Interreg CENTRAL EUROPE

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H2CE

Work Package (WP1): H2-ready for European and regional spatial planning and development

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1. Introduction

The **Interregional Strategy in Croatia** is a collaborative initiative developed by the City of Zagreb and the Regional Energy and Climate Agency (REGEA), with expert guidance from Prof. Ankica Kovač. This strategy aims to provide a comprehensive framework for Croatian regions to navigate the complexities of hydrogen regulation, infrastructure development, and funding mechanisms, fostering collaboration across regional boundaries.

In the context of Interreg, "interregional" refers to cooperation between multiple regions within Croatia and across neighboring countries. The strategy focuses on shared challenges that require joint solutions, such as hydrogen infrastructure development and regulatory alignment. Projects like H2CE exemplify this approach by connecting regions with aligned planning priorities, enabling coordinated action for hydrogen deployment.

Prof. Ankica Kovač, a leading expert in green hydrogen, has been instrumental in shaping Croatia's hydrogen landscape. As an Associate Professor at the University of Zagreb's Faculty of Mechanical Engineering and Naval Architecture, she leads the Hydrogen and Fuel Cell Laboratory and the Power Engineering Laboratory and has significantly contributed to the development of the Croatian Hydrogen Strategy. Her innovative work includes designing Croatia's first hydrogen-powered bicycle and establishing the nation's first hydrogen refueling station. Prof. Kovač's expertise is recognized internationally, and she serves as a representative of Croatia in various hydrogen-related organizations, including Hydrogen Europe Research and the International Energy Agency's Collaboration Programme on Advanced Fuel Cells.

Furthermore, Prof. Kovač is an active member of the **Women in Hydrogen** network, an international platform dedicated to promoting gender diversity and empowering women in the hydrogen sector. Her involvement in this network underscores her commitment to fostering inclusive and collaborative approaches to hydrogen development. By supporting initiatives like the Interregional Strategy, Prof. Kovač contributes to creating a more equitable and innovative hydrogen ecosystem in Croatia and beyond.

Her involvement ensures that the Interregional Strategy is grounded in scientific research and practical experience, providing Croatian regions with the knowledge and tools necessary to advance hydrogen initiatives effectively.

1.1. H2CE project

The Interreg Project **H2CE** addresses the challenge of integrating hydrogen solutions and renewable energy sources into the regional energy transition. To date, available information and support have primarily targeted project developers and industry stakeholders, while public authorities are often perceived as passive framework setters. Their expertise, mandate, and decision-making power hold significant potential to actively drive transformation.

H2CE aims to empower public authorities and administrations across Central Europe (CE) to take a proactive and sustainable role in incorporating hydrogen into regional planning and development. This approach is expected to accelerate the deployment of hydrogen infrastructure and enhance the effectiveness of available funding.

The project’s main expected outcomes include:

- Mechanisms enabling regional decision-makers to actively support the hydrogen-based energy transition.
- The establishment of a cross-regional and transnational network of H2-ready regions.
- The development of a digital collaboration platform for knowledge sharing and coordination.

The project partnership comprises regions and organizations from seven Central European countries, including: the Regional Development Agency Northwestern-Brandenburg, City and Regional Utilities Luebben, Energy Agency of Styria, Foundation "Dumni z Lubina", Institute for Transport and Logistics Foundation, Regional Union of Chambers of Commerce of Veneto Region, the Pomorskie Voivodeship, Economic and Social Council of the Ústí region, City of Zagreb, North-West Croatia Regional Energy and Climate Agency, and the Institute for Public Service Development. All project partners are regional authorities or their representatives, ensuring effective coordination, development, and implementation of project outcomes. Their commitment and authority are essential to advancing the regional energy transition and supporting the hydrogen agenda.

H2CE is structured into three **Working Packages (WP):**

- **WP1:** "H2-ready for European and regional spatial planning and development"
- **WP2:** "H2-ready regions: Support mechanisms for energy system transition and participation"
- **WP3:** "Developing Central Europe Hydrogen network and Collaboration Platform"

The transnational strategy is embedded within **WP1**, which focuses on analysing and identifying common challenges and solutions in planning and governance processes for regions transitioning to become H2-ready (hydrogen-ready). WP1 is divided into two main activities:

- **A.1.1: Planning the transition in European regions:** This involves creating a Fact Sheet of common indicators (D.1.1.1), conducting a regional analysis, and summarising the findings in a Summary of regional analysis (D.1.1.2). The goal is to gain a clear understanding of the current situation and the challenges faced by different regions.
- **A.1.2: Strategy and action plan development:** Building on the previous analysis, this activity provides Guidelines on hydrogen strategies and action plans (D.1.2.1). It culminates in the formulation of regional, interregional, and transnational strategies (D.1.2.2), as well as specific regional action plans (D.1.2.3), to support the transition toward hydrogen readiness.

A graphical representation of **WP1** can be found in Figure 1 below.

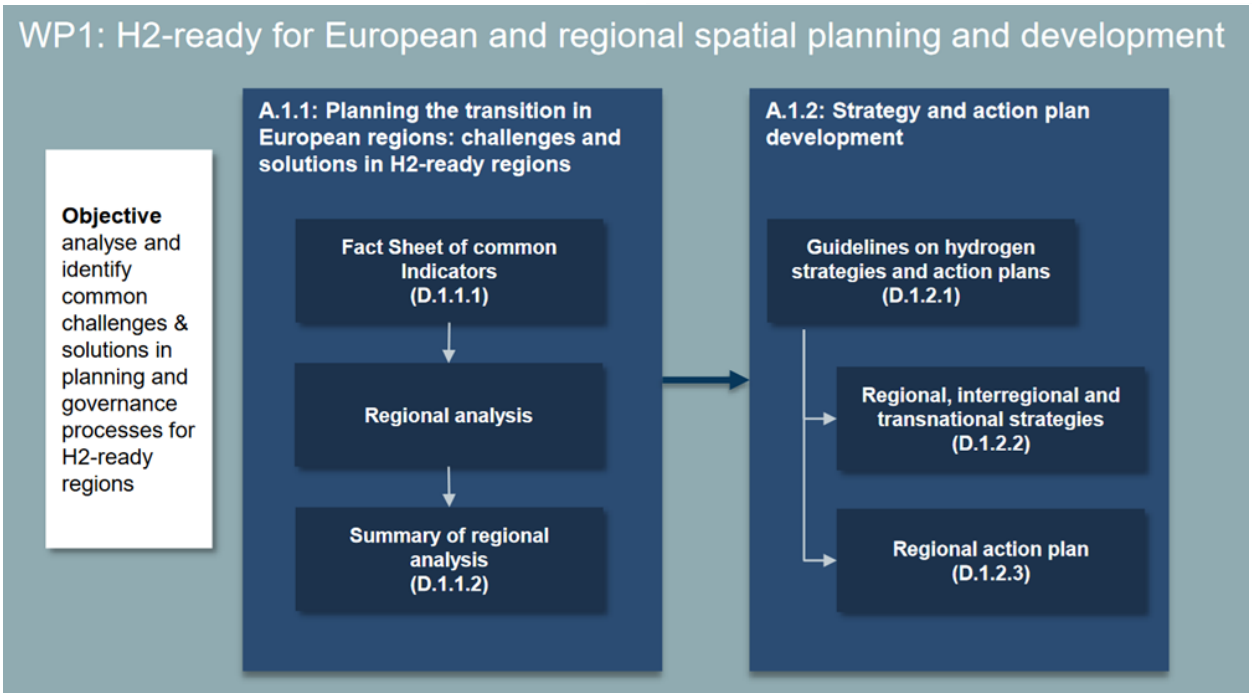

Figure 1: Overview of Working Package 1

1.2. The Interregional Strategy

The Interregional Strategy establishes a coherent and future-oriented framework for coordinating hydrogen development across Croatian regions, ensuring consistency with the European Union's strategic objectives on decarbonisation, renewable energy integration, and the creation of a functional European hydrogen market. It provides a structured mechanism that bridges EU-level policy ambitions, national hydrogen objectives, and regional implementation capacities, enabling Croatia to contribute effectively to the emerging European Hydrogen Economy.

At the macro level, the Strategy is guided by key EU targets, such as the planned 40,000 km hydrogen pipeline network by 2040 and the production of 10 million tonnes of renewable hydrogen by 2030. These targets provide the strategic orientation for national planning and require strong engagement from regional authorities to ensure effective absorption of EU funding instruments, including Horizon Europe, Clean Hydrogen Partnership, the Innovation Fund, the Modernisation Fund, and Cohesion Policy programmes.

At the micro level, Croatian regions are responsible for operationalizing these high-level goals by planning and implementing production capacities, expanding hydrogen infrastructure, and supporting industrial and mobility applications. Regional implementation is essential not only for enabling concrete hydrogen deployment but also for generating practical feedback that helps refine national regulatory frameworks and EU policy alignment.

Through analytical work conducted within WP1 of the H2CE project, two Croatian regions were identified as having the strongest prerequisites for hydrogen deployment:

1. North-West Region

This region benefits from concentrated industrial activity, existing energy and gas infrastructure, and strong research and innovation capacity. It is well positioned for early integration of hydrogen into industrial

processes, public transport systems, and local energy networks. The presence of leading academic institutions further strengthens its potential to develop regional competence centres and testbed facilities.

2. Northern Adriatic Region

Defined by strategic ports, significant renewable energy potential, and strong cross-border connectivity, this region is ideal for scaling up hydrogen production, storage, and distribution. The Port of Rijeka and the Krk LNG terminal offer opportunities for future hydrogen and ammonia import-export corridors, linking Croatia directly to the European Hydrogen Backbone.

The Interregional Strategy formalises cooperation between these regions by:

- aligning regional priorities with EU and national policy frameworks
- facilitating coordinated infrastructure planning (e.g., hydrogen-ready grids, refuelling networks, port-based hydrogen hubs)
- promoting shared investment models and cross-regional project pipelines
- strengthening knowledge exchange, capacity-building, and stakeholder engagement
- ensuring regulatory coherence and permitting streamlining across regional boundaries

The Strategy also emphasises an iterative governance model, in which top-down policy direction from the EU and national government is continuously complemented by bottom-up input from regions, enabling adaptive planning and accelerated project implementation.

Overall, the Interregional Strategy acts as a strategic, operational, and coordination tool, enabling Croatian regions to jointly mobilise resources, reduce fragmentation, integrate hydrogen into spatial and energy planning frameworks, and contribute meaningfully to Croatia's national hydrogen goals and the wider EU decarbonisation agenda.

1.3. Methodology

The development of the Interregional Strategy for Hydrogen-Ready Regions in Croatia was carried out through a systematic, multi-stage process that combined analytical research, expert knowledge, stakeholder involvement, and continuous cooperation with the project consortium. The methodological approach ensured that the strategy is grounded in reliable data, aligned with national and regional development frameworks, and consistent with the broader direction of the H2CE project.

The work began with an extensive review of the strategic, legislative, and planning documents relevant to hydrogen development at European, national, and regional levels. This included Croatia's Hydrogen Strategy until 2050, the National Energy and Climate Plan, and sectoral and spatial planning documents, as well as the analytical foundations produced within WP1 of the H2CE project. This initial review created a clear understanding of the regulatory and institutional context in which Croatian regions can develop hydrogen projects.

A structured assessment of regional potential followed, based on the common indicators defined within WP1. The analysis included renewable energy availability, existing energy and gas infrastructure, transport corridors, industrial activity, research capacity, and spatial constraints. Through this evidence-based evaluation, two regions—North-West Croatia and the Northern Adriatic—were identified as having the strongest prerequisites for future hydrogen deployment. These regions were therefore elaborated in more

detail in the strategy, reflecting their strategic value, existing industrial base, port and logistics infrastructure, and opportunities for cross-border cooperation.

A significant component of the methodological process was expert involvement. **Assoc. Prof. Ankica Kovač** contributed directly to the preparation of **Chapter 3**, providing scientific validation and guidance on technological feasibility, regional hydrogen pathways, and alignment with current international practices. Her expertise ensured that the regional assessments were technically sound and in line with ongoing developments in hydrogen technologies.

Stakeholder engagement was carried out continuously and represented one of the core elements of the methodology. Input was collected from national institutions, regulatory bodies, energy companies, industrial stakeholders, regional development agencies, research centres, and local authorities. These interactions took the form of bilateral consultations, data exchanges, and targeted discussions, helping to identify practical barriers, infrastructure needs, investment priorities, and opportunities for regional cooperation.

In parallel, Croatian project partners participated in several online meetings with the wider H2CE consortium. These sessions were used to harmonise methodological approaches, clarify expectations regarding the interregional and transnational strategies, exchange experience among regions, and ensure that the Croatian analysis is consistent with the overall WP1 framework. Such cross-regional dialogue significantly contributed to the coherence and quality of the final document.

In addition to online activities, partners took part in physical workshops organised as part of H2CE project implementation. During these in-person sessions—particularly those dedicated to exercises for the development of the transnational strategy—partners discussed not only the transnational dimension but also the structure and content of the Interregional Strategy. These workshops were used to verify analytical assumptions, compare regional challenges across countries, and refine the approach used in preparing the Croatian strategy.

The final stage of the methodology involved synthesising analytical findings, stakeholder inputs, expert consultations, and the outcomes of consortium discussions into a coherent strategic document. Through this integrated and iterative process, the Interregional Strategy was developed as a realistic, regionally anchored and future-oriented framework that supports Croatia’s hydrogen ambitions and contributes to coordinated hydrogen planning across Central Europe.

2. National fields of action for H2-ready regions

2.1. National vision and target-setting for Hydrogen in Croatia

Croatia's national vision for hydrogen development is embedded within the broader framework of the European Union's decarbonization agenda, the European Green Deal, and the REPowerEU plan. Recognizing hydrogen as a cornerstone of the transition towards climate neutrality by 2050, Croatia has positioned hydrogen as a strategic energy vector to decarbonize hard-to-abate sectors, foster industrial competitiveness, and enhance energy security.

