for Smart Specialization (ISSS) 2021-2027** presents a comprehensive plan for Bulgaria's technological advancement and economic growth. Central to this strategy is the recognition of hydrogen as a key driver for energy independence and decarbonization across multiple industries and economic sectors under the thematic area "Clean Technologies, Circular and Low-Carbon Economy." The strategy underscores the significance of hydrogen-based technologies, encompassing green hydrogen production, storage, transportation, and utilization in industry, energy, transport, and households.

Additionally, it emphasizes the development and deployment of technologies associated with sustainable mobility, particularly battery and hydrogen fuel cell technology, along with supporting infrastructure and eco-mobility solutions. Notably, for the first time in a national document, battery and hydrogen electro-mobility are explicitly defined. A special focus is placed on Bulgaria's expertise in retrofitting "fuel cell/battery" systems onto various types of vehicles.

This innovative approach not only enhances vehicle sustainability but also holds the potential to stimulate growth in other high-value sectors of the economy. To fully leverage these opportunities, the integration of these advancements into the roadmap is highly recommended.

The **National Recovery and Sustainability Plan (NRSP)** establishes a comprehensive framework applicable throughout the Republic of Bulgaria. It includes 47 reforms and 57 investments across 12 components aimed at achieving the primary goal of economic and social recovery from the crisis. Hydrogen plays a significant role through Reform 7, which involves drafting a National Roadmap to improve conditions for developing hydrogen technologies and mechanisms for hydrogen production and delivery. This roadmap will have a multiplier effect, filling gaps in other documents and creating a favorable environment for accelerating the adoption of hydrogen technologies. It will also serve as a basis for updating the NRSP according to recommendations

from the European Commission. Investment 5, titled "Scheme for Supporting Pilot Projects for Green Hydrogen and Biogas Production," will lay the groundwork for launching the first pilot projects in this field.

In the **Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030 (IEECP)**, the main objectives for stimulating low-carbon economic development, fostering competitive and secure energy, and reducing dependency on imported fuels and energy are outlined. Achieving the goals set in the IEECP requires comprehensive actions across all areas of socio-economic relations. In this context, the IEECP includes provisions for using green hydrogen produced via renewable energy sources, including electricity generated from wind and solar power. As a foundation for developing hydrogen capacity in Bulgaria, the IEECP aims to establish a pilot project for hydrogen production with a total installed capacity of 20 MW by 2030.

The **National Framework for Policy Development of the Alternative Fuels Market in the Transport Sector and Deployment of Relevant Infrastructure** proposes forecast targets, opportunities, and potential measures regarding charging infrastructure for electric and hydrogen-powered vehicles. According to the National Framework, Bulgaria is one of 14 countries committed to building hydrogen refueling station (HRS) infrastructure.

In the **Integrated Transport Strategy up to 2030**, Strategic Priority 5 focuses on "Reducing Fuel Consumption and Increasing Energy Efficiency in Transport." One of the goals under this priority is "Promoting the Use of Alternative Fuels," with specified measures for its achievement.

Additional complementary measures outside the National Recovery and Resilience Plan can be found in programs for the period 2021-2027: the Environment Program, Regional Development Program, and Transport Connectivity Program.

These documents and strategies outline Bulgaria's commitment to transitioning towards a greener, more sustainable economy while addressing critical challenges in energy, climate, and transport sectors. They provide a framework for policy development, investment, and collaboration between public and private stakeholders.

INVESTING IN THE FUTURE: FINANCIAL STRATEGIES FOR HYDROGEN INFRASTRUCTURE DEVELOPMENT

Public-Private Partnerships: Bridging the Funding Gap and Catalyzing Growth

Where is the place of Bulgaria on the European and global hydrogen map?

Figure 4 SDG Bulgaria overview

Source: Eurostat database

The first Strategic Energy Technology Plan (SET) was launched in 2008, aiming to stimulate the development of low-carbon technologies through collaboration between Member States, businesses, academia, and the European Union. A review of this plan is planned for 2022, with the Commission proposing that hydrogen become a key element in the transition to clean energy. In the same year, the European Energy Research Alliance (EERA) was established to coordinate research activities in EU countries in line with the strategic plan. Since 2014, the Bulgarian Academy of Sciences (BAS) has been part of the EERA in the "Fuel Cells and Hydrogen" and "Energy Storage" programs.

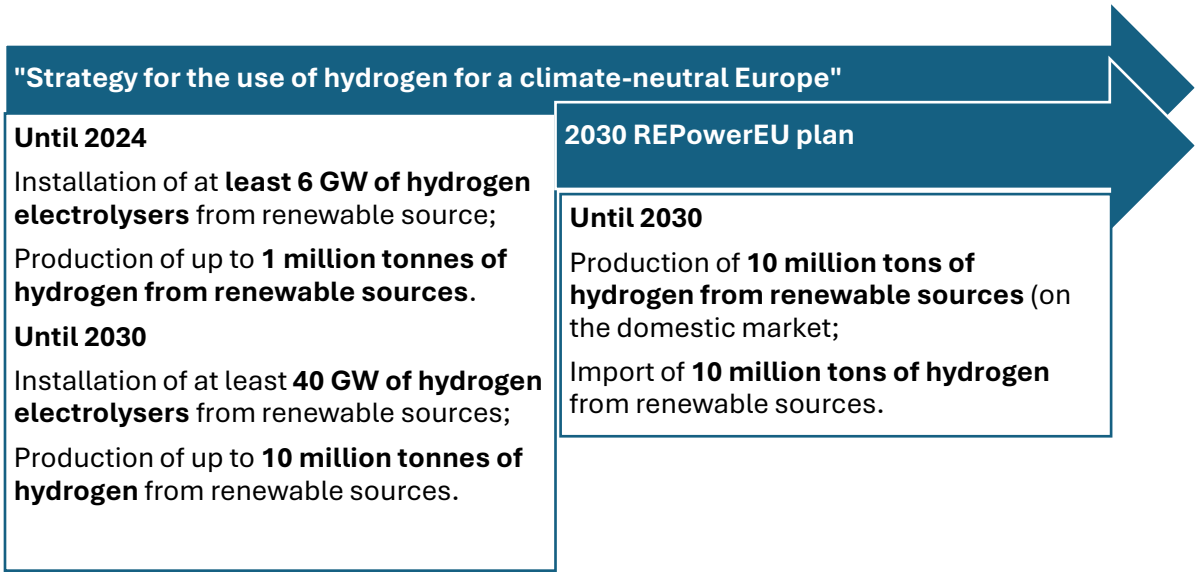
In 2008, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) was launched – an ambitious project bringing together the efforts of the European Commission, European industry, and science. The goal? To accelerate the implementation of hydrogen technologies in the real world through large-scale investments in research and innovation. Bulgaria is not lagging either – since 2014, the Bulgarian Academy of Sciences (BAS) has been actively participating in the research group, and since 2021, the Institute for Sustainable Transition and Development (ISTD) at Trakia University has also joined. Finally, Bulgaria is also part of the Association Group of the Industrial Group with the Bulgarian Association for Hydrogen, Fuel Cells and Energy Storage.

