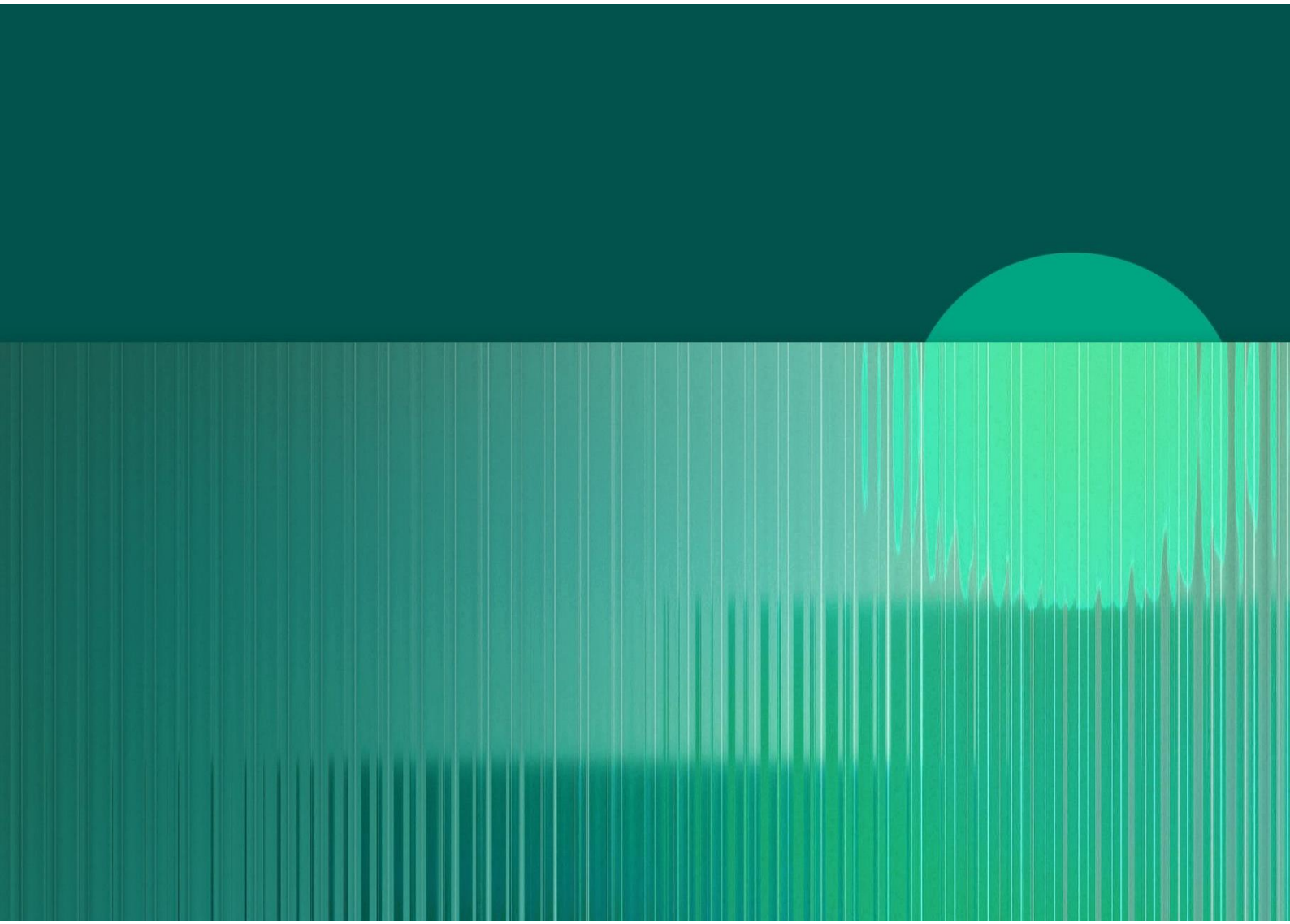

Monography about RI for green hydrogen and lithium (D2.2)

Research infrastructures cooperation for energy transition between European and Latin American and the Caribbean countries.