The Hydrogen Strategy of the Republic of Croatia until 2050, adopted in 2022, lays the foundation for a comprehensive approach to developing a domestic hydrogen economy. This strategy aligns with the EU Hydrogen Strategy (2020) and Fit for 55 package, emphasizing renewable hydrogen as the primary driver of a sustainable and resilient energy system.

Croatia envisions becoming a regional hub for green hydrogen production, storage, and distribution in Southeast Europe, leveraging its abundant renewable energy potential — particularly solar, wind, and hydropower — as well as its well-developed gas infrastructure and favourable geographic position.

The long-term vision focuses on integrating hydrogen into the national energy system, fostering synergies between electricity, gas, transport, and industrial sectors. The aim is not only to decarbonize domestic energy consumption but also to establish Croatia as a key player in the European hydrogen market, particularly through export opportunities and regional cooperation in the Adriatic-Balkan corridor.

The vision is guided by three core pillars:

1. Sustainability: Promote the use of renewable hydrogen to support Croatia's commitment to carbon neutrality by 2050.
2. Energy Security and Independence: Reduce reliance on imported fossil fuels through domestic hydrogen production.
3. Economic Development and Innovation: Stimulate industrial transformation, innovation, and job creation across the hydrogen value chain.

Croatia's hydrogen targets are structured around three main time horizons — **2026, 2030, and 2050** — in alignment with EU goals and technological maturity milestones. The short-term targets (by 2026) are listed below.

- Establish a **national hydrogen ecosystem**, including regulatory, institutional, and technical frameworks.
- Develop **pilot and demonstration projects** for renewable hydrogen production, focusing on electrolysis powered by solar power plants and wind farms.
- Deploy **initial hydrogen refueling infrastructure** for public transport and logistics in major cities such as Zagreb, Rijeka, and Split.
- Initiate **industrial trials** in refineries, chemical plants, and steel industries to assess hydrogen substitution potential.
- Strengthen **R&D and innovation capacities**, supporting universities, research centers, and startups in hydrogen technologies.

The medium-term targets (by 2030) are outlined below.

- Achieve **production capacity of at least 70 MW of installed electrolyzers**, generating **up to 10,000 tonnes of renewable hydrogen annually**.
- Integrate hydrogen into the **national energy and transport systems**, including blending in the natural gas grid where feasible.
- Establish **a network of at least 10 hydrogen refueling stations** nationwide to support heavy-duty and fleet vehicles.
- Develop **hydrogen valleys** — regional clusters connecting renewable energy production, hydrogen generation, industrial use, and transport.
- Begin **cross-border cooperation projects** with neighboring countries (Slovenia, Hungary, Italy, and others) for hydrogen trade and infrastructure connectivity.
- Ensure **alignment with EU certification schemes** for renewable and low-carbon hydrogen.

The long-term targets (by 2050) are presented below.

- Position Croatia as a **regional exporter of renewable hydrogen**, particularly toward Central and Western European markets.
- Reach **full integration of hydrogen** across energy, transport, and industrial systems, contributing significantly to net-zero emissions.
- Expand electrolyzer capacity to **more than 1 GW**, using Croatia's renewable energy potential.
- Decarbonize **hard-to-abate sectors** such as aviation, shipping, cement, and steel industries through large-scale hydrogen deployment.
- Establish **hydrogen storage and distribution infrastructure**, including underground storage in depleted gas fields and dedicated hydrogen pipelines (part of the future European Hydrogen Backbone).

Croatia's hydrogen vision is closely tied to the EU's ambition to deploy 40 GW of renewable hydrogen electrolysis capacity by 2030 and produce 10 million tonnes of renewable hydrogen annually. Croatia aims to contribute to this goal through regional collaboration within the **Adriatic-Ionian Hydrogen Corridor** and participation in Important Projects of Common European Interest (IPCEI) on hydrogen.

Moreover, Croatia's geographical advantages — including access to the Adriatic Sea, proximity to renewable energy resources, and existing LNG infrastructure — position it strategically within the emerging **European Hydrogen Backbone**, a network designed to transport hydrogen across the continent.

Hydrogen development in Croatia is expected to:

- Create **new high-skilled jobs** in engineering, manufacturing, and energy services.
- Enhance **industrial competitiveness** by enabling low-carbon production.
- Stimulate **technological innovation and export opportunities** in clean technologies.
- Support the **just transition** of traditional energy regions, offering alternative employment and economic growth paths.

Croatia's national vision for hydrogen represents a transformative agenda that aligns environmental, economic, and technological objectives. Through strategic investments, regulatory support, and cross-sectoral collaboration, Croatia aims to harness its renewable potential to become a **hydrogen leader in Southeast Europe** by 2050. The country's targets reflect not only its commitment to the EU's climate neutrality goals but also its aspiration to secure a competitive and sustainable energy future.

2.2. Institutional and regulatory framework of the Republic of Croatia

The institutional and regulatory framework for hydrogen in the Republic of Croatia is structured to ensure full alignment with the European Union's decarbonization objectives, internal energy market legislation, and the Green Deal. Croatia recognizes hydrogen as a strategic enabler of energy transition and industrial transformation, and therefore, the establishment of a coherent governance and regulatory system has become a national priority.

The framework aims to facilitate the safe, efficient, and economically viable deployment of hydrogen technologies — from production to distribution and end-use — while ensuring compliance with EU standards on sustainability, competition, and environmental protection.

Croatia's institutional landscape for hydrogen governance is characterized by coordinated action among central government bodies, agencies, public institutions, and private stakeholders. The roles and responsibilities are defined to ensure an integrated approach across the entire hydrogen value chain.

1. Ministry of Economy (MoE)

The **MoE** serves as the lead authority for hydrogen policy, strategy, and coordination. It oversees the implementation of the **Hydrogen Strategy of the Republic of Croatia until 2050**, ensures consistency with the **National Energy and Climate Plan (NECP)**, and represents Croatia in EU and international energy forums.

Its main functions include:

- Development and supervision of national hydrogen legislation and strategic documents.
- Coordination of intersectoral policies on energy, climate, industry, and innovation.
- Facilitation of access to EU funds and state aid for hydrogen projects.
- Representation of Croatia in **EU Hydrogen Alliance**, **IPCEI Hydrogen projects**, and regional hydrogen cooperation initiatives.

2. Energy Institute Hrvoje Požar (EIHP)

The **EIHP** provides analytical and technical expertise for policy design, energy system modelling, and feasibility studies. It supports the government in defining regulatory measures, evaluating hydrogen integration into the national grid, and conducting cost-benefit analyses of hydrogen projects.

3. Croatian Energy Regulatory Agency (HERA)

HERA is responsible for regulatory oversight of the energy sector, including hydrogen-related activities as they integrate with electricity and gas markets. Its key tasks involve:

- Defining tariff methodologies and market rules for hydrogen transmission and distribution.
- Setting technical and safety standards for hydrogen infrastructure.
- Overseeing certification and licensing of hydrogen market participants.

4. Croatian Energy Market Operator (HROTE)

HROTE manages incentive mechanisms for renewable energy and will play a critical role in supporting the certification and trading of renewable hydrogen. Its expected responsibilities include:

- Administration of guarantees of origin (GoO) for renewable hydrogen.
- Integration of hydrogen into renewable support schemes and balancing markets.
- Facilitation of pilot auctions and market instruments for hydrogen producers.

5. Environmental Protection and Energy Efficiency Fund (EPEEF)

The **EPEEF** supports investment projects promoting sustainable energy, including hydrogen production, storage, and transport technologies. Through national and EU funds (such as the Modernisation Fund and Cohesion Fund), it provides co-financing for demonstration projects and hydrogen valleys.

6. Croatian Hydrocarbon Agency (CHA)

The CHA serves as the national coordinating authority for hydrogen in Croatia. it was assigned this role in 2023 by the Ministry of Economy to providetechnical support for programming, strategic planning, implementation, and reporting concerning hydrogen deployment throughout the country.

7. Research and Innovation Institutions

Croatian universities and research centers — notably the **University of Zagreb Faculty of Mechanical Engineering and Naval Architecture (FSB)** and the **Rudjer Bošković Institute** — conduct applied research in hydrogen technologies, materials science, electrolyzer, hydrogen storage, and fuel cell development. These institutions collaborate with industry to foster innovation and technology transfer under the **National Recovery and Resilience Plan (NRRP)**.

8. Industry and Private Sector Stakeholders

The private sector is emerging as a key driver of hydrogen deployment, with participation from energy companies (e.g., **INA**, **HEP**, **Plinacro**) and technology firms investing in renewable hydrogen projects. Plinacro, in particular, is leading feasibility studies for **hydrogen transportation and storage infrastructure** as part of the future **European Hydrogen Backbone**.

Croatia's regulatory architecture for hydrogen is under active development to create a transparent and investor-friendly environment. The key legislative instruments and processes are structured around three pillars: **energy legislation, environmental compliance, and market integration**.

The principal national documents guiding hydrogen regulation are:

- **Hydrogen Strategy of the Republic of Croatia until 2050** (Official Gazette, 2023)
- **Energy Development Strategy of the Republic of Croatia until 2030, with a View to 2050** (Official Gazette, 2020)
- **National Energy and Climate Plan (NECP)**
- **Low-Carbon Development Strategy until 2030 with a Vision to 2050**
- **Environmental Protection Act** (Official Gazette 80/13, 78/15, 118/18, 110/21)

These documents collectively establish the policy direction for hydrogen development, define long-term emission reduction targets, and integrate hydrogen as a key vector of Croatia's green transition.

Croatia's legal framework is harmonized with the **EU Hydrogen and Decarbonised Gas Market Package** (2023), ensuring compliance with provisions concerning:

- Market access for renewable and low-carbon hydrogen.
- Infrastructure unbundling and third-party access.
- Cross-border hydrogen transport and network interoperability.
- Certification and traceability of hydrogen origin based on the **EU Delegated Acts (2023/2400 and 2023/1184)** defining renewable hydrogen criteria.

Furthermore, Croatia participates in the **European Hydrogen Backbone (EHB)** initiative, contributing to the regional planning of hydrogen pipelines and interconnections in Central and Southeast Europe.

Croatia is actively working on Acts and Guidelines related hydrogen technology across hydrogen value chain. The Guidelines on systems for supplying motor vehicles with compressed hydrogen, that was initiated by MoE, is currently in its final stage and is expected to be published very soon.

The licensing framework for hydrogen facilities is currently being adapted from existing natural gas and electricity regulations, and new hydrogen-specific legislation is under preparation by the Ministry of Economy and Sustainable Development. Croatia has adopted a national Hydrogen Strategy to 2050, outlining strategic goals for hydrogen production, transport, and utilisation that is aligned with EU policy frameworks. Additionally, national authorities are progressing with implementing hydrogen safety and infrastructure regulations (e.g., draft rules for hydrogen refuelling stations), in the context of emerging EU legislation such as Directive (EU) 2024/1788 on common rules for gas and hydrogen markets. The forthcoming **Hydrogen Act (Zakon o vodiku)** — under preparation by the MoE — will establish:

- Licensing procedures for hydrogen production, storage, transport, and distribution.
- Safety and environmental standards for hydrogen installations.
- Rules for connection to energy networks.
- Criteria for designation of hydrogen infrastructure as **Projects of Common Interest (PCI)** or **Projects of Energy Community Interest (PECI)**.

This law will also define the roles of regulatory authorities, ensuring coherence between hydrogen, electricity, and gas markets.

Hydrogen projects must comply with Croatia's **Environmental Impact Assessment (EIA)** and **Strategic Environmental Assessment (SEA)** procedures, in accordance with the **Environmental Protection Act** and **EU Directive 2011/92/EU**. Safety standards are governed by the **Occupational Safety Act**, the **Fire Protection Act**, and relevant EU technical directives, ensuring secure handling and operation of hydrogen technologies.

While Croatia has established a strong institutional foundation, several challenges remain:

- Finalization and implementation of a **dedicated Hydrogen Act** and secondary legislation.
- Development of a **comprehensive certification system** for renewable hydrogen aligned with EU standards.
- Streamlining **permitting and administrative procedures** for hydrogen infrastructure.
- Strengthening **capacity building** within regulatory bodies and technical institutions.
- Encouraging **public-private partnerships** to accelerate investment and deployment.

In the coming years, Croatia's focus will be on consolidating the regulatory framework, enabling market access, and ensuring that hydrogen policy supports broader economic, industrial, and climate goals.

Croatia's institutional and regulatory framework for hydrogen is rapidly evolving to meet the challenges and opportunities of the energy transition. Anchored in EU legislation and national strategies, the framework establishes clear governance structures, harmonized technical standards, and financial incentives that collectively create a conducive environment for the development of a competitive hydrogen economy.

Through continued alignment with EU policy, regional cooperation, and strategic investments, Croatia is poised to become a **reliable partner in Europe's hydrogen ecosystem**, contributing both to energy security and the achievement of the Union's climate neutrality objectives by 2050.

2.3. Guidelines for the regulatory framework

As Croatia accelerates its transition toward a low-carbon economy, a robust, transparent, and forward-looking regulatory framework for hydrogen is essential. The effective regulation of hydrogen across its value chain — production, transport, storage, distribution, and use — will determine the pace of market development and the country's ability to participate competitively in the emerging European hydrogen economy.

This chapter provides **guidelines and strategic recommendations** for strengthening Croatia's regulatory framework for hydrogen. It aims to ensure full **alignment with EU law**, **support cross-border cooperation**, and **facilitate investment** under interregional hydrogen initiatives, particularly those co-financed through **EU programs and transnational partnerships** (e.g. INTERREG, IPCEI Hydrogen, CEF Energy, Horizon Europe, Clean Hydrogen Partnership).