The Clean Energy for All Europeans energy package was presented in 2016, which aims to accelerate the transition to a clean and efficient energy system. This package contains specific measures and instruments that oblige each Member State, including Bulgaria, to create its own framework program. These programs, called integrated national energy and climate plans, provide the basis for implementing new policies and strategies. The Energy Package has evolved into the most ambitious European program for achieving a climate-neutral economy by 2050, supported by the new policy initiatives of the European Green Deal.

In 2020, the European Union adopted the "Strategy for the use of hydrogen for a climate-neutral Europe." In this document, hydrogen was identified as a key element in achieving the Green Deal

and the transition to clean energy through the decarbonisation of various sectors such as energy, transport, construction and industry. Hydrogen also plays a role as a storage medium for renewable energy. In July 2021, as part of the Fit for 55 package, measures were presented to achieve at least a 55% reduction in net greenhouse gas emissions by 2030 and climate neutrality by 2050, in line with the European Green Deal. On May 18, 2022, Europe presented the new, more ambitious REPowerEU plan, aimed at rapidly reducing dependence on Russian fossil fuels by accelerating the transition to clean energy and strengthening the sustainable energy system. National reforms and investments are a key focus of the REPowerEU plan. In addition, the European Parliament and the Council adopted directives and regulations on the internal markets for renewable gases and hydrogen, which aim to facilitate the entry of renewable and low-carbon gases into the energy system and create uniform rules for the hydrogen market and the necessary infrastructure.

Figure 5 Synergy between "Strategy for the use of hydrogen for a climate-neutral Europe" and 2030 REPowerEU plan



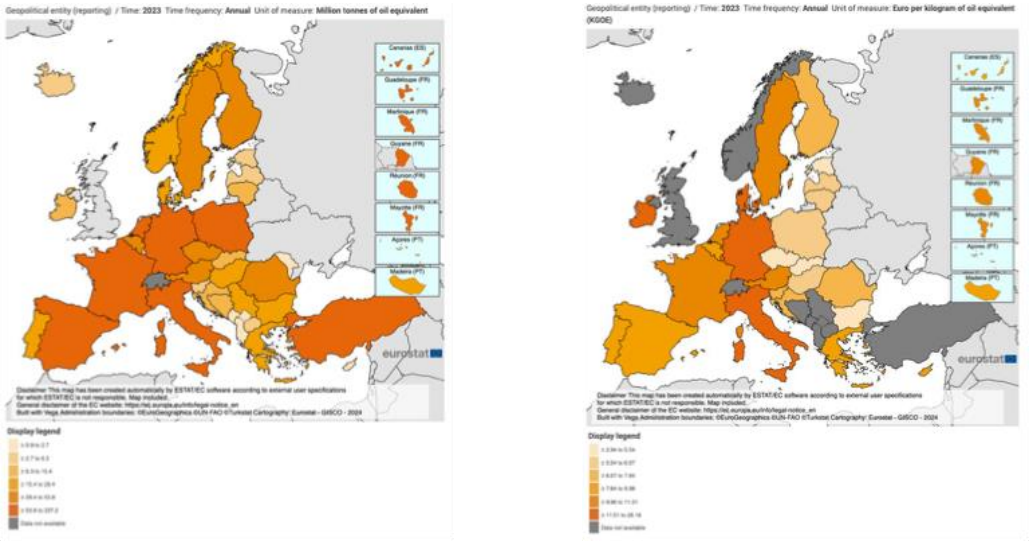
Bulgaria fully supports the objectives and strategies outlined in the latest REPowerEU summary plan, which is being collectively developed at the European level. This comprehensive plan aims to reduce Europe's reliance on Russian fossil fuels and accelerate the transition towards cleaner, more sustainable energy sources. To achieve this, Bulgaria must adapt the overarching EU strategy to suit its unique national circumstances, ensuring that the plan aligns with the country's specific resources, infrastructure, and economic considerations.

A significant part of Bulgaria's adaptation process involves creating a detailed roadmap for integrating hydrogen technologies into its economy. Hydrogen is considered a vital element in future energy systems due to its potential as a clean, versatile energy carrier and storage solution. This roadmap will guide Bulgaria in developing and utilizing hydrogen technology to meet its energy goals, contributing to a more sustainable and resilient energy sector.

Furthermore, Bulgaria has committed to the Paris Agreement, an international treaty aimed at limiting global warming to well below 2 degrees Celsius above pre-industrial levels. This commitment reflects Bulgaria's dedication to addressing climate change and preserving the environment for future generations. By adhering to the Paris Agreement, Bulgaria joins other

nations in a collective effort to mitigate the impacts of climate change and promote sustainable development.

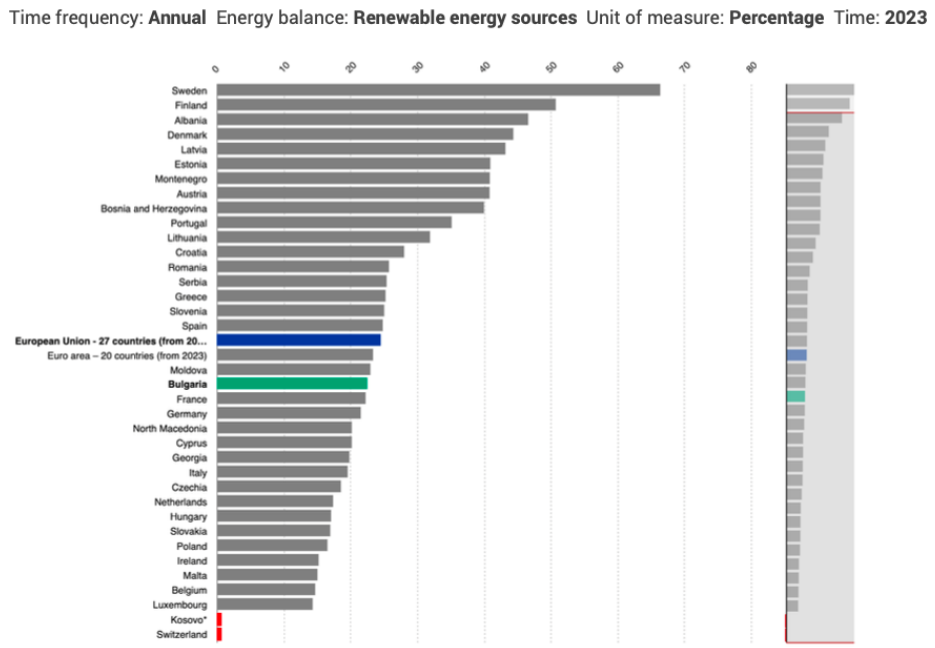
Figure 6 Primary energy consumption and energy productivity - Bulgaria and EU 27



Source: Eurostat database

The country is among the first 14 countries to recognize hydrogen as an alternative fuel through the National Policy Framework for the Development of the Alternative Fuels Market in the Transport Sector and Related Infrastructure.