This project has received funding from the European Union's Horizon research and innovation programme under grant agreement No. 101131725

Document Control Information

Settings	Value
Document Title:	Book - Developments and perspectives of hydrogen production and lithium supply chain for energy transition
Project Title:	EULAC Energytran: Research infrastructures cooperation for energy transition between Europe and Latin-American and the Caribbean countries
Project Coordinator:	OEI
Deliverable leader:	TECNM
Number and type of deliverable:	Ð2.2 – R – Technical publications
Work Package number:	WP2
Doc. Version:	Final version
Description:	Monography (or book) on the capabilities and limitations of research infrastructure available in LAC and EU countries to support and consolidate the green hydrogen production and lithium supply chains.
Dissemination level:	Public
Date:	30/06/2025

Deliverable (webpage) Approver(s) and Reviewer(s)

All Approvers are required. Records of each approver must be maintained. All Reviewers in the list are considered required unless explicitly listed as Optional.

Name	Role	Action	Date
EU Solaris / TecNM	Work package leader / Project participant	Elaboration	30/05/2025
General Assembly of the project	Decision-making body of the consortium	Review	20/06/2025
Steering Committee	Executive body of the consortium	Approve	23/06/2025

Deliverable (monography) history

The Deliverable Author is authorized to make the following types of changes on the deliverable without requiring re-approving:

- Editorial, formatting, and spelling
- Clarification

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Changes on the deliverable (monography) are summarized in the following table in reverse chronological order (latest version first).

Revision	Date	Created by	Short Description of Changes
Version 1	30/06/2025	EU Solaris/TecNM	Final version included on the EU Portal and https://energytran.oei.int https://aguascalientes.tecnm.mx/energytran/

Executive Summary

Within the framework of the ENERGYTRAN project, for the Work package 2, led by the EU Solaris, the Deliverable D2.2 – Monography about RI for green hydrogen and lithium has been prepared. This monography collects the contributions of specialists focusing on the developments, advances, and challenges in strengthening the lithium and hydrogen supply chains for energy transition in the European Union, Latin America and the Caribbean (EULAC). Researchers from Mexico, Spain, France, Costa Rica and Chile were invited to collaborate in the preparation of this monography. It contains 15 chapters that analyze and describe statistics, challenges, and developments in the role of lithium and hydrogen in the EULAC energy transition, the production of green hydrogen from different sources, alternatives for solving its storage and its application to obtain other biofuels, the development and role of lithium-ion batteries and fuel cells, and technical aspects of alkaline electrolyzer operation to produce hydrogen, including case studies. This monography has been integrated into a book format and can be downloaded from: https://aguascalientes.tecnm.mx/energytran/

A brief description of monography contents is given below:

Chapter 1 covers an introduction of climate change and energy transition in the EULAC context. Statistics of renewable energy capacity in EULAC are also discussed including a brief analysis of the Mexican energy mix. This introductory chapter also describes the content of this monography.

Chapter 2 provides an overview of the synergies, opportunities, and barriers in green hydrogen and lithium development across LAC and the EU. It provides a strategic outlook for leveraging these resources to drive global energy sustainability where case studies are also analyzed and policy recommendations are discussed.

Chapter 3 reports the analysis of the current challenges faced by LAC and EU countries for sustainable energy generation and storage using green hydrogen and lithium for batteries. The authors provide EULAC statistics on green hydrogen production initiatives, lithium reserves and demand trends giving a special emphasis on battery sector, including the importance of lithium recycling.

Chapter 4 explores the hydrogen potentialities for Mexico's energy transition, highlighting the application in industry, transportation, and power generation. Basic concepts on green hydrogen production, renewable energy sources such as wind and solar, and the country's strategic position to become a regional leader are also discussed. The authors also analyze the high-cost production, technological gaps, regulatory frameworks, and green hydrogen projects in Mexico.

Chapter 5 focuses on the role of green hydrogen in Chile's energy transition. The authors indicate that the southern region of Magallanes has wind capacity factors of over 50%, which makes the region a place with optimal conditions to generate renewable electricity at a very low cost and, consequently, competitive prices in the renewable hydrogen markets and its derivatives. Chile is a stable, reliable country with clear rules and a National Hydrogen Strategy that aims to make Chile a world leader in the production and export of green hydrogen. However, some challenges must be considered, such as production costs, availability of ports, transport and storage infrastructure, and geographical location. Renewable hydrogen can contribute significantly to the Chilean economy; therefore, it is relevant to know how its development is progressing in Chile, which are aspects discussed in this chapter.

Chapter 6 overviews the application of different porous materials for hydrogen storage where the main capabilities and limitations, including their challenges, are discussed. The analysis includes zeolites, porous carbon materials, metal-organic frameworks, covalent organic frameworks, and other materials. Details and limitations of synthesis routes and hydrogen capacity storage of these materials are also discussed.