To establish a sustainable and integrated hydrogen ecosystem, Croatia's regulatory framework should be built upon the following foundational principles:

1. **Legal certainty and predictability** – Investors and operators require clear, stable, and transparent rules governing hydrogen production, certification, and network access.
2. **Market integration** – Hydrogen must be regulated as part of the broader energy system, ensuring interoperability between electricity, gas, and hydrogen networks.
3. **Sustainability and traceability** – Regulations must guarantee that renewable hydrogen meets EU-defined sustainability and greenhouse gas reduction criteria.
4. **Technology neutrality with green priority** – The framework should support a range of low-carbon technologies while prioritizing renewable hydrogen consistent with Croatia's decarbonization goals.
5. **Regional cooperation** – Harmonization with neighboring countries is essential for infrastructure planning, cross-border trade, and market coupling.
6. **Safety and public confidence** – Safety standards, public awareness, and acceptance mechanisms must accompany all regulatory steps.

Although Croatia has adopted the **Hydrogen Strategy until 2050** and incorporated hydrogen in its **National Energy and Climate Plan (NECP)**, the legislative framework remains **in its formative stage**. Key gaps include:

- Absence of a **dedicated Hydrogen Act** defining market rules, licensing, and grid integration.
- Lack of **comprehensive certification and guarantees of origin (GoO)** system aligned with EU Delegated Acts (2023/2400 and 2023/1184).
- Limited regulatory clarity regarding **hydrogen blending**, **transport tariffs**, and **storage access**.
- Need for **standardized permitting procedures** for hydrogen projects and facilities.
- Insufficient provisions for **cross-border hydrogen trade and interconnection**.
- Limited **coordination mechanisms** among ministries, regulatory agencies, and research institutions.

These gaps create uncertainty for investors and may slow Croatia's integration into the wider **European Hydrogen Backbone** and regional hydrogen corridors.

To ensure coherence with EU legislation and interregional strategies, the following guidelines are proposed for structuring the national regulatory framework.

3.1. Legislative and Institutional Development

1. **Adopt a Dedicated Hydrogen Act**
   - Establish the legal status of hydrogen as an independent energy carrier.
   - Define rules for production, transmission, storage, distribution, and consumption.
   - Clarify roles and responsibilities of regulatory bodies (HERA, HROTE, MoE).
   - Ensure alignment with the EU Hydrogen and Decarbonised Gas Market Package.
2. **Develop Secondary Legislation and Technical Regulations**
   - Create technical codes for hydrogen infrastructure (pipeline standards, blending limits, safety norms).
   - Define grid connection procedures and access rules.
   - Integrate hydrogen within national energy market rules and tariff systems.
3. **Establish a National Hydrogen Regulatory Coordination Council**
   - Comprising representatives of ministries, HERA, EIHP, academia, and industry.
   - Tasked with monitoring regulatory progress, providing advice, and ensuring coherence with EU standards.

3.2. Market and Certification System

1. **Implement a Guarantees of Origin (GoO) Scheme for Hydrogen**
   - Aligned with EU standards under the Renewable Energy Directive (RED II/III).
   - Administered by HROTE to certify renewable hydrogen production and facilitate cross-border trade.
2. **Develop a Transparent Pricing and Market Access Mechanism**
   - Introduce pilot auctions or Contracts for Difference (CfD) for renewable hydrogen.
   - Enable bilateral trading platforms for hydrogen supply contracts.
3. **Integrate Hydrogen into the Gas and Power Markets**
   - Allow blending where technically feasible while preparing for dedicated hydrogen networks.
   - Coordinate hydrogen dispatch with electricity grid operations to support system balancing.

3.3. Infrastructure Planning and Permitting

1. **Streamline Permitting Procedures**
   - Establish a “one-stop-shop” for hydrogen project approvals to reduce administrative burden.
   - Introduce clear EIA/SEA guidance specific to hydrogen infrastructure.
2. **Incorporate Hydrogen in National and Regional Spatial Planning**
   - Identify hydrogen production zones, storage sites, and transport corridors.
   - Prioritize connection to renewable energy sources and industrial clusters.
3. **Promote Cross-Border Infrastructure Integration**
   - Support participation in the **Adriatic-Ionian Hydrogen Corridor (AIHC)** and the **European Hydrogen Backbone (EHB)**.
   - Coordinate pipeline planning with Slovenia, Hungary, Italy, and other neighboring countries.

3.4. Safety, Standards, and Public Acceptance

1. **Adopt EU and ISO Standards for Hydrogen Safety**
   - Ensure compliance with international norms for storage, transport, and refueling.

- Develop training programs for emergency services and technical personnel.

2. **Enhance Public Awareness and Acceptance**
   - Implement communication campaigns highlighting hydrogen's safety, climate, and economic benefits.
   - Engage local communities early in project development.

3.5. Financing and Investment Facilitation

1. **Leverage EU and National Funding Mechanisms**
   - Integrate hydrogen projects within the **Modernisation Fund**, **Innovation Fund**, and **Cohesion Policy** programs.
   - Support participation in **IPCEI Hydrogen** and **INTERREG transnational cooperation**.
2. **Establish a National Hydrogen Investment Platform**
   - Facilitate public-private partnerships and connect investors with viable projects.
   - Provide de-risking instruments such as guarantees and green bonds.

For Croatia to become an effective participant in the **European hydrogen ecosystem**, coordinated interregional actions are essential. The following recommendations aim to enhance cross-border alignment and maximize synergies with EU projects.

1. **Develop an Interregional Hydrogen Roadmap**
   - Align national infrastructure plans with neighboring Member States.
   - Identify cross-border hydrogen corridors and joint investment opportunities.
2. **Establish Common Certification and Market Rules**
   - Work with regional partners to ensure mutual recognition of renewable hydrogen certification and guarantees of origin.
3. **Participate Actively in European Platforms**
   - Engage in the **European Clean Hydrogen Alliance**, **EHB Initiative**, and **Hydrogen Valleys Partnership** to share best practices and technical knowledge.
4. **Promote Regional Hydrogen Valleys**
   - Support integrated projects that connect renewable production, industrial users, and transport applications across borders.
5. **Encourage Knowledge Exchange and Capacity Building**
   - Create regional centers of excellence for hydrogen regulation, R&D, and workforce training.
   - Foster collaboration between universities, public institutions, and private companies.

Croatia's strategic geographic position — connecting Central Europe, the Balkans, and the Mediterranean — provides a unique opportunity to act as a **hydrogen transit and production hub**.

Through regulatory harmonization, Croatia can:

- Facilitate the **flow of renewable hydrogen** from the Adriatic coast to Central Europe.
- Support **interregional supply chains** for green industrial development.
- Contribute to **EU energy security and diversification goals**, and
- Strengthen **cohesion and economic convergence** among neighbouring Member States and Energy Community partners.

A forward-looking regulatory framework that supports regional integration, transparency, and sustainability will ensure that Croatia not only meets its national hydrogen targets but also becomes an indispensable link

in the European Hydrogen Economy. The development of a comprehensive hydrogen regulatory framework in Croatia is both a national imperative and a regional opportunity. It requires legislative innovation, institutional coordination, and proactive alignment with EU directives and cross-border initiatives.

By implementing the guidelines and recommendations outlined in this chapter, Croatia can establish a predictable, harmonized, and investment-ready regulatory environment that supports its role within a broader interregional hydrogen strategy, reinforcing the objectives of the European Green Deal, REPowerEU, and EU climate neutrality by 2050.

2.4. Stakeholder mapping for Hydrogen development in Croatia

Hydrogen development in Croatia is a multi-stakeholder process that requires close collaboration between public institutions, private enterprises, research organizations, and civil society. Each stakeholder group plays a distinct role in shaping the national hydrogen ecosystem — from policy design and regulation, through research and technology deployment, to market uptake and regional cooperation.

A comprehensive stakeholder mapping helps identify key actors, their interdependencies, and potential synergies to ensure coordinated progress toward Croatia's hydrogen strategy goals and its integration within the European Hydrogen Economy.

The stakeholder ecosystem in Croatia can be divided into five main categories:

1. Government and Regulatory Bodies
2. Public Enterprises and Infrastructure Operators
3. Private Sector and Industry Associations
4. Research, Development and Innovation (RDI) Institutions
5. Regional, Financial and Civil Society Actors

These institutions define Croatia's hydrogen policy, legal framework, and international commitments.

Institution	Main role in hydrogen development	Influence level
Ministry of Economy (MoE)	Lead authority for national hydrogen policy; prepares and implements the Hydrogen Strategy of the Republic of Croatia until 2050; coordinates legislative and funding mechanisms.	Very High
Croatian Energy Regulatory Agency (HERA)	Regulates energy markets; will extend competence to hydrogen pricing, network codes, and safety standards.	High
Croatian Energy Market Operator (HROTE)	Manages renewable energy incentives; develops guarantees of origin (GoO) and market certification schemes for hydrogen.	High
Ministry of Science, Education, and Youth (MoSEY)	Oversees R&D funding and supports academic hydrogen programs and innovation centers.	Medium
Environmental Protection and Energy Efficiency Fund (EPEEF)	Provides co-financing for hydrogen and decarbonisation projects from EU and national sources.	High
Energy Institute Hrvoje Požar (EIHP)	Advisory body for modelling, scenario analysis, and policy evaluation; supports regulatory drafting.	High
Ministry of Transport and Infrastructure	Integrates hydrogen mobility (public transport, logistics) into transport decarbonisation plans.	Medium
Croatian Hydrocarbon Agency (CHA)	National coordinating authority for hydrogen	Medium

Table 1: Government and Regulatory Stakeholders

State-owned or majority public enterprises are pivotal in developing large-scale hydrogen infrastructure and integrating hydrogen into existing energy systems.

Entity	Role	Focus areas
HEP Group (Hrvatska Elektroprivreda)	National electricity utility; developer of renewable generation projects and pilot electrolyzers; future provider of hydrogen power balancing services.	Renewable-based hydrogen production, sector coupling
INA Group	National oil and gas company; exploring hydrogen production and use in refineries and mobility; participant in IPCEI projects.	Industrial hydrogen use, refining, low-carbon fuels
Plinacro d.o.o.	Gas transmission system operator; studying conversion of gas pipelines for hydrogen transport; national partner in the European Hydrogen Backbone (EHB).	Infrastructure conversion, cross-border interconnection
JANAF d.d.	Operator of oil pipeline network; potential partner in developing hydrogen logistics and storage facilities.	Transport and storage
HŽ Infrastruktura & Croatian Motorways (HAC)	Evaluate hydrogen applications in rail and heavy transport corridors.	Mobility integration

Table 2: Public Enterprises and Infrastructure Operators

The private sector provides technological innovation, investment capital, and early-stage deployment initiatives.

Category	Key stakeholders	Contributions
Renewable Energy Developers	Encro, Končar Energy, E.ON Croatia, Professio Energy, Altpro	Invest in solar + electrolyzer + fuel cells projects; pilot hydrogen valleys.
Industrial Off-Takers	Petrokemija Kutina, Đuro Đaković Group, cement and steel industries	Potential large-scale hydrogen users; decarbonisation of process heat.
Technology and Equipment Suppliers	Siemens Energy Croatia, Končar Group, Rimac Technology	Provide electrolysis, storage, and mobility solutions.
Industry Associations	Croatian Chamber of Economy (HGK), Croatian Employers' Association (HUP)	Facilitate industry coordination and represent private-sector interests.

Table 3: Private Sector Stakeholders

Below is an overview of the regional and financial stakeholders.

Actor type	Key stakeholders	Role
Regional and Local Authorities	County development agencies (e.g. Split-Dalmatia, Primorje-Gorski Kotar), City of Zagreb	Promote regional hydrogen valleys and integrate hydrogen into local energy plans.
Financial Institutions	Croatian Bank for Reconstruction and Development (HBOR), commercial banks, EIB	Provide financing, guarantees, and risk-sharing mechanisms for hydrogen investments.
EU Programmes & Platforms	INTERREG ADRION, CEF Energy, IPCEI Hydrogen, European Clean Hydrogen Alliance	Facilitate regional cooperation, funding, and standardization.
Civil Society & NGOs	Green Action, Energy Transition Initiative Croatia	Promote awareness, social acceptance, and community participation.

Table 4: Regional and Financial Stakeholders

Hydrogen development requires multi-level governance and cross-sectoral collaboration.
Existing and recommended cooperation mechanisms include:

- National Hydrogen Council (proposed) – a formal coordination body linking government, industry, and academia.
- Public-Private Partnerships (PPPs) – joint ventures for hydrogen valleys, refuelling networks, and infrastructure development.
- EU Project Consortia – Croatia's participation in interregional projects such as the Adriatic-Ionian Hydrogen Corridor (AIHC).
- Knowledge Networks – national and regional hydrogen clusters facilitating information exchange and workforce training.

These mechanisms enable policy coherence, accelerate technology transfer, and ensure that hydrogen deployment supports both national and EU-wide climate goals.

Stakeholder group	Influence on policy	Implementation capacity	Engagement priority
Government & Regulators	Very High	High	Maintain strategic coordination
Public Enterprises	High	Very High	Prioritize for infrastructure rollout
Private Sector & Industry	Medium-High	High	Encourage investment and innovation
Research & Academia	Medium-High	Medium-High	Strengthen R&D and skills
Regional & Financial Actors	Medium	Medium	Integrate financing and local planning
Civil Society	Low	Medium	Increase outreach and acceptance

Table 5: Stakeholder Influence and Engagement Priority

The following recommendations are provided to strengthen stakeholder collaboration in the development of the hydrogen economy. It is recommended to **establish a National Hydrogen Platform** to formalize cooperation among ministries, regulators, industry, and academia. Furthermore, efforts should be made to **encourage cluster development** by supporting regional hydrogen valleys that connect renewable energy resources with industry and transport sectors. Another key action is to **enhance stakeholder capacity building** through targeted training programmes and knowledge exchange initiatives with the European Union. It is also essential to **develop transparent communication channels** to improve public understanding and acceptance of hydrogen technologies. Finally, it is recommended to **foster interregional partnerships** with **neighboring countries** through joint investment plans and shared infrastructure initiatives under frameworks such as INTERREG or IPCEI.