Figure 7 Share of renewable energy in gross final energy consumption by sector



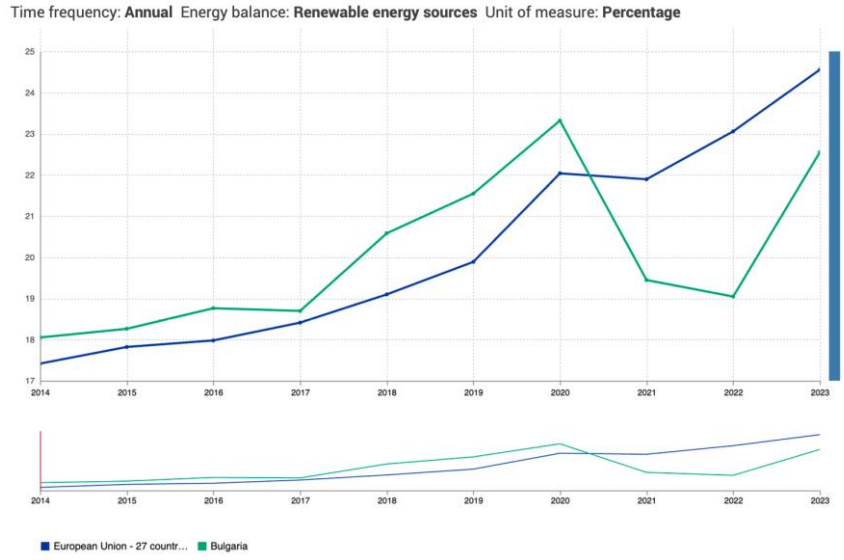
Source: Eurostat database

Currently, Bulgaria operates a high-carbon economy, heavily reliant on fossil fuels for its energy needs. About 36% of the country's electricity is produced by thermal power plants that use low-

calorific coal, a particularly carbon-intensive fuel source. Projections made for 2022 indicated that the Maritsa East complex, boasting a capacity of 3.4 GW, would contribute approximately 80% of this coal-fired electricity generation[26]. This heavy reliance on coal has had severe environmental consequences. For several years, Bulgaria has consistently ranked among the worst in Europe in terms of air pollution, primarily due to emissions from industrial processes, household heating, and transportation. Air quality in Bulgaria is significantly worse than the European average, leading to serious health issues for its citizens. Specifically, Bulgaria tops the list when it comes to "Years of healthy life lost due to air pollution." While the EU average stands at 1,500 people per 100,000 inhabitants, this figure skyrockets to 2,400 in Bulgaria, highlighting the urgent need for measures to improve air quality and public health[27].

A transformative solution to Bulgaria's current challenges could emerge through the widespread adoption of hydrogen technologies across various sectors of the economy, including industry, transportation, and daily life. Despite its limited fossil fuel reserves, Bulgaria holds promising potential for developing a robust hydrogen economy. This potential stems from the country's abundant yet largely untapped renewable energy resources. However, realizing this potential faces hurdles such as complex regulatory frameworks and bureaucratic inefficiencies, as highlighted by Gocheva (2022) and the Center for the Study of Democracy (2018). Overcoming these obstacles is crucial for harnessing the full benefits of hydrogen technologies and driving sustainable economic growth in Bulgaria.

Figure 8 Share of energy from renewable sources



Source: Eurostat database

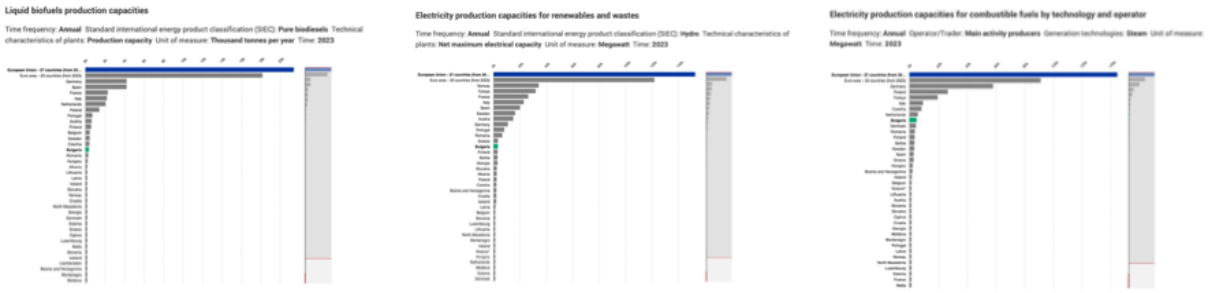
Bulgaria has demonstrated progress in the realm of renewable energy, having successfully met its 2020 targets for Renewable Energy Sources (RES) alongside 10 other EU member states. As early as 2012, Bulgaria achieved its national objective of sourcing 16% of its gross final energy consumption from RES by 2020. Currently, the country boasts an installed capacity of 3.2 GW in hydropower, 1.1 GW in photovoltaic systems, and 0.7 GW in wind turbines. Notably, these figures

[26] Accelerating the Energy Transition in Bulgaria: A Roadmap to 2050 Policy Brief No. 96, December 2020, Center for the study of democracy

[27] https://www.stateofglobalair.org/health/life-expectancy#:~:text=Current%20levels%20of%20air%20pollution,and%20Somalia%20(3.04%20yr).

represent only a fraction of Bulgaria's true potential in renewable energy, suggesting ample room for further expansion and development in this sector[28].

Figure 9 Development capacities for renewables and wastes



Source: Eurostat database

Up until the end of 2023, only those producing hydrogen from fossil fuels within the European Union were eligible to receive free allowances designed to offset carbon emissions. Starting from 2024, however, producers of hydrogen derived from electricity, including renewable sources, will also qualify for these allowances. Nevertheless, there is a caveat: until 2026, operators of existing fossil fuel hydrogen facilities will not be able to avail themselves of these benefits.

