



# LNEG, bringing Green H2 research to the economy



**Encontro Ciência**  
**Sessão Temática dedicada ao**  
**Hidrogénio Verde**  
Alfândega do Porto  
5 julho 2024



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water resources for electrolysis

platinum loading

(social) life-cycle assessment

techno-economic competitiveness

policy, strategy and regulation

TIMES energy systems modelling

**SUSTAINABLE GREEN H2 ATLAS**

critical raw materials for H2

solar/wind for electrolysis

circular economy

PEM fuel cells diagnostics

tools for electrolyser diagnostics and control

MATERIALS, COATINGS AND COMPONENT DESIGN FOR H2 PRODUCTION

Underground H2 storage

**SUSTAINABILITY OF H2 LIFECYCLE**

**Energy resources for green H<sub>2</sub> production | Wind, solar and biomass**

**Resources for H<sub>2</sub> production | Water & critical raw materials**

**Materials and components for H<sub>2</sub> production and conversion processes**

**Underground H<sub>2</sub> storage**

**Sustainability analysis H<sub>2</sub> life-cycle, techno-economic analysis & competitiveness**

**Policy, markets and business models**

# **Areas of Activity**

## **Green H<sub>2</sub>**

**Tools for H<sub>2</sub> mapping and competitiveness assessment – LNEG Geo Portal**

# Sustainability analysis H<sub>2</sub> life-cycle, techno-economic analysis & competitiveness

## Techno-economic analysis

- \*Process simulation (biorrefineries, H<sub>2</sub> production processes)
- \*Aspen Plus (Aspentech)
- \*SuperPro Designer (Intelligen, Inc.)
- \*Energy & Mass Balances
- \*Energy integration
- \*Process optimisation
- \*Economic viability analysis (escala, MSP)



## EU and Portugal Energy system analysis

TIMES IEA-ETSAP Energy system model



## Life-cycle analysis – environmental (LCA)

- \*Methodology ISO 14040 / REDII
- \*Software: SimaPro v9.3 (PRé Sustainability BV)
- \*Databases: Ecoinvent v3.7
- \*Environmental impacts (GHG, water use, fossil resources, etc.)



## Life-cycle analysis – social (S-LCA)

- \*PNUMA<sup>1</sup> (UNEP) 2020 Guidelines
- \*Social Hotspots Database – identification of positive impacts




<sup>1</sup> PNUMA – United Nation Programme for the Environment (Programa das Nações Unidas para o Meio Ambiente)

# Selected projects and publications




**H2Excellence - Fuel Cells and Green Hydrogen Centres of Vocational Excellence towards affordable, secure, and sustainable energy for Europe**

Funded by the European Union

**PTDC/EQU-EPQ/2195/2021**

**Understanding CO2 electro-reduction in porous materials**



**Agenda M2N - Moving2Neutrality**

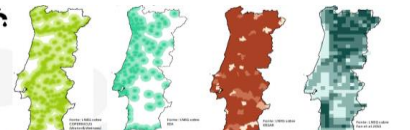
**Avaliação técnica e económica das soluções de transporte de H2 para redes de abastecimento e do H2 liquefeito**





**Decision Support for H2 projects deployment**

techno-economic and policy / regulatory assessment of green H2 production in Portugal identifying drivers and barriers and making use of a participatory process with main key stakeholders in Portugal



**Sustainable Green H2 Atlas**

Spatial planning tool development for mapping H2 favorable areas in Portugal for the development of green H2 projects. Currently working on a second generation of the Atlas to incorporate more constraints and costs of hydrogen variability.

**LNEG | Policy Brief**

**Using natural gas grids for transport and distribution of H2**

March 2020



With the increasing importance of the role of H2 in the European and global energy systems (notably in Japan, United Kingdom, South Korea and Canada), there is an ongoing study and debate on the possible use of the existing natural gas grid infrastructure for H2 transport.

At European level the following key issues are being discussed:

- Technical issues regarding the admissible and viable percentage of H2 blending in the grids and at what scale the corresponding regulation will be undertaken (national or European);
- Guarantees of origin certificates (GO);
- Articulation with current European legislation, and in particular the almost absence of mentions to H2 in the legislation in place.