The stakeholder landscape for hydrogen development in Croatia is diverse, dynamic, and expanding rapidly. Strong collaboration between public institutions, industry leaders, research bodies, and financial actors will be crucial to achieve Croatia's hydrogen ambitions and contribute meaningfully to the European Hydrogen Economy.

By creating structured coordination mechanisms and aligning national actors with interregional hydrogen corridors and EU strategic projects, Croatia can transform its stakeholder ecosystem into a cohesive, innovation-driven partnership network — ensuring long-term competitiveness, sustainability, and regional leadership in clean hydrogen deployment.

3. Interregional Hydrogen readiness in Croatia

Croatia is generally most suited for hydrogen development in regions with high industrial demand, plenty of potential for Renewable Energy Sources (RES), and convenient access to markets and infrastructure. A coordinated interregional plan that links inland industrial demand and innovation hubs with coastal RES power plants is necessary to maximise the benefits of the hydrogen economy for the entire country. Hydrogen may play a significant role in Croatia's transition to a low-carbon economy. Opportunities for the creation of a hydrogen value chain tailored to each region are presented by the country's diverse regional energy profiles, which range from industrial areas to areas abundant in RES like solar and wind energy both inland and along the coast. Assessing regional readiness involves analysing the availability of RES, industrial demand, infrastructural readiness, research and innovation capabilities, and regional policy support mechanisms.

3.1. Identification of regions with the highest potential

Croatia's ability to establish a competitive and resilient hydrogen economy is influenced by significant regional variations in natural resources, industrial composition, and energy infrastructure. These disparities should not be viewed as limitations. Instead, they present an opportunity to develop a polycentric and synergistic national hydrogen system, in which each region leverages its comparative advantages. This section highlights the regions with the greatest potential for swift hydrogen deployment and the development of integrated hydrogen ecosystems, which can support national decarbonization goals and align with the EU Hydrogen Strategy[1].

Regional Overview and Strategic Relevance

Hydrogen potential in Croatia is unevenly distributed because of regional climate, RES availability, industrial activity, and the presence of important transportation and port infrastructure.

The four regions are North-West Region, Northern Adriatic Region, Slavonia, and Dalmatia, as shown in Figure 1. Their advantages form the essential pillars of a hydrogen economy, opening doors for sustainable mobility, industrial decarbonization, renewable hydrogen production, and international collaboration.

Figure 2: Regions of Republic of Croatia

North-West Region

North-West Region, which includes Zagreb and Central Croatia, serve as the administrative, economic, and scientific centre of the country. The region hosts prominent universities, research institutions, technology hubs, and significant energy corporations, establishing it as the intellectual and organizational catalyst for the country's hydrogen transition. This region is especially well positioned for the development of hydrogen-powered mobility solutions, urban energy applications, and advanced technologies including smart

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0301

infrastructure and power-to-gas (P2G) systems. Research institutions, led by the University of Zagreb Faculty of Mechanical Engineering and Naval Architecture (UNIZAG FSB), serve a vital function in promoting hydrogen-related research and development (R&D), fostering workforce development, and supplying scientific expertise for pilot initiatives and policy formulation. At the governance level, Zagreb's prominent position in national planning enables it to function as the central coordinating authority for hydrogen policy, assuring coherence among regional initiatives, public institutions, industry stakeholders, and EU funding structures.

Northern Adriatic Region

The Northern Adriatic Region, which includes Primorje-Gorski Kotar and Istria, provides a special combination of port infrastructure, industrial capacity, and RES potential. This area has a strong industrial base with immediate prospects for hydrogen use in petrochemicals, heavy transportation, logistics, refinery, and maritime applications. It is driven by the Rijeka refinery and the Port of Rijeka. The Port of Rijeka is well-positioned to serve as a hub for the import, export, and distribution of hydrogen due to its strategic location on the Trans-European Transport Network (TEN-T). Clean shipping routes, hydrogen-ready port equipment, and future hydrogen supply services can all be created in accordance with EU marine decarbonization regulations. Further value is added by the region's onshore and offshore wind potential, which makes it possible to expand green hydrogen production at a reasonable cost. These benefits make the Northern Adriatic Region an ideal location for industrial demonstrations, pilot hydrogen projects, and the construction of a cross-border hydrogen corridor connecting Croatia with markets in Slovenia, Italy, Austria, and Central and Southeast Europe.

Dalmatia

The Dalmatian region exhibits significant RES in Croatia, especially in solar and wind energy. These factors position it effectively as a significant centre for green hydrogen production via water electrolysis. Solar irradiation levels along the coast and islands are among the highest in Europe, facilitating consistent conditions for photovoltaic (PV) deployment, while strong and stable winds enhance wind farm integration. The strategic maritime infrastructure of Dalmatia, comprising the ports of Split, Zadar, and Šibenik, enhances its potential by enabling efficient hydrogen export and facilitating the utilization of hydrogen in maritime transport, port operations, and coastal logistics. The substantial tourism sector in the region is progressively focussing on sustainability, thereby generating demand for low-emission mobility solutions, including hydrogen-powered buses, ferries, and service fleets. Dalmatia's abundant RES potential, port access, and sectoral demand establish it as a pivotal region for the early large-scale hydrogen production and for promoting the decarbonization of coastal and island communities.

Slavonia

Due to its geographical position and accessible resources, Slavonia serves as an advantageous site for the generation of green and low-carbon hydrogen, as well as for carbon capture and storage (CCS) in exhausted gas fields. The developed industrial zones in Slavonia, along with a comprehensive gas transmission network, offer the necessary physical infrastructure for hydrogen transportation via existing natural gas pipeline network, distribution, and storage. Moreover, hydrogen can facilitate the decarbonization of agro-industrial value chains, including fertilizer manufacturing, drying grains, and food processing. By advancing green and low-carbon hydrogen and integrating it into the natural gas grid, Slavonia can significantly contribute to improving national energy security and diversifying hydrogen supply sources.

Integrated National Perspective

These areas build a solid and useful basis for Croatia's future hydrogen economy. Dalmatia supplies substantial RES, the Northern Adriatic presents industrial demand and maritime infrastructure, Slavonia enhances green and low hydrogen and natural gas grid integration, while North-West Region guarantees

scientific capacity, innovation, and national coordination. This polycentric regional model improves resilience, allocates economic advantages, and allows Croatia to engage actively in developing European hydrogen networks. Utilising the strengths of each region and promoting interregional synergies will enable Croatia to expedite its advancement towards climate neutrality, enhance energy independence, and establish itself as a leader in the hydrogen sector of Southeast Europe.

3.1.1. Nort-west region

The North-West Region, which includes the City of Zagreb and the counties of Krapinsko-zagorska, Varaždinska, and Međimurska, is recognized as one of the country's most economically developed and industrially varied regions. The region's extensive transport infrastructure, robust industrial activity, and concentration of prominent scientific and research institutions establish it as a pivotal catalyst for the development, testing, and deployment of hydrogen technologies. Its geographic proximity to Austria, Slovenia, Italy and Hungary facilitates cross-border cooperation, integration into Central European hydrogen corridors, and engagement in emerging transnational energy markets. The North-West Region provides a solid basis for green hydrogen production. The consistent expansion of rooftop and ground-mounted PV systems, especially on industrial facilities, commercial establishments, and public-sector infrastructure, signifies a growing local capacity for electricity generation from RES. The region's substantial municipal waste streams, in conjunction with these resources, establish a reliable basis for decentralized and distributed hydrogen production. These production systems have the potential to provide hydrogen directly to local transport operators, industrial facilities, and logistics hubs, thereby facilitating the development of regional hydrogen microgrids and enhancing local energy resilience. The industrial profile of the region further supports its appropriateness for hydrogen adoption. In Croatia, key sectors such as chemicals, cement and construction materials, and advanced manufacturing are identified as the most energy intensive. Industries are under growing pressure to decrease greenhouse gas (GHG) emissions and may significantly benefit from the introduction of hydrogen as an energy carrier and industrial feedstock. Hydrogen-based processes present an opportunity to decarbonize high-temperature industrial operations, diminish reliance on fossil fuels, and improve long-term competitiveness in accordance with EU climate and industrial policies. Moreover, transportation constitutes a significant domain for the initial implementation of hydrogen technology. The North-West Region, particularly the broader Zagreb metropolitan area, is positioned at the convergence of significant TEN-T corridors, establishing it as a strategic site for the deployment of hydrogen-powered buses, heavy-duty trucks, and rail applications. Zagreb International Airport presents opportunity for the exploration of hydrogen applications in airport ground operations, hydrogen-based auxiliary power units, and, in the long term, sustainable aviation fuels. The introduction of hydrogen into aviation energy systems will facilitate the airport's shift to low-emission operations and comply with expected European decarbonization standards in the aviation industry. The current energy infrastructure in the region is adequately equipped to facilitate hydrogen integration. The natural gas transmission and distribution system, in conjunction with the electricity grid, establishes a basis for the future transport and distribution of hydrogen. Industrial zones located along these networks may function as initial locations for pilot projects related to hydrogen storage, grid balancing, and combined heat and power (CHP) applications. The strategic location of the North-West Region along cross-border energy routes enhances its potential to develop as a hydrogen distribution hub, supporting domestic flows and future exports to neighbouring markets. The region's research, innovation, and educational ecosystem is equally significant. Zagreb, as Croatia's primary academic centre, is home to number of universities, faculties, and research institutes that focus on energy transition issues. The UNIZAG FSB is pivotal in promoting hydrogen research, engineering education, and the advancement of innovative hydrogen technologies. These institutions promote collaboration between industry and academia, facilitate high-quality feasibility studies and simulations, and assist in the commercialization of advanced hydrogen solutions. Their participation guarantees that the region adopts hydrogen technologies and contributes to their scientific and

technological advancement. These factors suggest that the North-West Region demonstrates significant readiness for hydrogen deployment. The robust industrial demand, developed transport infrastructure, growing RES sector, and advanced innovation ecosystem provide conducive conditions for the establishment of a regional hydrogen cluster. The region is strategically positioned to function as Croatia's national coordination and innovation centre for hydrogen development. This role can initiate pilot and demonstration projects, evaluate new technological approaches, enhance workforce training, and reinforce connections between renewable energy generation, industrial applications, and national sustainable mobility solutions.

3.1.2. Northern Adriatic

The Northern Adriatic Region, which includes the counties of Istarska and Primorsko-goranska, is a strategically significant area in Croatia for the early establishment of a hydrogen economy. The integration of a diverzified and energy-intensive industrial base, advanced maritime and port infrastructure, strong cross-border connectivity, and improving RES conditions positions it advantageously for domestic hydrogen deployment and engagement in wider European hydrogen networks. The region, located along the northern Adriatic Sea, functions as a natural channel between the Mediterranean and Central Europe, providing optimal conditions for incorporation into transnational hydrogen corridors that align with the developing European Hydrogen Backbone and EU decarbonization efforts. The energy landscape of the region is experiencing significant transformation due to the expansion of wind and solar investments, with notable potential for further offshore wind development in the Kvarner area. The spatial configuration of the coastal belt, coastal hinterland, and islands, along with favourable wind patterns and increased solar irradiation, facilitates a significant RES capacity factor. The foundation of RES, supported by increasing investment in PV systems, establishes a reliable basis for local green hydrogen production via water electrolysis. These RES sites can be effectively connected to significant industrial consumers and port facilities, facilitating the development of an integrated, self-sustaining low-carbon hydrogen ecosystem in the region. The industrial readiness of the Northern Adriatic constitutes a significant strength. The Rijeka industrial zone encompasses the Rijeka refinery, petrochemical facilities, manufacturing plants, and nearby logistics complexes, presenting immediate opportunities for hydrogen adoption in heavy industry, refining processes, and energy-intensive production chains. Hydrogen possesses the capability to substitute fossil fuels in high-temperature applications, diminish emissions in petrochemical and refinery processes, and serve as a clean feedstock for the production of synthetic fuels and chemicals. The existing infrastructure, particularly the LNG terminal on the island of Krk and the established natural gas network, offers significant technological and logistical benefits for future hydrogen transport, distribution, storage, and export, positioning the region as a pivotal energy hub. The Port of Rijeka, as Croatia's largest and most strategically significant seaport, enhances this potential. The port, as a significant node of the TEN-T, is well-positioned to serve as a hydrogen import, supply for vessels, and distribution hub. A hub of this nature would facilitate hydrogen-powered maritime transport, port machinery, and industrial operations, while also allowing for the export of hydrogen or hydrogen-derived fuels to global markets. The port's involvement in EU green corridor initiatives enhances its strategic significance, establishing it as a prospective Adriatic gateway for clean fuels and a key element in regional maritime decarbonization efforts. In addition to its established heavy industry and maritime logistics sectors, the Northern Adriatic Region presents significant potential for hydrogen integration in urban mobility and tourism transport systems. Cities like Rijeka, Pula, and other coastal municipalities may lead in the implementation of hydrogen-powered buses, municipal fleets, ferries, and service vehicles. These initiatives would significantly reduce the carbon footprint of the region's tourism sector, which is economically vital and environmentally sensitive. Local authorities, with the backing of regional development agencies and EU funding programs aimed at clean mobility and RES integration, are showing a growing interest in these solutions. The research, innovation, and knowledge ecosystem in the region facilitates the transition to hydrogen. The University of Rijeka and its associated research centres are

instrumental in promoting initiatives concerning energy transition and maritime innovation. These institutions are involved in research pertaining to port decarbonization strategies and integrated energy system modelling. Engagement in international initiatives, including Horizon Europe, Interreg, and cross-border research consortia, enhances the region's technical capabilities and ensures alignment of innovation efforts with European standards and global technological trends. The Northern Adriatic Region demonstrates significant readiness for the early implementation of hydrogen technology. The significant industrial demand, RES potential, developed transport and port infrastructure, and a strong innovation ecosystem create a suitable environment for hydrogen technologies. The region's strategic location at the intersection of Mediterranean maritime routes and Central European energy corridors positions it as Croatia's primary hub for hydrogen production and distribution. It is also poised to significantly contribute to regional hydrogen exchanges, maritime decarbonization pathways, and the broader European clean energy transition.