These free allowances are scheduled to be gradually phased out between 2026 and the end of 2033. Currently, the carbon border adjustment mechanism applies to ammonia but excludes other hydrogen derivatives such as methanol, electrofuels, or liquid organic hydrogen carriers. Furthermore, this mechanism does not extend to exports destined for countries outside the EU, which introduces potential risks of circumvention.

These recent policy shifts underscore the dynamic nature of the European Union's approach to fostering cleaner hydrogen production and effectively managing carbon emissions. The gradual inclusion of hydrogen producers using electricity, especially from renewable sources, signifies a concerted effort to incentivize the shift towards greener energy solutions. This move aligns with the broader EU strategy to decarbonize industries and reduce the bloc's overall carbon footprint.

Between 2021 and 2027, the European Union is investing heavily in the development of technologies for hydrogen production from renewable sources and low-carbon hydrogen. This initiative is part of the EU's broader strategy to achieve climate neutrality by 2050 and aligns with its commitments under the Paris Agreement to reduce greenhouse gas emissions.

Various programs managed by different directorates-general within the European Commission offer funding through diverse mechanisms such as grants, loans, and public-private partnerships. These programs aim to stimulate technological advancements and commercial viability of hydrogen solutions. The European Court of Auditors (ECA) plays a crucial role in overseeing these programs. It ensures transparency and accountability by monitoring the progress and publishing regular reports on the commitments made and the allocation of funds.

[28] Bulgaria: Renewable Energy, Penkov, Markov & Partners, 2025

Table 5 Descriptive information on mechanisms for suport

Initiatives	**Description**
Projects of common interest (PCIs)	Projects of common interest (PCIs) are large-scale cross-border initiatives involving multiple Member States, aimed at overcoming significant market or systemic failures.
Guidelines on State aid for climate, environmental protection, and energy (CEEAG)	PCIs are part of a framework designed to help Member States provide the necessary support to achieve the objectives of the Green Deal. The guidelines were updated in early 2022 to explicitly include investments in hydrogen from renewable sources and, for the first time, investments in the decarbonization of production processes.
Temporary Framework for State aid in the context of the crisis and transition (TFTC)	Member States may implement support measures necessary for the transition to a net-zero emissions industry, including schemes to accelerate the deployment of renewable energy and energy storage, as well as schemes for the decarbonisation of industrial production processes. The duration of the Temporary Crisis Framework (TCF) is limited, as aid must be granted by December 31, 2025.
General Block Exemption Regulation (GBER)	Under this regulation, unless otherwise specified, investment aid for environmental protection that does not exceed €30 million per undertaking for an investment project is exempt from the requirement for notification and approval by the Commission.

Source: EU industrial policy on hydrogen from renewable sources, Special Report, European Court of Auditors, 2024

According to the latest estimates provided by the ECA, approximately €18.8 billion is earmarked for projects related to hydrogen technology development. A significant portion of this funding, around 72%, comes from the Recovery and Resilience Plan (RRF), which was established to help member states recover from the COVID-19 pandemic while also advancing sustainable growth and resilience. While the total amount allocated is fixed at €18.8 billion, the actual expenditure may vary based on project performance and evolving priorities[29]. The ECA's monitoring ensures that the funds are used effectively and efficiently to drive innovation and progress in the hydrogen sector.

The Innovation Fund is another key source of EU funding for renewable hydrogen projects. It provides funding for:

- Projects selected by the European Climate, Infrastructure and Environment Executive Agency (CINEA) on the basis of annual calls for project proposals.
- An innovative instrument called the "Hydrogen Bank," which was launched in 2023. *Domestic pillar:* Hydrogen producers from renewable sources in the EU can receive subsidies through an auction to compensate for the difference between the production price and the market price. This is financed by the Innovation Fund. *International pillar:* Producers from third countries who want to export hydrogen to the EU can also apply for green premiums through an auction.

Venture Capital Investments: H2 Innovation

Bulgaria holds a notable position in hydrogen production within the European Economic Area (EEA), securing the 12th spot among the 32 countries. Annually, Bulgaria produces approximately

[29] Special report 13/2025: Support from the Recovery and Resilience Facility for the digital transition in EU member states – A missed opportunity for strategic focus in addressing digital needs, © European Union, 2025

200,000 tons of hydrogen, which accounts for roughly 5% of Europe's total hydrogen output. This places Bulgaria as a significant contributor to the continent's hydrogen supply. Lukoil Neftohim Burgas, the leading oil refinery in Southeast Europe and Bulgaria's largest industrial enterprise, is heavily reliant on this resource. The refinery consumes around 80,000 tons of hydrogen each year, primarily sourced through steam reforming. However, this method of production generates substantial carbon dioxide (CO2) emissions, amounting to a staggering 720,000 tons annually. These emissions represent nearly 40% of the facility's total carbon footprint, highlighting the environmental impact associated with traditional hydrogen production methods. With expansion plans on the horizon, the demand for hydrogen at Lukoil Neftohim Burgas is expected to increase further[30].

This presents both opportunities and challenges for Bulgaria. On one hand, increased hydrogen production could bolster the country's economic standing and contribute to regional energy security. On the other hand, it underscores the need for cleaner and more sustainable hydrogen production methods to mitigate the environmental impact and align with the EU's climate goals.

Bulgaria's significant hydrogen production capacity positions it as an important player in the European hydrogen market. However, addressing the environmental challenges associated with current production methods will be crucial for the country to maintain its competitive edge while contributing to a greener future.

Ammonia is a vital component in the production of nitrogen fertilizers, which are essential for maintaining high crop yields in agriculture. In Bulgaria, two major nitrogen fertilizer plants play a significant role in meeting the country's agricultural needs: Neochim AD in Dimitrovgrad and Agropolychim AD in Devnya. Ammonia is central to their operations, with Agropolychim AD relying on ammonia imports to sustain its production processes. However, the imminent implementation of the EU taxonomy, a classification system aimed at promoting sustainable activities, poses a significant challenge to these practices. If Bulgarian companies fail to comply with the new regulations, they risk being excluded from certain financial incentives and investments, potentially forcing them to cease fertilizer production altogether.

According to the Fuel Cells and Hydrogen Joint Undertaking, Bulgaria contributes approximately 3% to the EU's overall ammonia output. One of the key players in this sector is Neochim AD, which has a nominal capacity to produce 55,300 tons of hydrogen annually from natural gas. In 2019, the plant produced 50,000 tons of hydrogen. However, this process generates substantial CO2 emissions, with steam reforming alone accounting for 503,000 tons of CO2 per year (450,000 tons in 2019).