Chapter 7 also addresses the major challenges regarding the storage and transportation of green hydrogen. It highlights the advantages and limitations of different storage methods, including compressed hydrogen, liquefaction, cryo-compression, and solid-state storage. The authors report findings on an alternative hydrogen storage technology: clathrates (gas hydrates). This chapter indicates that clathrate hydrates have emerged as a potential candidate for safely storing hydrogen.

Chapter 8 covers the main technologies to produce hydrogen from biomass including the main bottlenecks and opportunities regarding its production in LAC. The analysis is focused on aspects related to the supply chain and sustainability certification schemes, in order to provide valuable insights for decision makers.

Chapter 9 explores the role of biohydrogen in energy transition, the use of municipal solid waste to produce this energy carrier via dark fermentation, and prospects for supporting its large-scale deployment in LAC. Dark fermentation enables the conversion of high-organic-load waste into biohydrogen, using residues as a raw material. LAC region has significant potential for the implementation of this technology due to their high municipal solid waste generation. However, challenges remain in terms of infrastructure, public policies, and financing. This chapter shows that dark fermentation can be an efficient alternative for hydrogen generation from various types of waste, but further progress is needed to enhance the process stability, yield, and pH control under real-scale conditions, as well as the economic feasibility and scalability of this process.

Chapter 10 focuses on the importance of hydrogen in the production of biojet fuels. The discussion focuses on how green hydrogen is positioned as an indispensable tool in the transition to more sustainable aviation. This chapter indicates that the alcohol-to-jet route is attractive for processing hydrogen and transforming olefinic oligomers into stable, high-performance paraffinic fuels that meet the rigorous technical specifications of jet fuel. A case study is also described to illustrate how process integration can be technically optimized, economically justified, and aligned with emerging policy frameworks to accelerate the deployment of hydrogen-enabled sustainable aviation fuel pathways.

Chapter 11 presents a comparison of alkaline electrolyzer configurations in terms of efficiency, cost, and economic viability. It examines the issues of series and parallel systems to highlight their pros, cons, and aid decisions in hydrogen generation. This provides a detailed technical analysis for accurately evaluating the relative advantages of alkaline electrolyzers configured in parallel versus series. It also discusses alternatives for improving current hydrogen generation by reviewing the costs, operational efficiency, and overall economic viability of different approaches.

Chapter 12 describes Mexican perspectives related to the development of lithium-ion batteries using abundant minerals without much refinement. It is indicated that Mexico has deposits of lithium-containing minerals that can be exploited for battery production. Furthermore, the country has other minerals (e.g., manganese oxides and calcium carbonates) that can also be used as active materials for batteries with either stable capacities or high rate charging capabilities. However, these minerals are currently being used for other purposes. This chapter also discusses the possibility of producing batteries from Mexican onyx.

Chapter 13 deals with the current advancements in solid oxide fuel cells, with a focus on progress in Mexico and LAC, identifying opportunities, material trends, and future prospects for this technology. Solid oxide fuel cells have gained attention due to their solid-state components and ability to operate at different temperatures. This flexibility offers several advantages, such as manufacturing, cell design, and architecture adaptability, allowing diverse applications from portable devices and residential or automotive auxiliary power units to power plants and gas turbines. This chapter indicates that these fuel cells must be cost-effective compared to existing systems to compete in the energy market, prompting researchers to improve their efficiency and performance while reducing production costs. A key strategy is to develop advanced materials for electrolyte, cathode, and anode to enable lower operating temperatures.

Chapter 14 presents a case study to analyze the potential and limitations of lithium in Mexico, assuming different scenarios and technologies. A modelling approach is described to integrate desalination units within the lithium supply chain, facilitating water recovery during the brine concentration stage. This model incorporates the optimal management of the water used in lithium production plants as a key environmental objective. The proposed framework also includes the estimation, distribution, and location of processing facilities, selection of appropriate technologies for each site, and determination of their optimal capacities.

Chapter 15 analyzes the viability of establishing a Mexican Li supply chain in a timely manner. Both the progress and remaining challenges in pursuing the leverage of Li for other (public) means are discussed. The recent efforts and

results obtained by the authors of this chapter regarding the processing of minerals to produce advanced Li-based materials for energy storage applications are also described.

General information included on the monography

The monography "Developments and perspectives of hydrogen production and lithium supply chain for energy transition" contains 311 pages organized in 15 chapters, and its specific content is given below:

Process followed to create the monography

EU Solaris and TecNM have followed a participatory methodology to elaborate this technical publication. Researchers from EULAC institutes, including partners from Energytran consortium and external collaborators, were involved in the preparation and edition of this monography.

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Funded by the European Union

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