3.2. Hydrogen production in identified regions

With the North-West Region and the Northern Adriatic Region emerging as the two most strategically significant sites for early and sustained hydrogen deployment, Croatia's hydrogen production environment is marked by great regional variability. They provide complementary capabilities in the areas of industrial demand, innovation capability, RES generation, and international connectivity, forming the basis of a future Croatian hydrogen economy. A strong, scalable, and resilient hydrogen production system that serves both national decarbonization objectives and integration into European hydrogen networks can be established by a concerted effort bringing these two regions together. The Northern Adriatic Region has the potential to produce renewable (green) hydrogen, whereas the North-West Region offers the intellectual resources, innovative frameworks, and varied demand essential for the integration of hydrogen into transportation, industrial applications, and urban energy systems. Establishing dedicated infrastructure, including hydrogen-compatible pipelines, hydrogen refuelling infrastructure, and integrated logistics networks, would connect these two regions and create a North–South hydrogen axis. This development would facilitate national decarbonization and enhance Croatia's engagement in the European hydrogen market.

3.2.1 North-West Region

The North-West Region, encompassing the City of Zagreb and the counties of Krapinsko-zagorska, Varaždinska, and Međimurska, offers a unique yet highly complementary basis for hydrogen development. The region, while having lower RES potential than the Adriatic coast, provides a solid basis for distributed green hydrogen production via water electrolysis through solar power plant installations and potential waste-to-hydrogen technologies. Rooftop PV installed on industrial, commercial, and public buildings, combined with municipal and agricultural waste streams, establish favourable conditions for small-scale and medium-scale electrolysis systems. Decentralized production units have the potential to supply hydrogen directly to urban transport operators, industrial zones, and logistics hubs, facilitating the establishment of local hydrogen microgrids that improve energy resilience. The region's varied industrial foundation offers significant prospects for substituting fossil fuels in high-temperature industrial processes and integrating hydrogen as a clean feedstock. Moreover, the North-West Region serves as an important hub for hydrogen-based mobility. Zagreb's strategic position at the convergence of key TEN-T corridors makes it an optimal location for the initial implementation of hydrogen-powered buses, heavy-duty vehicles, and rail services. Zagreb International Airport offers enhanced long-term prospects for hydrogen utilization in ground operations and sustainable aviation systems. The region's established natural gas and electricity transmission networks facilitate pilot projects related to hydrogen transportation, storage, and distribution. The proximity to Slovenia, Austria, Italy, and Hungary enhances its role in cross-border hydrogen initiatives and

future pipeline connectivity. The North-West Region serves as Croatia's primary hub for research, innovation, and technology having institutions that lead the national hydrogen research initiatives and promote technological innovation, system integration, modelling, and workforce development. The region is uniquely positioned to function as the National hydrogen centre of excellence, coordinating technological development, testing new systems, and facilitating collaboration between industry and academia.

3.2.2 Northern Adriatic Region

The Northern Adriatic Region, which includes Istarska and Primorsko-goranska counties, provides optimal conditions for large-scale green hydrogen production in Croatia. The region has an expanding portfolio of solar and wind energy projects, with significant potential for offshore wind development in the Kvarner area. These conditions facilitate a stable RES basis that can effectively power high capacity electrolyzers with reduced intermittency. Proposed RES installations in Istria and Kvarner may be directly associated with electrolysis power plants, facilitating closely integrated renewable-hydrogen systems and minimizing transmission losses. The region contains a concentration of strategic industrial and logistics assets that create immediate demand for hydrogen and facilitate rapid commercialization opportunities. The Rijeka refinery, LNG terminal on the island of Krk, and Port of Rijeka constitute an integrated industrial ecosystem capable of accommodating substantial quantities of green hydrogen for applications in industrial processes, refinery operations, and synthetic fuel manufacturing. The LNG terminal offers significant potential for future hydrogen transportation, storage, and export, establishing the region as a key component in the developing European Hydrogen Backbone. The Port of Rijeka's pivotal position within the TEN-T corridor network positions it as a prime candidate for a hydrogen import, supply, and distribution hub in the maritime sector. Hydrogen-powered port machinery, fuel-cell ferries, and hydrogen-fuelled auxiliary systems can facilitate initial emissions reductions and serve as models for maritime decarbonization in the Adriatic region. The integration into EU green shipping corridor initiatives enhances the region's significance as a transnational clean-fuel hub linking the Mediterranean and Central Europe. In addition to its heavy industry and shipping sectors, the Northern Adriatic possesses significant potential for hydrogen-enabled mobility. Urban centres like Rijeka and Pula have the potential to lead in the implementation of hydrogen-powered buses, municipal vehicles, and coastal ferries, thereby contributing to decarbonization and energy independence in a tourism-dependent region. Local governments, with the support of EU programs, are actively investigating the introduction of hydrogen in clean mobility and the integration of RES projects. The research and innovation ecosystem in the region, spearheaded by the University of Rijeka and its affiliated institutes, enhances its ability to adopt and scale hydrogen technologies. Regional research and development initiatives in energy systems modelling, maritime decarbonization, and hydrogen applications align with industrial capabilities, facilitating simultaneous advancement in innovation and deployment.

3.3. Potential uses of Hydrogen in identified regions

In Croatia, the possible uses of hydrogen vary a lot from one region to another. This is because different regions have different industrial structures, energy systems, levels of infrastructure development, and research abilities. The North-West Region and the Northern Adriatic Region are the most advanced and well-placed for early hydrogen deployment. The main factors that support Croatia's new hydrogen economy are its industry demand, its access to RES, its innovation ecosystems, and its ability to connect with other countries. The North-West Region and the Northern Adriatic Region form the backbone of Croatia's hydrogen economy. The Northern Adriatic has the potential to produce significant amounts of renewable hydrogen using coastal and offshore resources, whereas the North-West Region provides innovation capabilities, urban demand, industrial testing environments, and strategic transport connectivity. Enhancing infrastructure connections among these regions via hydrogen-ready pipelines, refuelling corridors, multimodal transport

hubs, and coordinated logistics would establish a North–South Hydrogen Hub. This hub would link production sites with consumption centres and facilitate the transfer of knowledge, technology, and expertise throughout the national hydrogen ecosystem. This interregional partnership has the potential to develop into a multi-regional hydrogen corridor, establishing Croatia as a significant participant in the Central and Southeast European hydrogen sector. This corridor would enable extensive decarbonization of transport, heavy industry, and urban energy systems, while incorporating Croatia into trans-European hydrogen networks and improving national energy security.

3.3.1 North-West Region

The North-West Region offers significant opportunities for hydrogen utilization, attributed to its diverse industrial base, comprehensive transport infrastructure, and advanced research and educational ecosystem. The transport sector is identified as a particularly promising application area. The region's extensive motorway network, significant logistics centres, and well-developed public transport systems make it a suitable site for the implementation of hydrogen-powered buses, heavy-duty vehicles, and potentially rail services. Establishing early hydrogen infrastructure in and around Zagreb, especially along TEN-T corridors, would enhance passenger and freight mobility while significantly decreasing emissions from urban and intercity transport. Hydrogen mobility may facilitate public-sector decarbonization by providing clean fuel for municipal and regional service fleets. Hydrogen presents potential for substituting fossil fuels in energy-intensive processes necessitating elevated temperatures, particularly in chemical production within the industrial sector. Hydrogen demonstrates significant potential in urban energy systems, especially within the modernizing district heating network of Zagreb. Integrating hydrogen with natural gas to a concentration of 100% has the potential to decrease emissions while optimizing the use of current infrastructure. The integration of advancements in P2P technologies could establish the North-West Region as a model for urban hydrogen energy systems in Central and Southeast Europe, thereby enhancing circular economy principles and facilitating pathways towards renewable hydrogen production. The region's function as a leader in innovation and demonstration is of significant importance. The North-West Region, characterized by a robust presence of research institutions, is positioned to lead in the development and validation of hydrogen technologies. Investigations into smart grids, P2P systems, microgrids, and renewable configurations facilitate pilot projects that examine hydrogen's function in grid balancing, seasonal energy storage, and system flexibility.

3.3.2 Northern Adriatic Region

The Northern Adriatic Region, which includes Istarska and Primorsko-goranska counties, provides a significant foundation in Croatia for the swift adoption of hydrogen technology, due to its strong industrial base, notable RES potential, and strategic port infrastructure. The Port of Rijeka serves as the country's busiest maritime gateway and a vital component of the TEN-T corridor. With suitable investments, the port has the potential to develop into a hub for hydrogen import, storage, and distribution, serving both domestic consumers and international shipping routes. Hydrogen-powered cargo handling equipment, fuel-cell ferries, and maritime auxiliary systems will facilitate the EU's goals for creating green maritime corridors in the Adriatic region. The Rijeka refinery and adjacent petrochemical facilities represent the primary demand centre for hydrogen in the industrial sector. The gradual replacement of grey hydrogen with green hydrogen would substantially aid in meeting both European and national decarbonization goals. The LNG terminal on the island of Krk enhances strategic value by potentially facilitating the import and export of hydrogen and hydrogen carriers, including ammonia and methanol. This development reinforces Croatia's position as a regional energy transit hub connecting the Mediterranean with Central and Southeast Europe. The extensive coastline and numerous islands in the region provide advantageous conditions for the implementation of hydrogen-powered ferries, buses, municipal vehicles, and coastal distribution fleets. The elevated energy demand driven by tourism and significant seasonal variability in RES necessitate enhanced balancing

solutions. Hydrogen storage, whether seasonal or short-term, has the potential to stabilize the grid and guarantee energy availability during peak tourism periods. Ongoing research in maritime decarbonization, port electrification, and integrated energy systems facilitates the creation of hydrogen solutions that are customised to meet local requirements. Regional development agencies and EU-funded programs that emphasise green ports, clean mobility, and RES integration enhance the region's ability to translate innovation into practical applications.

3.4. Action Plan for leveraging existing infrastructure and expanding Hydrogen networks

Building Croatia's hydrogen economy involves more than just increasing energy production from RES. It also relies on the country's ability to utilize current infrastructure and to strategically enhance hydrogen networks throughout essential areas. Croatia enjoys a robust network of natural gas pipelines, electricity transmission systems, industrial facilities, transport corridors, and port infrastructure. By making suitable adjustments, these assets can be adapted to facilitate the production, storage, and distribution of hydrogen. This section outlines a step-by-step action plan aimed at expediting the creation of a national hydrogen network, specifically targeting the North-West Region and the Northern Adriatic Region, which serve as the strategic gateways for Croatia's hydrogen transition.

Phase 1 (2026-2028): Evaluating and Modifying Existing Infrastructure

The initial phase emphasises a thorough evaluation and enhancement of Croatia's existing energy and industrial infrastructure suitable for hydrogen applications. This encompasses: **1.** Repurposing sections of the natural gas transmission and distribution network for hydrogen transportation; **2.** Adapting industrial facilities for hydrogen introduction; and **3.** Leveraging existing port, logistics, and storage infrastructure to facilitate initial hydrogen handling and distribution. In the Northern Adriatic Region, it is advisable to prioritize the integration of hydrogen within the Rijeka industrial-port complex, as it presents the most significant immediate demand and logistical capabilities. The Rijeka refinery and the LNG terminal on the island of Krk present a significant opportunity for the early integration of hydrogen, encompassing refinery decarbonization, hydrogen storage, and the import and export of hydrogen and hydrogen carriers like ammonia and methanol. The Port of Rijeka has the potential to function as a pilot site for hydrogen-powered port machinery and vessels, facilitated by specialized storage tanks and hydrogen refuelling station (HRS). Comprehensive mapping and technical evaluations of these assets will facilitate the identification of immediate opportunities and inform investment strategies. In the North-West Region, emphasis should be placed on the mapping of industrial zones, logistics hubs, and district heating systems that are conducive to early hydrogen integration. The region's comprehensive natural gas infrastructure and energy-intensive manufacturing sector position it favourably for initial hydrogen transportation and the substitution of fossil fuels in combined heat and power systems. Collaboration among Plinacro, research institutions, and local governments is crucial for the development of pilot infrastructure and feasibility studies for a hydrogen distribution corridor linking Zagreb to the Adriatic coast.

Phase 2 (2028-2030): Establishing Hydrogen Hubs and Transportation Networks

The second phase seeks to establish regional hydrogen hubs and transport corridors that connect production, storage, and consumption centres. The Northern Adriatic Hydrogen Hub will be propelled by coastal RES initiatives, industrial demand centres, and maritime transport applications. The North-West Hydrogen Hub will concentrate on urban and industrial applications, technological advancements, and demonstration initiatives. The foundation of Croatia's initial hydrogen network ought to be a North-South Hydrogen Corridor extending from Rijeka-Krk to Zagreb-Sisak. This corridor can initially leverage

existing natural gas infrastructure for hydrogen transportation, gradually transitioning to dedicated hydrogen pipelines. A network of HRS for heavy-duty vehicles would establish a continuous zero-emission mobility route along key motorways and freight corridors, particularly the A6 (Rijeka–Zagreb) and A1 highways. International interconnections should be actively explored to align with the European Hydrogen Backbone initiative. Croatia would be positioned as a strategic transit and export hub within the regional hydrogen market.