As such, these environmental challenges highlight the urgent need for Bulgaria to transition towards more sustainable and low-carbon ammonia production methods. Failure to do so could not only jeopardize the country's contribution to the EU's ammonia supply but also undermine its efforts to meet the bloc's ambitious climate targets. As the EU continues to prioritize green initiatives, **Bulgarian industries must adapt to ensure their long-term viability and competitiveness in the global market**.

[30] Hydrogen Funding Compass - Funding Opportunities for Bulgaria. https://bgh2a.bg/wp-content/uploads/2025/05/BGH2A_HydrogenFundingCompass-Bulgaria.pdf

In the glass manufacturing industry, hydrogen plays a crucial role as an inert and protective gas, particularly in the production of flat glass for the automotive industry and flame polishing processes. The "Pashabahce Bulgaria" plant in Targovishte uses green hydrogen in the glass forming stage, with a specialized installation for producing green hydrogen through electrolysis.

An analysis of current industrial hydrogen needs in Bulgaria shows that they amount to approximately 150,000 tons per year. The primary method for obtaining hydrogen currently is through steam reforming of natural gas, which results in a significant carbon footprint of around 1,400 kilotons of CO_2 annually. These figures do not include emissions from using natural gas for high-temperature processes, such as those accompanying hydrogen production and consumption, as well as other industrial processes.

Bulgaria is a major producer and exporter of ammonia and nitrogen fertilizers, sectors that must be preserved and further developed within the framework of the green hydrogen economy, stimulating the production of green ammonia. Interest in this industry will grow due to the potential for green ammonia to become a fuel for shipping. The quantities of green hydrogen needed for the oil refining and ammonia industries cannot be fully met by local production alone; therefore, it will be necessary to establish hydrogen production from renewable energy sources as a standalone economic activity. In this context, hydrogen production from renewable energy sources as an energy carrier and raw material will play a vital role in decarbonizing the industry.

Figure 10 Venture capital investment opportunities in Bulgaria

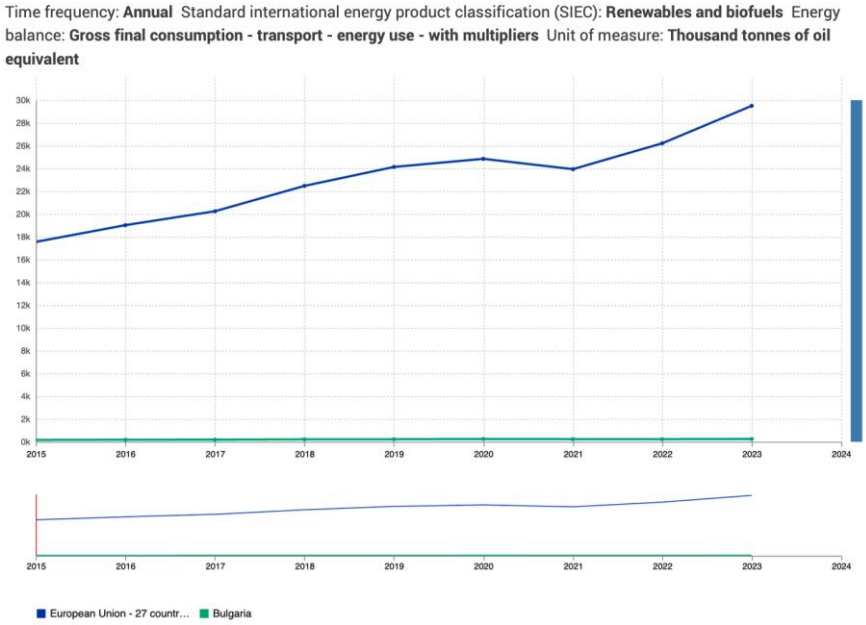
High-temperature processes involving natural gas are indeed a significant source of CO_2 emissions in various industries, including those producing glass, metals, and cement. These emissions can be substantial, as evidenced by the case of Neochim AD, which consumes approximately 3 terawatt-hours (TWh) of natural gas annually, resulting in a carbon footprint of 600,000 tons of CO_2. Fortunately, there is growing momentum to decarbonize these sectors. Efforts are underway at both European and global levels to gradually replace natural gas with green hydrogen in these high-temperature processes. Green hydrogen, produced using renewable energy sources, offers a promising alternative that can significantly reduce the carbon footprint of these industries. A favorable aspect of this transition is that a large portion of natural gas consumption, similar to that of Neochim AD, is concentrated in about ten plants across the glass, metalworking, and cement industries. This concentration allows for targeted interventions and economies of scale, making it easier to implement and manage the shift to green hydrogen. Current efforts involve replacing natural gas with green hydrogen in varying proportions, ranging

from 15% to 100%. This gradual approach enables industries to adapt and optimize their processes while minimizing disruptions. As green hydrogen becomes more widely available and cost-effective, the potential for complete decarbonization of these high-temperature processes increases.

The push to replace natural gas with green hydrogen in high-temperature industrial processes represents a significant step towards reducing CO_2 emissions and achieving sustainability goals. With concerted efforts at both European and global levels, industries such as glass, metalworking, and cement can make substantial strides in lowering their carbon footprints and contributing to a greener future.

Despite the current absence of hydrogen fuel cell transport in Bulgaria, there is significant potential for its development in the near future. Although it is not explicitly mentioned in key strategic documents such as the Integrated Energy and Climate Plan of the Republic of Bulgaria for the period 2021-2030, the National Recovery and Resilience Plan 2030, and the National Roadmap for Electric Vehicles (NRPV), which primarily focus on battery electric vehicles (BEVs), the landscape is poised for change.

Figure 11 Use of renewables for transport



Source: Eurostat database

Several factors indicate a positive outlook for hydrogen fuel cell transport in Bulgaria. Firstly, hydrogen fuel cell technology is rapidly advancing, with improvements in efficiency, durability, and cost-effectiveness. As these advancements continue, hydrogen fuel cell vehicles are becoming increasingly competitive with BEVs in terms of performance and practicality. Secondly, strategic documents are dynamic and subject to updates. As the benefits of hydrogen fuel cell technology become more apparent, there is room for policymakers to incorporate hydrogen into future revisions of national plans and strategies. Thirdly, the European Union is actively promoting hydrogen as a key component of its clean energy transition. Bulgaria, as a member state, can leverage EU funding and collaborative projects to accelerate the development of hydrogen infrastructure and vehicle fleets. Moreover, hydrogen fuel cell vehicles emit only water vapor, making them a zero-emission solution for transportation. This aligns with Bulgaria's commitment

to reducing greenhouse gas emissions and improving air quality. Additionally, hydrogen fuel cell vehicles can complement BEVs, offering advantages in specific applications such as long-distance travel and heavy-duty transportation. Integrating both technologies can enhance the overall sustainability of Bulgaria's transportation sector. Lastly, developing hydrogen fuel cell technology can create new economic opportunities, fostering innovation and job creation in the automotive and energy sectors. With continued technological advancements, supportive policies, and collaboration at the European level, Bulgaria can pave the way for a more sustainable and diversified transportation future.

The energy sector in Bulgaria represents the largest source of greenhouse gas emissions in the country. Coal-fired power plants alone are responsible for nearly half of these emissions. One significant challenge during the energy transition will be effectively implementing reforms in regions heavily reliant on carbon-intensive energy sources. This process requires comprehensive horizontal measures, substantial investments, and proactive social initiatives. Hydrogen has the potential to play a crucial role in these reforms by contributing to grid balancing. During peak hours for renewable energy production, excess electricity can be harnessed to generate hydrogen, which can subsequently be stored and utilized in several ways: it can be stored and reintroduced into the grid through fuel cells, or it can serve alternative purposes, such as powering hydrogen charging stations or being blended with natural gas.

The hydrogen economy presents exceptional opportunities for Bulgaria in terms of energy efficiency and independence, particularly through leveraging its abundant natural resources for renewable energy generation. Bulgaria is one of the 11 EU member states that have already met their 2020 renewable energy targets. As early as 2012, the country achieved its national mandatory goal of a 16% share of renewable energy in gross final energy consumption for 2020. However, the potential remains largely untapped, with data from Hydrogen Europe suggesting that Bulgaria currently utilizes only around 4% of its renewable energy production capacity. The National Recovery and Resilience Plan 2030 set ambitious national targets for a 27.09% share of renewable energy in gross final energy consumption by 2030. To achieve this goal, specific targets have been established for the two main economic sectors—electricity production and transport. In the electricity sector, a 30.33% share is aimed for, anticipated to be realized by increasing installed capacities of renewable energy facilities up to 3,000 MW. Projections indicate that by 2030, approximately 6,973 MW of renewable energy facilities will be connected to the electricity system[31].

The Integrated Energy and Climate Plan of the Republic of Bulgaria for 2021-2030 envisions a promising future for renewable energy in the transport sector, targeting an impressive 14.2% share. This forward-thinking plan aims to champion hydrogen and renewable electricity through strategic reforms and investments detailed in the National Recovery Plan, emphasizing green and sustainable mobility solutions. Additionally, Bulgaria is actively participating in European projects to bolster its efforts. Significant investments are earmarked to support the EU's ambitious goals of installing 6 GW of electrolyzers and producing and transporting 1 million tons of renewable hydrogen, as outlined in the European initiative "Accelerating Clean Technology." These investments encompass innovative pilot projects within the National Recovery Plan, including the construction of 55 MW electrolyzers, the annual production of 7,800 tons of green

[31] Balancing Bulgaria’s Energy Future, Policy Brief No. 160, October 2025

hydrogen, and the establishment of advanced infrastructure capable of efficiently transporting hydrogen and low-carbon gaseous fuels.[32]

Innovative Financing Mechanisms: Green Bonds and Beyond

Hydrogen is recognized as a pivotal component in the shift towards a more sustainable and eco-friendly energy system, aligning perfectly with the objectives of the European Green Deal and the imperative to reduce carbon emissions. By strategically funding hydrogen technologies through a mix of grants and financial instruments, we can create an attractive environment for both public and private investment. This approach not only fosters the development of cutting-edge technologies but also accelerates their deployment and commercialization, driving us closer to our shared vision of a greener future.

The Competitiveness and Innovation Program for Enterprises (CIP) and the Research, Innovation, and Digitalization for Smart Transformation Programme 2021-2027, overseen by the Ministry of Innovation and Growth, are instrumental in fostering these endeavors. These programs offer a robust framework and essential resources to catalyze research, technological advancements, and innovation in the dynamic field of hydrogen. Their strategic support plays a vital role in propelling Bulgaria towards a more sustainable and competitive future. **These initiatives have the potential to position Bulgaria as a leader in the region in terms of hydrogen technologies and to create new opportunities for economic growth and sustainable development.** However, it is important to ensure effective management of these funds and to guarantee transparency and accountability in the implementation of projects.

The reasons for investing in the hydrogen industry can be summarized as follows[33]:

- Exposure to one of the fastest growing industries in the world;
- Innovation: Renewable energy, electric vehicles, and data centers are just some of the sectors focusing on the development of hydrogen technologies;
- Investments in environmental protection (ESG investments);
- Protecting existing capital from inflation;
- Capital gains and achieving financial goals;
- Diversification of asset portfolio;
- Building a stream of passive income by receiving dividends;
- High asset liquidity: You can buy and sell your assets in seconds;
- Low investment costs: Due to high liquidity, you can take advantage of low spreads and commissions.

Hydrogen companies can be broadly classified into distinct categories, each playing a unique role in advancing the hydrogen economy. These classifications highlight the diverse contributions made by different types of organizations in the hydrogen sector:

- **Large Hydrogen Producers** primarily produce gray hydrogen through steam reforming. While many are transitioning towards green hydrogen production, they remain in the midst of this transformative process. Despite their profitability, these companies do not exclusively specialize in hydrogen, often supplying other industrial gases as well. This diversification mitigates risks associated with investing in them.

[32] https://www.mig.government.bg/wp-content/uploads/2023/04/naczionalna-patna-karta-za-podobryavane-na-usloviyata-za-razgrasthane-na-potencziala-za-razvitie-na-vodorodnite-tehnologii-i-mehanizmite-za-proizvodstvo-i-dostavka-na-vodorod.pdf

[33] https://admiralmarkets.com/bg/education/articles/shares/akcii-na-kompanii-za-vodord

- **Electrolyzer Manufacturers**, though smaller in size, are highly focused on the hydrogen business, making them potentially riskier compared to larger manufacturers. However, their specialized nature could yield higher returns on investment.
- **Fuel Cell Companies** concentrate on hydrogen-powered fuel cells or flexible fuel cells. Their diverse applications and varying market segments make direct comparisons challenging yet intriguing.
- With hydrogen becoming a prominent part of political agendas and recovery plans centered around renewable energy sources, **large industrial companies** are increasingly shifting their focus towards hydrogen. This trend is driving significant investments in the hydrogen sector.
- As investment in the hydrogen sector continues to grow, **hydrogen vehicle companies** are experiencing a surge in interest and support.