Phase 3 (2030–2035): Enhancing Infrastructure and Integrating Systems

In the third phase, Croatia's hydrogen infrastructure is expected to develop into a comprehensive national hydrogen network, underpinned by sophisticated energy planning and digital management systems. Key actions include: **1.** Developing large-scale hydrogen storage in geological formations, particularly in the Pannonian Basin, such as depleted gas fields in Slavonia; **2.** Constructing dedicated hydrogen transmission lines to connect major production and demand centres; **3.** The integration of hydrogen production facilities with electricity and gas grids facilitates P2G operations, thereby improving system flexibility and grid balancing; **4.** Expanding hydrogen infrastructure for public and freight transport to ensure comprehensive coverage across major cities and ports. In this phase, the North-West Region is expected to function as the national centre for digital integration, smart grid advancement, and cutting-edge research and development, enhancing hydrogen system efficiency. The Northern Adriatic Region will enhance its position as Croatia's industrial and maritime hydrogen hub by increasing hydrogen production, export capabilities, and port-based hydrogen infrastructure. The integration of these two regions will establish a polycentric national hydrogen system, providing operational advantages to Dalmatia, Slavonia, and additional areas.

Phase 4 (2035-onward): Strengthening Institutions and Expanding the Market

The success of Croatia's hydrogen transition cannot be assured by infrastructure alone. It is essential to enhance institutional, regulatory, and market frameworks. Key actions include: **1.** Establishing a National Hydrogen Infrastructure Agency or Coordination Body to align regional initiatives and ensure regulatory coherence (the existing Agency for Hydrocarbons serves as a Coordination body but requires increased activity and operational capacity); **2.** Implementing market incentives and fostering public-private partnerships to enhance investment in hydrogen infrastructure; **3.** Establishing EU-compliant standards, certification schemes, and safety frameworks for hydrogen production, storage, transportation, and utilization; **4.** Promoting collaboration among municipalities, universities, and industry, especially via hydrogen innovation clusters in Zagreb and Rijeka. These actions will facilitate coordinated growth, attract EU and private capital, and support infrastructure development that is technologically and economically sustainable.

3.5. Measures to support regional Hydrogen development

Through the repurposing of existing assets and the strategic expansion of its hydrogen network, Croatia can develop a resilient, flexible, and future-ready hydrogen system. The Northern Adriatic Region is poised to facilitate extensive hydrogen production and maritime applications, whereas the North-West Region will focus on fostering innovation, urban integration, and system optimization. They represent the two drivers of Croatia's hydrogen transformation, connecting coastal RES with inland industrial demand and establishing Croatia as a model of effective hydrogen infrastructure and innovation in Central and Southeast Europe.

3.5.1 North-West Region

The North-West Region possesses significant potential to emerge as Croatia's primary centre for hydrogen innovation, urban applications, and decentralised production. Various targeted initiatives can facilitate success in this region, as illustrated in Table 1.

Measure	Description
Enhancing local hydrogen production	The region should promote the installation of small and medium-sized electrolyzers, especially those utilizing solar energy, to produce renewable hydrogen and enhance local supply within a more flexible and sustainable energy framework. Research initiatives converting municipal or industrial waste into hydrogen can enhance circular economy objectives and expand local production pathways.
Promoting hydrogen mobility	The area is ideally suited for early hydrogen mobility projects because of its extensive transportation network. If HRS were set up in key spots along Zagreb's main transportation and logistics lines, it would be easier to use hydrogen-powered buses, delivery and trash trucks, and even regional rail services. Because Zagreb Airport offers great potential for testing hydrogen in ground-handling operations and other airport activities, the shift may also extend to aviation.
Facilitating industrial implementation	Hydrogen-based technologies could provide substantial advantages to industrial zones in Zagreb, Varaždin, and Međimurje. The integration of hydrogen-powered CHP systems or fuel cells in these sectors enables companies to reduce emissions and enhance efficiency. Targeted programs should assist energy-intensive industries in understanding how hydrogen can facilitate high-temperature processes and contribute to long-term decarbonization.
Integrating hydrogen into urban energy Infrastructure	Opportunities to integrate hydrogen into existing natural gas networks will arise as Zagreb and nearby cities improve their district heating infrastructure and energy systems. In the long term, P2G initiatives have the potential to contribute to the stabilization of the electricity grid by transforming excess RES into hydrogen for seasonal storage. Aligning urban development strategies with hydrogen-compatible infrastructure will facilitate the seamless integration of low-carbon energy solutions into new buildings and districts.
Improving research, innovation, and competencies	The strong academic base in the region, led by UNIZAG FSB, makes it a natural place for hydrogen study and development. Adding more test labs, study programs, and labs for smart grids, electrolyzers, and fuel cells will speed up the development of technology. By building a Regional Hydrogen Centre, businesses, researchers, policymakers, and public institutions would have a place to work together to try solutions before they are used in real life. Also, developing the workforce is very important. Giving engineers, technicians, and city employees specialized training will help make sure that everyone in the region has the skills they need to run hydrogen systems safely and efficiently.

Table 6: Strategic measures to support hydrogen development in the North-West Region

3.5.2 Northern Adriatic Region

The Northern Adriatic Region possesses all the necessary elements to establish itself as one of Croatia's premier hydrogen hubs. It incorporates industry, ports, RES, and strong connections to other countries. To fully exploit that potential, many practical measures can be implemented, as indicated in Table 2.

Measure	Description
Supporting green (renewable) hydrogen production	In order to provide a consistent supply of clean electricity for electrolyzers, it will be crucial to accelerate the installation of new wind and solar power plants, with a focus on offshore wind potential in the Kvarner area. Croatia should simultaneously support renewable-hydrogen projects, where electrolysis and energy generation are planned and developed together from the start. Identifying zones for the concurrent development of RES systems and hydrogen production facilities, especially in proximity to substantial industrial complexes and the Port of Rijeka, would facilitate project execution and enhance the efficiency of integrated hydrogen production.
Constructing hydrogen facilities	Establishing hydrogen infrastructure at the Port of Rijeka will be essential to establishing the area as a major clean fuels marine hub. This includes setting up a specific Port of Rijeka Hydrogen Hub with capabilities for delivering hydrogen to ships, backed by onshore HRS for road transportation and storage facilities. The port's shift to cleaner operations can be supported by early pilot initiatives like the introduction of hydrogen-powered ferries and the deployment of hydrogen-powered port machinery. In a longer term, all significant port investments, whether they involve ships, cargo handling systems, or more general logistics operations, must take hydrogen into account from the very beginning.
Endorsing the decarbonization of industry	To help reduce carbon emissions in industry, it is needed to switch from fossil fuels to green hydrogen. Aside from the refinery, specific incentives should be used to get local businesses, especially those in the cement and petrochemical industries, to try out and adopt hydrogen-based technologies. Setting up an industrial innovation zone in the refinery area would give businesses a real-life setting to try out new hydrogen solutions. This would help them learn faster and boost their confidence in using these solutions on a big scale in industry.
Enhancing cross-border connections	The Northern Adriatic's long-term position in the European hydrogen market will depend on enhancing storage and fortifying cross-border connections. In order to facilitate future import and export possibilities, this involves getting the Krk LNG terminal ready to take hydrogen carriers like ammonia or methanol. Sections of the regional natural gas grid should start adjusting to transport a specific amount of hydrogen at the same time, with the goal of eventually switching to 100% hydrogen. To guarantee alignment with the European Hydrogen Backbone and to place the region within developing cross-border hydrogen corridors, close international collaboration is crucial.
Developing skills and improving knowledge	Developing the necessary knowledge and skills for an effective hydrogen transition necessitates strong support for education, research, and workforce development. Establishing a strong connection with the Regional Hydrogen Centre in Zagreb would enhance access to technical guidance and innovation support for businesses, local authorities, and

	project developers. Simultaneously, customised training programs for port operators, engineers, and technicians will ensure that the regional workforce is adequately prepared to operate and maintain hydrogen technologies as they expand.

Table 7: Strategic measures to support hydrogen development in the Northern Adriatic Region

3.5.3 Synergy between North-West Region and Northern Adriatic Region

The proposed measures for the North-West and Northern Adriatic Regions outline a clear framework for establishing a strong and coordinated hydrogen ecosystem in Croatia. The Northern Adriatic facilitates extensive production and maritime applications due to its ports, industrial capabilities, and RES, whereas the North-West Region provides the necessary research, innovation, and urban demand to evaluate and expand new technologies. Advancing these complementary strengths in parallel and connecting them through shared infrastructure, knowledge transfer, and joint planning may lead to the development of a multi-regional hydrogen corridor. This corridor would link Croatia to Central and Southeast European markets, enabling Croatia to establish a resilient, future-ready hydrogen economy that supports national decarbonization and enhances the country's position within the broader European energy landscape.

4. Hydrogen project landscape in Croatia

4.1. Current status of Hydrogen projects in Croatia

As of 2025, the hydrogen sector in Croatia is at an early yet strategically significant stage of development. The foundations for a comprehensive hydrogen economy have been established through the Hydrogen Strategy of the Republic of Croatia until 2050 and its accompanying Implementation Study (June 2024), which outlines the pathway toward integrating renewable hydrogen into the national energy, transport, and industrial systems. The study identifies 32 hydrogen-related projects currently under development across the country, encompassing a wide range of maturity levels—from conceptual design to early implementation and pilot operation. These projects collectively demonstrate the growing national commitment to decarbonisation through renewable hydrogen and to Croatia's alignment with the European Union's Green Deal and REPowerEU objectives.

Most existing Croatian hydrogen projects focus on renewable hydrogen production from solar and wind power, primarily through electrolysis. According to the study, around one-fifth of all identified projects are designed as fully integrated hydrogen ecosystems—meaning they include both hydrogen generation and its end-use applications in mobility or industry. Cumulatively, these integrated projects are expected to produce approximately 975 tonnes of hydrogen per year, while the total production potential of all announced projects exceeds 33,000 tonnes annually. By contrast, current hydrogen consumption projects amount to roughly 380 tonnes per year, reflecting a clear supply–demand imbalance in the early phase of market development.

A significant portion of Croatia's hydrogen activity is associated with the North Adriatic Hydrogen Valley (NAHV), a transnational initiative involving Croatia, Slovenia, and Italy (Friuli Venezia Giulia Region). This EU-funded project represents the first cross-border hydrogen valley in Southeast Europe and is supported under the Horizon Europe Clean Hydrogen Partnership. Croatian participation includes the integration of industrial and transport pilot projects in Rijeka, Sisak, and Zagreb, with the total investment value estimated at more than €70 million. The NAHV is expected to create the first regional renewable hydrogen value chain, including production, storage, distribution, and consumption, and to establish Croatia as a key component of the European hydrogen backbone in the Adriatic region.

Domestically, two industrial facilities currently dominate hydrogen production: the Rijeka Oil Refinery, which produces hydrogen through steam methane reforming (SMR) for refining processes, and Petrokemija Kutina, which uses hydrogen for ammonia and fertilizer production. Both facilities are expected to gradually transition toward low-carbon or renewable hydrogen production. INA, the national oil and gas company, has launched preparatory studies to partially replace grey hydrogen with renewable hydrogen produced via electrolysis at the Rijeka refinery by 2030. Similar efforts are being explored in Kutina, where co-electrolysis could support the decarbonisation of ammonia synthesis.

In the transport sector, Croatia is initiating several pilot projects designed to demonstrate hydrogen use in mobility and public transport. The cities of Zagreb, Rijeka, Split, and Osijek have all announced plans to procure hydrogen-powered buses and install hydrogen refuelling stations (HRS). These projects are co-financed through the National Recovery and Resilience Plan (NPOO) and the Connecting Europe Facility (CEF). The first operational HRS is expected to be commissioned in Zagreb in 2026, with a capacity of around 400 kg/day. The integration of hydrogen trains for non-electrified railway lines is also being studied in cooperation with HŽ Infrastruktura and supported by feasibility analyses funded by the European Investment Bank (EIB).

Croatia's national gas transmission operator, Plinacro, is preparing two strategic projects—Croatia North Hydrogen Supply System and Croatia South Hydrogen Supply System—aimed at repurposing parts of the existing high-pressure natural gas network for hydrogen transport. These projects are part of the European Hydrogen Backbone (EHB) initiative and will enable future cross-border connections with Slovenia and

Hungary. In parallel, LNG Terminal Krk and Port of Rijeka are being assessed as potential future entry points for imported renewable hydrogen or ammonia, reinforcing Croatia's role as a regional energy hub in Southeast Europe.

Beyond industrial and transport applications, several Croatian energy companies, including HEP Group and Končar Group, are developing pilot electrolyzers integrated with solar power plants, particularly in Dalmatia and Slavonia. The Green H2 Dalmatia project, currently in development, foresees a 10 MW electrolyzer powered by local photovoltaic capacity and coupled with hydrogen storage for use in maritime transport and grid balancing.

The Croatian Hydrocarbon Agency (CHA) has been designated as the coordinating body for the implementation of hydrogen-related projects, with tasks encompassing project certification, monitoring, and regulatory alignment with EU directives, including the Renewable Energy Directive (RED III) and the Hydrogen and Decarbonised Gas Market Package. The government is also developing financial mechanisms—such as production subsidies and contracts-for-difference (CfD)—to close the economic gap between grey and green hydrogen, estimated at €3–5 per kilogram.

Croatia's current hydrogen landscape demonstrates a strong orientation toward developing a self-sustaining renewable hydrogen ecosystem. However, several systemic challenges remain. The main barriers include the absence of a mature domestic market and of large-scale off-takers, limited regulatory clarity for hydrogen certification and grid connection, and the relatively high cost of renewable electricity. Furthermore, while significant renewable resources exist—particularly solar and wind—additional investments in transmission capacity and water infrastructure are required to support large-scale hydrogen production.

Nevertheless, Croatia's progress within the North Adriatic Hydrogen Valley, the gradual decarbonisation of its industrial hydrogen use, and the alignment of its national infrastructure with the European Hydrogen Backbone collectively position the country as an emerging regional hydrogen hub. Continued coordination with EU institutions and the integration of national projects into broader European frameworks will be essential to ensuring scalability, interoperability, and market readiness by 2030.