This classification provides a clear picture of the different types of companies involved in the hydrogen sector and their specific characteristics and risks.

Case Studies: Successful Hydrogen Projects

ZAHYR[34] Hydrogen Valley Project

The ZAHYR Hydrogen Valley project serves as a prime example of the remarkable benefits that can be unlocked by integrating hydrogen into critical industrial applications. Key implementations of ZAHYR have been realized in the following sectors:

1. **Transport Sector**: Modernization and operation of a fleet of hydrogen vehicles through comprehensive measures aimed at gradually transitioning to fully hydrogen-powered engines. This includes the development of advanced propulsion systems and infrastructure to support hydrogen fuel cell technology.
2. **Industrial Processes**: Innovative solutions for storing ammonia and utilizing it to produce hydrogen; hybrid infrastructure for hydrogen production combining electrolysis and ammonia cracking technologies; industrial applications of hydrogen for heating and fertilizer production. These advancements leverage cutting-edge chemical engineering principles to optimize energy efficiency and reduce environmental impact.
3. **Infrastructure Development**: Installation and operation of a hydrogen refueling station to ensure a reliable supply of hydrogen for both vehicles and industrial applications, thereby facilitating the integration of energy systems. This involves the design and implementation of high-pressure storage and distribution networks.

H2START Initiative

H2START provides researchers with a vibrant and dynamic environment equipped with state-of-the-art facilities, strategic partnerships, and international mobility opportunities that bridge academia and industry. Its primary objectives are to:

- **Cultivate a Unique R&I Management and Administrative Ecosystem**: H2START aims to develop a distinctive approach to managing research and innovation, creating a supportive and collaborative environment.

[34] ZAHYR Hydrogen Valley is funded from the Clean Hydrogen Joint Undertaking. The project is currently under revision.

- **Implement a Tailored Strategic Research and Innovation Agenda**: By crafting and executing its own Strategic Research and Innovation Agenda, H2START ensures a focused and impactful direction for scientific advancement.
- **Foster "Brain Gain" Through Human Resources Strategies**: Introducing a Human Resources Strategy and Rules for "Brain Gain" helps attract and retain top talent, enhancing the overall quality of research conducted.
- **Elevate Bulgaria's Scientific Standing**: H2START strives to raise Bulgaria's scientific intensity and quality to meet international standards, positioning the country as a leader in research and innovation.
- **Drive Cross-Cutting Activities in Key Areas**: Advancing cross-cutting activities in critical fields ensures that H2START addresses pressing challenges and contributes to global scientific progress.

This initiative encourages interdisciplinary collaboration and knowledge exchange, fostering scientific excellence and technological innovation. It creates a fertile ground for groundbreaking discoveries and advancements, ultimately benefiting both Bulgaria and the broader scientific commun

GH2M Project

GH2M empowers participating regions to champion and accelerate the integration of green hydrogen into their sustainable mobility and infrastructure strategies. It plays a pivotal role in decarbonizing hard-to-electrify sectors within the transport industry, emphasizing zero-carbon synergies between urban and other types of end-use mobility applications, such as heavy-duty logistics and rail transport. The project is dedicated to expediting the adoption of green hydrogen mobility across various regions of the European Union.

This initiative is a critical stride towards achieving the EU's ambitious climate neutrality goals by 2050. It presents a golden opportunity for EU regions to pioneer sustainable mobility solutions and significantly contribute to the EU's carbon emission reduction targets. By fostering collaboration and innovation, GH2M paves the way for a cleaner, more sustainable future for transportation in Europe.

COMMIT Project

The COMMIT project equips local and regional authorities with the tools to cultivate an ecosystem that nurtures small and medium-sized enterprises (SMEs) throughout the industrial transition. Navigating the shift to a low-carbon economy presents a considerable challenge for regions striving to evolve their SME landscape towards sustainable practices while preventing "carbon leakage" – the unintended consequence of companies relocating to less stringent regulatory environments. Ensuring "good jobs" and addressing territorial inequalities are integral components of this transition.

As large industries embrace decarbonization, SMEs within their supply chains must adapt their processes to maintain competitiveness. Many SMEs, especially micro-enterprises, grapple with limited resources and restricted access to information, financing, technology, and skilled labor.

The effectiveness of supporting SMEs in capitalizing on low-carbon opportunities varies widely across European regions, influenced by factors such as SME profiles, developmental trajectories, and the capabilities of both public and private sectors. Successful assistance necessitates a

bottom-up approach, fostering partnerships and collaboration, particularly with SMEs themselves.

By empowering SMEs to adopt sustainable practices, the COMMIT project drives innovation, enhances competitiveness, and contributes to a more equitable and resilient European economy. This initiative underscores the importance of collective action and collaboration in achieving a greener, more prosperous future for all.

GREENSMARTMED Initiative

GREENSMARTMED aims to integrate and build upon the methodologies developed in the Interreg EuroMED GREENOMED and FinMED projects. Leveraging the GREEN GROWTH community, it seeks to develop, test, and disseminate a new integrated methodology and accompanying toolkit. The GREENSMARTMED methodology and toolkit are designed to foster enhanced transregional collaboration among stakeholders from the quadruple helix in the five participating regions (Italy, Spain, France, Greece, and Bulgaria). This initiative cultivates a European community poised to embrace innovation for environmentally friendly and sustainable production. By supporting research and the implementation of innovative strategies for smart specialization (RIS3), GREENSMARTMED empowers SMEs to transform sustainability challenges into opportunities. This approach paves the way for sustainable business development, driving economic growth while preserving the environment.

Through this collaborative effort, GREENSMARTMED contributes to a more resilient and sustainable future, uniting stakeholders across borders to address common challenges and unlock new possibilities for innovation and prosperity.

RuralMED Mobility Project

The RuralMED Mobility project, aptly named "Promoting Electric Mobility in Underserved Rural and Remote Mediterranean Areas," is dedicated to enhancing the infrastructure for electric vehicles (EVs) and accelerating the adoption of sustainable mobility in rural regions of commercial significance. This initiative supports local authorities in cultivating an environment conducive to the development of customized, collaborative solutions. Investments in charging points, electric vehicle leasing, and monitoring systems will be implemented, along with the strategic use of ICT tools. These efforts aim to increase the frequency of trips to and from pilot municipalities using electric vehicles and multimodal solutions. By doing so, the project seeks to reduce CO2 emissions and improve residents' access to essential public services.

RuralMED Mobility is committed to fostering a greener, more connected future for underserved rural communities, enabling them to participate fully in the transition to sustainable transportation. This initiative underscores the importance of inclusive development and demonstrates how innovative solutions can drive positive change in even the most remote areas.

SITRANS Project

SITRANS is an EU-funded project under the LIFE+ program that champions a regional approach to management and tailored policies for coal regions navigating the transition process. By meticulously evaluating the socio-economic impact of the energy transition, SITRANS aims to establish an effective governance model grounded in the principle of inclusivity, ensuring that no one is left behind. The outcomes of these actions will culminate in the creation of an Observatory for a Just Energy Transition (OEEP). This observatory will serve as a hub for designing, hosting, and monitoring assessment models based on predefined indicators and criteria.

The primary objective of SITRANS is to foster a cohesive regional management strategy and develop specialized policies that cater to the unique needs of coal regions undergoing transformation. By doing so, SITRANS paves the way for a more equitable and sustainable energy future, where the benefits of the transition are shared by all stakeholders.

European Digital Innovation Hub (EDIH) Zagore

The European Digital Innovation Hub (EDIH) Zagore envisions a thriving environment for innovation and a sustainable future for the South East Region (SER) of Bulgaria. Its primary mission is to drive digital transformation and decarbonization in the region, fostering equality and competitiveness within the European context. EDIH Zagore is dedicated to nurturing a society where innovation and digital technologies are foundational pillars of sustainable development and improved quality of life. The project SynGReDiT – Synergy for Green Regional Digital Transformation of the Southeast Region of Bulgaria – is an initiative spearheaded by EDIH Zagore. It encompasses the entire Southeast Region (SER), encompassing the NUTS II level of Bulgaria, which comprises four NUTS III regions: Burgas, Sliven, Stara Zagora, and Yambol.

EDIH Zagore plays a pivotal role in coordinating services among all stakeholders, including digital transformation service users, partners, and subcontractors. It manages and controls related value streams, focuses on core services, and organizes activities to ensure user-centered development; and delivers the core values of the ecosystem, aligning all efforts with the overarching focus and efficiency. Meanwhile, EDIH Zagore provides essential resources such as premises, building technology, hardware/software infrastructure, and services through its robust network of members and service providers. Users of EDIH Zagore's services can also request additional services tailored to their specific digitization and digital business transformation needs.

SynGReDiT tackles the significant challenge of shifting the long-established industrial traditions and business interdependencies of the Southeast region's economy towards decarbonization and a dual – green and digital transformation. Targeted sectors include power generation, miscellaneous manufacturing, agriculture, transportation, and healthcare. The project aims to develop sectors with a smaller share and attract new segments based on industrial symbiosis.

RenewStart for Hydrogen Technologies

RenewStart is dedicated to the basic research on the potential of renewable energy sources and hydrogen is being conducted for Poland, Lithuania, Bulgaria, and Albania. A multinational consortium has been established with representatives from key sectors such as electricity production, energy storage, industrial processes, and end users representing the gas and oil industry, energy services, and others.

The consortium raises awareness and promotes the integration of renewable energy sources and hydrogen technologies. It works with governments, local authorities, civil society, academia, and the private sector to bring technology to market, stimulate market growth, attract investments, and strengthen the position of implementing countries on the global energy market.

RECCOMENDATIONS

The hydrogen economy offers tremendous potential for Bulgaria, enabling the country to enhance its energy security, reduce greenhouse gas emissions, and contribute to the broader European and global transition towards a cleaner, more sustainable energy future. Through strategic investments, policy reforms, and international cooperation, Bulgaria is well-positioned to capitalize on these opportunities and become a leading force in the emerging hydrogen economy.

The green transition offers a pathway to revitalize our economy, particularly through the burgeoning hydrogen market. By investing in modernizing our energy infrastructure and fostering technological advancements, we can enhance energy efficiency and reduce our reliance on foreign energy imports. Developing domestic renewable energy sources will not only bolster our energy security but also pave the way for sustainable growth. While the road ahead may be fraught with obstacles, the potential rewards are too significant to ignore.

What are the main gaps and the reasons behind the scarcity of hard numbers? The hydrogen sector is still in its early stages: Many initiatives are currently at the pilot-scale or demonstration phase, rather than being fully commercialized or operating at a large scale. As a result, actual production and consumption data are limited. There is also a lack of centralized statistics: Unlike sectors such as electricity or natural gas, there is no well-established national tracking system for hydrogen production and consumption. This means that data are scattered among various projects, research centers, and private companies. Furthermore, the growth of green hydrogen production is interdependent with the expansion of renewable energy sources. Until renewable energy capacity increases significantly and surplus power becomes readily available, hydrogen production will remain modest. Lastly, the necessary infrastructure is still under development. Electrolyzers, refueling stations, pipelines, and blending infrastructure are only beginning to be planned or constructed (e.g., ZAHYR). Consequently, use cases remain limited, and widespread adoption of hydrogen is still a future prospect.

In the following next years to assess the progress it will be needed to monitor:

Installed Electrolyser Capacity and Utilization: The total installed capacity of electrolysers in megawatts (MW) indicates the maximum amount of electrical power they can convert into hydrogen through electrolysis. Additionally, the utilization rate, measured in hours per year, provides insight into the efficiency and productivity of these electrolysers when they are operational.

Actual Annual Green Hydrogen Production: This metric measures the total amount of green hydrogen produced annually, typically expressed in tons. It reflects the practical output of hydrogen production facilities and serves as a tangible measure of progress in the sector.

Number of Hydrogen Refueling or Distribution Stations: Stations specifically designed for refueling vehicles powered by hydrogen, including cars, buses, and trucks, contribute to the overall network of hydrogen infrastructure. Additionally, distribution stations play a crucial role in supplying hydrogen to industrial users for various applications, such as chemical processing or energy generation.

Volumes of Hydrogen Blended into Gas Grid or Used in Energy/Industrial Applications: The integration of hydrogen into traditional energy systems is indicated by the volume of hydrogen mixed with natural gas in existing pipeline networks. Furthermore, the quantity of hydrogen

utilized directly in energy production (e.g., fuel cells) or in industrial processes (e.g., ammonia synthesis, steelmaking) highlights its diverse applications.

Investments in Hydrogen Infrastructure and Production: Both public and private investments are essential for supporting the development of hydrogen infrastructure and production facilities. Public funding from governments and public institutions plays a significant role, while private capital invested by companies and investors drives research, technology development, and infrastructure deployment.

Jobs Created in the Hydrogen Sector: Employment opportunities in the hydrogen sector span various roles, including those related to the manufacturing and operation of production facilities, logistics and delivery of hydrogen, maintenance of infrastructure and equipment, and research and development activities aimed at advancing hydrogen technologies and improving efficiency.

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