In summary, the current status of hydrogen projects in Croatia reflects a transition from strategic planning to practical implementation. The combination of industrial retrofitting, renewable hydrogen pilot plants, and cross-border infrastructure initiatives forms the foundation of a credible and growing hydrogen economy that is expected to expand rapidly over the next decade, in line with the European Union's objectives for climate neutrality and energy system integration.

4.2. Pilot projects of national importance for Croatia

Croatia has entered a decisive phase in the development of its hydrogen economy, with a growing number of well-defined projects and policy frameworks that reflect alignment with the European Union's climate and hydrogen ambitions. The national hydrogen strategy adopted in March 2022 set a goal of achieving approximately 70 MW of electrolyzer capacity by 2030, and up to 2,750 MW by 2050, with hydrogen accounting for roughly 0.2% of final energy consumption by 2030 and up to 11% by 2050.

At the corporate and project-level, one of the most visible developments has been the investment by INA d.d., Croatia's leading oil and gas company. In April 2024 INA signed two contracts worth EUR 98 million—one for the construction of a 10 MW electrolyser at the Rijeka refinery (to produce green hydrogen, coupled with a solar power facility) and a second project for biomethane production in Sisak from agricultural residues.

The hydrogen project is targeted for completion in 2026 and is intended to make INA the first commercial producer of green hydrogen in Croatia.

Further, in March 2025 the Croatian government granted INA EUR 15 million under the Recovery and Resilience Facility to support this green hydrogen production and distribution project for transport.

On the infrastructure and mobility side, the Ministry of Economy and Sustainable Development (Croatia) has launched a subsidy programme of approximately EUR 29.6 million for hydrogen refuelling stations (HRS) and e-charging infrastructure over three years. Some EUR 23 million of this budget is earmarked specifically for hydrogen HRS, with the aim of installing at least six hydrogen filling stations by 2026, on corridors linking Zagreb with Split, Varaždin and Rijeka. These investments underscore the focus on mobility (road, bus, truck) as one of the early uptake sectors.

In the research and innovation domain, a noteworthy initiative is the pilot project at the port of Žigljen on the island of Pag: an EU-funded wave-energy-to-hydrogen installation, led by the project "Innovative Green Hydrogen Production from Wave Energy in Žigljen Port (Novalja)". The system utilises wave energy converters, an electrolyzer of ~1 MW, and integrates storage. This sets a precedent in combining marine renewables and hydrogen production.

In parallel, Croatia is preparing to repurpose portions of its existing natural gas transmission network for hydrogen, as part of the wider envisaged European Hydrogen Backbone. Although less advanced, these steps represent the infrastructure dimension of the strategy.

While Croatia clearly demonstrates readiness and intent, several structural features define the current status:

- The pipeline of projects is still largely in the early to mid-stage: although contracts have been signed (e.g., INA's electrolyser), full commercial operation remains targeted around 2026.
- At present, demand offtake remains modest and initial applications are concentrated in transport and niche industrial uses; scaling to larger industrial, grid-injection or export roles remains a task ahead.
- The cost differential between renewable ("green") hydrogen and conventional hydrogen remains significant. Market mechanisms and support schemes (such as subsidies or contract-for-difference models) will need to be operational and reliable to bridge this gap.
- Renewable electricity availability, grid connection and permitting continue to be key enablers. In a country with considerable renewable potential (solar, wind, marine) the successful coupling of generation with electrolysis will be critical.
- Cross-border integration, via hydrogen pipelines or transport corridors (especially in the Adriatic and Central European context) offers strategic opportunity for Croatia to become a regional hydrogen hub—but this requires coordinated investment, standardisation and regulatory harmonisation.

In sum, Croatia is transitioning from strategy formulation to pilot implementation, with concrete projects now under contract and public support mechanisms being rolled out. The combination of industrial retrofits (e.g., at INA), mobility infrastructure (hydrogen refuelling stations), innovation pilots (wave-powered hydrogen) and emerging hydrogen shipping/transport infrastructure positions the country for an initial phase of hydrogen economy deployment. To achieve scale by 2030 and beyond in line with EU ambitions, continued attention will need to be paid to demand aggregation (off-take), cost competitiveness, enabling regulation and cross-border connectivity. Croatia is thus on a credible trajectory to integrate hydrogen into its energy system, provided the next decade sees sustained momentum and investment.

4.3. Conflict and risk assessment of hydrogen projects

The rapid emergence of hydrogen initiatives in Croatia, while strategically aligned with the European Union's decarbonisation agenda, introduces a complex array of technical, economic, environmental, and social risks that must be managed through structured governance and transparent project design. The following assessment outlines the main areas of potential conflict and risk associated with hydrogen project development in Croatia, based on the Study of the Development Plan and Implementation of the Croatian Hydrogen Strategy by 2050 (Ekonerg et al., 2024), combined with current European policy frameworks and recent developments in Croatia's hydrogen sector as of 2025.

1. **Regulatory and Institutional Risks**

A key structural challenge lies in the incomplete regulatory framework governing hydrogen production, certification, and market integration. Although Croatia has adopted the Hydrogen Strategy until 2050, secondary legislation defining renewable hydrogen certification, guarantees of origin, safety standards, and blending thresholds in gas grids remains under preparation. This regulatory vacuum creates uncertainty for investors and complicates project financing. Conflicts may arise between national energy regulators, the transmission system operator (Plinacro), and local authorities regarding the classification of hydrogen infrastructure (e.g., whether it falls under gas, electricity, or industrial regulation).

Moreover, administrative procedures for permitting renewable energy and hydrogen facilities are still fragmented, with multiple institutions involved at national and county levels. The lack of a single permitting authority can result in prolonged approval times, especially for projects combining renewable generation, electrolyzers, and storage facilities. Without streamlining and harmonisation, Croatia risks delays in reaching its 2030 capacity targets.

2. **Technical and Infrastructure Risks**

Technological risks are closely linked to the early maturity of Croatia's hydrogen ecosystem. Most domestic projects rely on imported electrolyzer technologies and components, with limited local industrial capability or maintenance expertise. This dependency on foreign suppliers exposes projects to supply chain disruptions, price volatility, and extended commissioning periods.

Infrastructure adaptation—particularly the repurposing of natural gas pipelines for hydrogen transport—poses additional risks. The technical feasibility of using existing steel pipelines for hydrogen blends depends on pipeline material compatibility, pressure management, and integrity testing. Hydrogen embrittlement, leakage risks, and safety concerns require comprehensive assessment and standardisation before large-scale blending or pure-hydrogen transport is implemented. Similarly, the lack of established hydrogen storage facilities, whether in salt caverns or depleted gas fields, represents a structural bottleneck for ensuring stable supply and balancing production with consumption.

3. **Economic and Financial Risks**

Green hydrogen production in Croatia remains significantly more expensive than conventional (grey) hydrogen. Current estimates place the levelised cost of renewable hydrogen between €5–7 per kilogram, compared to €1.5–2 per kilogram for hydrogen derived from natural gas. This cost disparity constitutes a major market risk, particularly in the absence of a stable carbon price signal or long-term offtake agreements.

Funding uncertainties further intensify this risk. Although several projects benefit from EU mechanisms—such as the Innovation Fund, Connecting Europe Facility (CEF), and Horizon Europe—most rely on a mix of public grants and private capital. Any changes in EU funding priorities or delays in disbursement could jeopardize project timelines. Additionally, local banks and financial institutions have limited experience with hydrogen-related investments, resulting in cautious lending and higher perceived credit risk.

Market demand uncertainty represents another financial vulnerability. While Croatia's hydrogen production pipeline already exceeds 30 kt per year, identified consumption projects account for less than 400 t annually. This imbalance underscores the absence of large-scale offtakers and exposes producers to price and utilisation risk unless industrial users, transport operators, or energy utilities commit to long-term supply contracts.

4. **Environmental and Water Resource Risks**

Although renewable hydrogen production is a low-emission process, its environmental footprint depends on the source of electricity, water use, and land allocation for renewable energy installations. Electrolysis requires substantial volumes of high-purity water—estimated at nearly 5 million cubic metres annually by 2050 under Croatia's baseline scenario. While this represents only a small fraction of national water consumption, localised extraction in coastal or arid regions could affect water availability and quality, particularly during summer droughts.

Furthermore, the deployment of large-scale solar and wind plants dedicated to hydrogen production may create land-use conflicts with agriculture, forestry, or tourism. Coastal areas—especially in Dalmatia and Istria—face additional constraints due to visual and environmental sensitivities associated with tourism. In such contexts, early environmental impact assessments and spatial planning integration are essential to prevent opposition from local communities or conservation organisations.

The risk of accidental hydrogen releases, though technically manageable, must also be carefully mitigated through rigorous safety design, emergency response planning, and public communication. Hydrogen's flammability and invisibility demand high technical standards, operator training, and transparent information to ensure public confidence.

5. **Social Acceptance and Stakeholder Conflicts**

Public perception of hydrogen projects in Croatia is still evolving. Surveys conducted under EU-funded projects such as North Adriatic Hydrogen Valley indicate moderate awareness but limited understanding of hydrogen's role in the energy transition. Social resistance may emerge where communities associate hydrogen infrastructure with industrial risks or where land use for renewables conflicts with tourism or local economic interests.

Ensuring local participation, benefit-sharing, and communication is therefore critical. Municipalities hosting hydrogen projects should be included in early planning phases and provided with clear information about environmental safeguards and socio-economic benefits, including employment opportunities and energy security improvements. Without proactive engagement, hydrogen projects risk encountering the same opposition patterns that have delayed wind and solar developments in parts of Croatia.

6. **Geopolitical and Supply Chain Risks**

Croatia's geographic position at the crossroads of Central and Southeastern Europe offers strategic advantages but also exposure to regional energy dynamics. Hydrogen imports and exports will likely depend on cross-border pipeline connections with Slovenia, Hungary, and Italy. Delays or divergences in regulatory frameworks between these countries could hinder the interoperability of future hydrogen infrastructure. In addition, Croatia's dependence on imported technology and materials exposes it to global market disruptions. The electrolyzer market is currently dominated by a few European and Asian suppliers. Delays in delivery, component shortages, or trade restrictions could have a cascading effect on project timelines. Ensuring local manufacturing capacity and participation in EU supply chain initiatives (such as IPCEI Hydrogen) would mitigate such risks.

The conflict and risk profile of hydrogen projects in Croatia reflects the early maturity of a sector that combines high technological potential with considerable structural uncertainty. The most pressing risks—regulatory gaps, high production costs, limited demand, and social acceptance—are not unique to Croatia but characteristic of emerging hydrogen economies across the EU. However, Croatia's strong alignment with

European hydrogen policy, its participation in cross-border initiatives such as the North Adriatic Hydrogen Valley, and its substantial renewable energy potential position it favourably to manage these challenges. By establishing a coherent regulatory framework, developing national safety and certification standards, securing offtake agreements, and enhancing public engagement, Croatia can mitigate the primary risks and ensure that hydrogen development proceeds sustainably and in harmony with EU climate and energy objectives.

In conclusion, the overall risk level of Croatia's hydrogen projects can be characterised as moderate, with high opportunity potential—provided that institutional coordination, financial stability, and stakeholder trust are maintained throughout the 2025–2030 implementation period.

4.4. Funding and financing roadmap

Croatia's hydrogen development pathway is increasingly shaped by a combination of EU strategies, national policy priorities, and emerging market opportunities. Funding and financing mechanisms are evolving in parallel to support both early-stage research and large-scale deployment, creating a clear roadmap for scaling up the hydrogen economy. At the European level, Croatia benefits from Horizon Europe, particularly within the Climate, Energy, and Mobility clusters, as well as the Innovation Fund, which targets demonstration and commercial-scale projects in renewable and low-carbon hydrogen. Complementary instruments, including the European Regional Development Fund (ERDF), the Cohesion Fund, and the Connecting Europe Facility (CEF), provide additional support for infrastructure development, particularly in transport corridors, industrial clusters, and islands with high renewable energy potential. These funds are instrumental in bridging the gap between pilot projects and commercially viable hydrogen solutions.

Nationally, the Croatian Government is aligning hydrogen initiatives with the National Energy and Climate Plan (NECP) and the Green Development Strategy, emphasizing the role of green hydrogen in decarbonizing industry, transport, and energy-intensive sectors. Public financing mechanisms, delivered through ministries and institutions such as the Croatian Bank for Reconstruction and Development (HBOR), offer grants, co-financing, and concessional loans designed to de-risk initial investments. In the short term, these funds are primarily directed toward research, development, and demonstration projects, creating a foundation for technical expertise and local supply chains.

In parallel, private investment is expected to grow as hydrogen technologies mature. Industrial players, energy companies, and venture capital investors are increasingly exploring projects ranging from electrolyzer production to hydrogen storage and transport infrastructure. Public-private partnerships will be pivotal for scaling up commercial deployment, particularly in high-impact applications such as hydrogen refuelling stations, industrial process integration, and renewable energy-linked electrolysis. EU-level financial instruments, including loans and guarantees from the European Investment Bank (EIB) and the European Fund for Strategic Investments (EFSI), can further reduce investment risk, unlocking larger volumes of private capital.

Looking ahead, the financing roadmap for hydrogen in Croatia can be framed in three phases. The initial phase focuses on research, pilot projects, and capacity building, leveraging EU grants and national R&D support. The second phase emphasizes demonstration and early deployment, combining public co-financing with private investment and EU de-risking mechanisms. Finally, the third phase targets full-scale commercialization, where market-driven investments dominate, supported by regulatory incentives and infrastructure funding. By strategically sequencing public and private financing, Croatia can accelerate the adoption of hydrogen technologies, enhance energy security, and contribute to EU-wide decarbonization objectives, while positioning itself as a regional hub for sustainable hydrogen solutions.

5. Strategic priority activities for Hydrogen development through 2030 and 2050

The Croatian Hydrogen Strategy and its Implementation Plan define a phased approach for developing a national hydrogen economy aligned with the European Green Deal, REPowerEU, and the Fit-for-55 package. Croatia's ambition is to become a **regional hydrogen hub by 2050**, integrating renewable hydrogen into industry, transport, and energy systems while contributing to the EU's climate-neutrality objectives.

The implementation pathway is structured around two key milestones:

By 2030: Building the foundation for a national hydrogen market

- Establish up to **510 MW of installed electrolyzer capacity** producing around **26 kt of renewable hydrogen annually**.
- Develop an initial **hydrogen refuelling network** across major cities and TEN-T corridors.
- Launch **pilot projects** in transport, industry, and public services to demonstrate technical and economic viability.
- Establish a **complete regulatory and institutional framework** in line with RED III, AFIR, and the Hydrogen and Decarbonised Gas Market Package.
- Create the **first hydrogen valleys and industrial hubs** supported by EU and national funding instruments.

By 2050: Achieving full integration and regional leadership

- Scale up to **4.7 GW of electrolyzer capacity** and reach over **240 kt of renewable hydrogen production per year**.
- Complete **integration into the European Hydrogen Backbone**, ensuring cross-border connectivity and trade.
- Achieve widespread use of hydrogen across **industry, transport, and energy sectors**, ensuring a significant contribution to net-zero emissions.
- Position Croatia as a **centre of hydrogen technology, innovation, and export** within South-East Europe.

The decade to 2030 is dedicated to laying the institutional, technological, and financial foundation of Croatia's hydrogen economy. The focus is on enabling conditions, pilot deployment, and market activation.

Croatia will integrate hydrogen development into the revised **Integrated National Energy and Climate Plan (NECP 2030)**, ensuring that renewable hydrogen is recognised as a strategic energy vector supporting both decarbonisation and energy security. Spatial planning procedures will identify renewable energy zones and industrial areas suitable for electrolysis, storage, and hydrogen refuelling infrastructure, in line with **RED III accelerated permitting provisions**.

The first stage of implementation will prioritise **renewable hydrogen production plants** based on solar and wind power. Coastal areas such as **Rijeka Bay and Dalmatia** will host hybrid wind-solar-electrolyzer systems, while inland industrial zones such as **Kutina and Zagreb** will integrate electrolyzers into existing facilities. The objective is to demonstrate fully renewable hydrogen supply chains combining generation, conversion, storage, and use.

The **development of hydrogen infrastructure** will proceed in parallel. Croatia will build a national network of **hydrogen refuelling stations (HRS)** connecting key cities and highways in accordance with the **Alternative Fuels Infrastructure Regulation (AFIR)**. This network will serve as a catalyst for the introduction of hydrogen-powered buses, trucks, and passenger vehicles. Pilot hydrogen train projects on non-electrified lines will expand the concept to rail transport, while the maritime sector will test hydrogen ferries and port applications.

Regulatory, institutional, and financial measures will be finalised to ensure market readiness. By 2030, Croatia will have transposed all relevant EU legislation, including the **Renewable Energy Directive (RED III)**, **Hydrogen and Decarbonised Gas Market Package**, **ReFuelEU Aviation**, and **FuelEU Maritime**. The **Croatian Hydrocarbon Agency (CHA)** will coordinate the national system for **certification and guarantees of origin (GO)** for renewable hydrogen and other renewable fuels of non-biological origin (RFNBOs). A **national premium mechanism** will support investors and ensure cost parity with fossil-based alternatives.

Investment and financing will rely on strong alignment with European mechanisms. Funding will be mobilised through the **National Recovery and Resilience Plan (NRRP)**, **Connecting Europe Facility (CEF)**, **Innovation Fund**, **Horizon Europe**, and the **Important Projects of Common European Interest (IPCEI Hydrogen)**. Croatia will promote public–private partnerships to accelerate the deployment of electrolyzer capacity, infrastructure, and industrial conversion projects.

Research and innovation will underpin this early phase. Croatia's universities and research institutions, in cooperation with industry, will focus on **electrolyzer technologies, fuel cells, hydrogen storage, and power-to-X applications**. These efforts will be coordinated with European research initiatives to ensure rapid knowledge transfer and cost reduction.

Public awareness and capacity-building programmes will be implemented to ensure the safe and socially acceptable introduction of hydrogen technologies. Educational campaigns, technical training, and certification schemes will prepare a skilled workforce for operation, maintenance, and safety management.

By the end of 2030, Croatia is expected to have a functioning hydrogen ecosystem with operational pilot projects in transport and industry, a fully compliant regulatory framework, and the first integrated renewable hydrogen production facilities. These developments will provide a robust foundation for large-scale deployment after 2030.

The period from 2030 to 2050 represents the scaling-up and integration phase, when hydrogen will transition from a niche technology into a cornerstone of Croatia's decarbonised energy system.

The country's ambition is to become a **regional hub for renewable hydrogen production, storage, and trade** within the framework of the **European Hydrogen Backbone (EHB)**. Existing natural gas pipelines will be repurposed for hydrogen transmission, and new dedicated pipelines—**Croatia-North and Croatia-South corridors**—will connect domestic hubs with international systems in Slovenia, Hungary, and beyond. The **Port of Rijeka** and the **Krk LNG terminal** will evolve into import–export terminals for hydrogen and ammonia, establishing Croatia as a gateway for renewable hydrogen flows in South-East Europe.

By 2050, large-scale hydrogen storage facilities will operate in **depleted gas fields and saline aquifers**, providing seasonal flexibility and enhancing energy security. Hydrogen will also serve as a grid-balancing mechanism, converting surplus renewable electricity into storable energy and reconverting it to power during peak demand through **hydrogen-ready gas turbines** and **fuel cells**.

Industrial decarbonisation will reach full maturity. Hydrogen will substitute fossil fuels and feedstocks in **fertiliser production, cement, glass, steel, and chemicals**, supported by **carbon pricing, Contracts for Difference (CfDs), and green procurement frameworks**. By 2050, renewable hydrogen will be the dominant energy source in these sectors, contributing significantly to Croatia's emission reduction targets.

Transport will undergo complete transformation. Hydrogen will fuel a major share of heavy-duty road transport, bus fleets, and passenger vehicles, and will become integral in **rail, maritime, and aviation**. Hydrogen-derived synthetic fuels will power ships and aircraft in line with **FuelEU Maritime** and **ReFuelEU Aviation** requirements.

The national energy system will evolve into a **fully integrated hydrogen-electricity-heat network**, where hydrogen acts as a flexible energy carrier supporting grid stability and district heating decarbonisation. Hydrogen blending in gas networks will gradually phase out as dedicated hydrogen infrastructure expands.

Institutional governance and financial mechanisms will also mature. Croatia will establish **long-term investment frameworks** supported by green bonds, ETS revenue recycling, and EU funding. International cooperation will expand through **regional hydrogen valleys**, joint research centres, and harmonised market rules. Skills development and education will continue to ensure a competent workforce for the expanding hydrogen sector.

By 2050, Croatia will have achieved a comprehensive hydrogen value chain—from renewable generation and large-scale electrolysis to storage, transport, and diverse end-uses. Hydrogen will play a central role in achieving climate neutrality, enhancing energy independence, and positioning Croatia as a leader in the South-East European hydrogen market.

Expected Strategic Outcomes

- **By 2030:** Croatia will have operational hydrogen pilot projects, a functioning refuelling network, at least 510 MW of electrolyzer capacity, and a complete regulatory and certification system.
- **By 2050:** The country will operate multi-gigawatt hydrogen infrastructure, produce over 240 kt of renewable hydrogen annually, achieve deep industrial and transport decarbonisation, and act as a regional hydrogen export hub connected to the European Hydrogen Backbone.

6. Strategic transnational collaboration for hydrogen development

Transnational collaboration is a critical pillar of Croatia's hydrogen development pathway, enabling the country to embed its regional initiatives into the wider European innovation ecosystem, accelerate technology deployment, and ensure compatibility with the evolving European Hydrogen Backbone. Croatia's hydrogen landscape is being shaped through a combination of academic expertise, EU-funded cooperation projects, cross-border research partnerships, and coordinated regulatory alignment with neighbouring Member States.

The current network of transnational activities reflects a structured and expanding engagement with the hydrogen ecosystems of Austria, Slovenia, and Central Europe. These collaborations support the development of hydrogen competence centres, facilitate the exchange of knowledge and best practices, and strengthen regional value chains essential for scaling hydrogen production, distribution, and utilisation.

Croatia's transnational positioning is reinforced by its participation in the following flagship initiatives:

- H2GreenTECH (Interreg Slovenia–Austria)

This project enhances cross-border research and innovation capacity, focusing on advanced hydrogen technologies. It strengthens cooperation among universities, research centres, and the private sector, and establishes a "one-stop-shop" hydrogen centre serving as a regional hub for technical expertise, testing, and knowledge transfer.

- H2GreenFUTURE (Interreg Slovenia–Austria)

This initiative supports the development of pilot infrastructures, regulatory frameworks, and competence-building programmes that are crucial for accelerating hydrogen deployment. It contributes to the creation of a stable innovation ecosystem that aligns Slovenia and Austria with European long-term climate objectives.

- Z-T-G 002 Hydrogen (Styria)

The project analyses international hydrogen strategies and assesses regional pathways for increasing hydrogen utilisation. It supports strategic planning and provides evidence-based input for shaping Styria's hydrogen roadmap, offering Croatia valuable insights into policy and technology alignment.

- HI2 Valley (Upper Austria, Styria, Carinthia)

A major EU-supported project (EUR 20 million), HI2 Valley focuses on reducing dependence on natural gas imports and building a robust regional market for green hydrogen. Its objectives include securing industrial jobs, stabilising energy systems, and creating a hydrogen ecosystem with EU-wide relevance.

To further strengthen Croatia's international cooperation in the hydrogen sector, a formal collaboration with HyCentA has already been established through the H2CE project. REGEA and the City of Zagreb organised an online webinar with HyCentA to initiate structured knowledge exchange and to lay the foundation for continued cooperation, enabling both sides to learn from each other's progress in hydrogen technology development.

As one of Europe's leading hydrogen research centres, HyCentA plays a significant role in technology validation, testing, and demonstration. Its relevance for Croatia lies in its ability to provide advanced technical expertise and support the integration of hydrogen technologies across multiple sectors.

Through this growing portfolio of collaborations, Croatia is building a resilient and future-proof hydrogen competence network encompassing education, industry, research, policymaking, and cross-border infrastructure planning. These initiatives also reinforce Croatia's engagement in major European platforms such as the European Clean Hydrogen Alliance, the Hydrogen Valleys Partnership, and the European Hydrogen Backbone Initiative, further strengthening the country's strategic integration into the common EU hydrogen market.

Critically, transnational cooperation supports Croatia in preparing for:

- cross-border hydrogen trade and certification
- harmonised regulatory and safety standards
- interoperability of infrastructure
- joint investment in hydrogen valleys and corridors
- coordinated skills development and workforce training
- integration of Adriatic, Central European, and Alpine hydrogen supply chains

In this context, the North Adriatic Hydrogen Valley serves as a flagship model for regional collaboration, illustrating how coordinated investment and planning across borders can accelerate deployment, achieve economies of scale, and strengthen Europe's collective energy resilience.

Overall, Croatia's strategic transnational engagement ensures that its hydrogen development efforts are not only nationally coherent but also compatible with EU-wide ambitions, supporting both regional economic growth and Europe's path toward climate neutrality.

Conclusion

Hydrogen development in Croatia is entering a decisive phase where strategic planning, regional cooperation, and transnational alignment must converge to accelerate the transition toward a climate-neutral and resilient energy system. As demonstrated throughout this Interregional Strategy, Croatia possesses significant renewable energy potential, emerging industrial demand, and strong institutional momentum that together form the foundation of a credible hydrogen economy.

However, the true catalyst for progress lies in effective collaboration—within Croatia's regions, between national institutions and industry, and across borders with neighbouring countries. Transnational initiatives such as the North Adriatic Hydrogen Valley show how coordinated action can unlock investment, accelerate technological deployment, and ensure compatibility with the wider European hydrogen infrastructure and emerging market frameworks.

Within this broader landscape, the Interregional Strategy developed under the H2CE project represents an important contribution to Croatia's hydrogen transition. Although it does not replace the officially adopted National Hydrogen Strategy, it offers an additional layer of guidance that can support regional authorities in shaping their own development pathways. The City of Zagreb, together with neighbouring counties such as Krapina-Zagorje—one of the founders of REGEA—will consider the insights and proposed approaches included in this document and seek to translate them into practical regional actions where appropriate and aligned with national priorities.

By following EU directives, national strategic guidance, and the complementary directions provided through this project, Croatian regions can further refine their hydrogen-related planning and strengthen their role within the expanding European hydrogen landscape. In this way, the Interregional Strategy serves as an added value—an outcome of transnational cooperation that can help bridge the gap between high-level policy and the specific needs and opportunities arising at regional level.

Looking ahead to 2030, accelerating hydrogen deployment will require concrete actions: installing electrolyzers, expanding hydrogen refuelling infrastructure, decarbonising industrial sites, and preparing the first hydrogen-ready pipeline corridors. At the same time, long-term planning for an integrated hydrogen system toward 2050 must continue, ensuring that Croatia is prepared to operate, exchange, and innovate within the broader European hydrogen market.

Ultimately, hydrogen is not solely an energy technology—it is a strategic enabler of industrial transformation, energy security, economic diversification, and regional development. Through strong interregional and transnational cooperation, and by applying strategies such as this one to guide and inspire action at the regional level, Croatia can fully unlock these benefits, support Europe's climate neutrality goals, and strengthen its position as an emerging leader in the hydrogen economy.

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