**Technical issues on the share of H2 blending**

This is one of the most controversial issues on this topic and several debates have come forward with contradictory views. According to some groups, the maximum share of H2 that is technically viable in the natural gas grids is of 5% in volume. MARCOGAZ (Technical Association of the European Natural Gas Industry) has defended that the maximum admissible share of H2 in all grids in Europe is of 20% (in volume), with some exceptions for some specific situations.

**Embottlement**

From a technical point of view the main drawback could be the pipeline embottlement, that is, the possibility of fissure in pipelines due to the reaction of H2 with the steel of which they are made of. This phenomenon is more relevant for the natural gas transport grids that are usually made of steel, while the natural gas distribution grids are mostly built on polyethylene pipes throughout Europe (with some exceptions for a few countries).

However, even for the steel pipelines, embottlement is only a case for concern for high-end steel (as API X70 or API X80). In any case, a share of H2 up to 20% in volume is viable and safe, according to MARCOGAZ.

Some of the solutions to overcome this limitation and increase the share of H2 in the natural gas grid above 20% could be: (i) adding copper to "blend" the content of H2 with the steel; (ii) relining transport pipelines with an inner lining of polyethylene, similarly to what has been done in Brazil in the 90s (note that this is a very expensive option).

However, even for the steel pipelines, embottlement is only a case


[https://www.lneg.pt/wp-content/uploads/2021/01/H2\\_red\\_es\\_gas\\_v4\\_EN2.pdf](https://www.lneg.pt/wp-content/uploads/2021/01/H2_red_es_gas_v4_EN2.pdf)

**LNEG | POLICY BRIEF**

**ÁGUA PARA A PRODUÇÃO DE HIDROGÉNIO VERDE (RENOVÁVEL) VIA ELETRÓLISE EM PORTUGAL**

Junho 2021

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O hidrogénio está no orden do dia das agendas da política mundial. Em Portugal, o hidrogénio está a considerar-se no planeamento estratégico:

- O Plano Nacional Energia e Clima (PNIEC 2035) refere valores de H2 em 2035 de 2,27 TWh (22.697 GWh) que representam aproximadamente 204.000t de H2 (0,4% do volume de águas residuais tratadas com tratamentos terciários em 2035);
- O Roteiro Nacional para a Transição Carbónica (RNC 2035) refere valores de H2 em 2035 de 1,20-1,29 TWh (12.427 - 12.750 GWh) ou de 1,44-1,60 (0,2% do volume de águas residuais tratadas com tratamentos terciários em 2035);
- A Estratégia Nacional para a Hidroginia EN-H2, cerca de releva valores de H2 em 2035 de 1,0 TWh (10.000 GWh) que representam aproximadamente 650.000t de H2 (1,2% do volume de águas residuais tratadas com tratamentos terciários em 2035).

Quais os tipos de fonte de água disponíveis em Portugal para alimentar projetos de produção de H2 por eletrólise?

Qual a qualidade de água necessária?

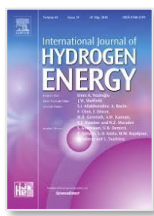
Quais as implicações da utilização de diferentes fontes de água nos custos de produção de H2 verde?

[https://www.lneg.pt/wp-content/uploads/2021/10/PB\\_UER\\_Fontes\\_de\\_Agua\\_para\\_H2\\_2021\\_PT\\_v7.pdf](https://www.lneg.pt/wp-content/uploads/2021/10/PB_UER_Fontes_de_Agua_para_H2_2021_PT_v7.pdf)

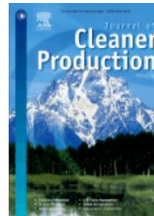
Scientific publications



**TiO2-reduced Graphene Oxide-Pt Nanocomposites for the Photogeneration of Hydrogen from Ethanol Liquid and Gas Phase.** M.A. Esteves, F. Fresno, V. R. Fernandes, F. Oropeza, V.A. de la Pena O'Shea, C.M Rangel, Catalysis Today, 380, 41-52 (2021). <https://doi.org/10.1016/j.cattod.2021.05.012>



**New modified Nafion-bisphosphonic acid composite membranes for enhanced proton conductivity and PEMFC performance.** F. C. Teixeira, A. I. de Sá, A. P.S.Teixeira, V.M. Ortiz-Martínez, A. Ortiz, I. Ortiz, C.M. Rangel, International Journal of Hydrogen Energy, 46(33), 17562-17571 (2021). <https://doi.org/10.1016/j.ijhydene.2020.01.212>



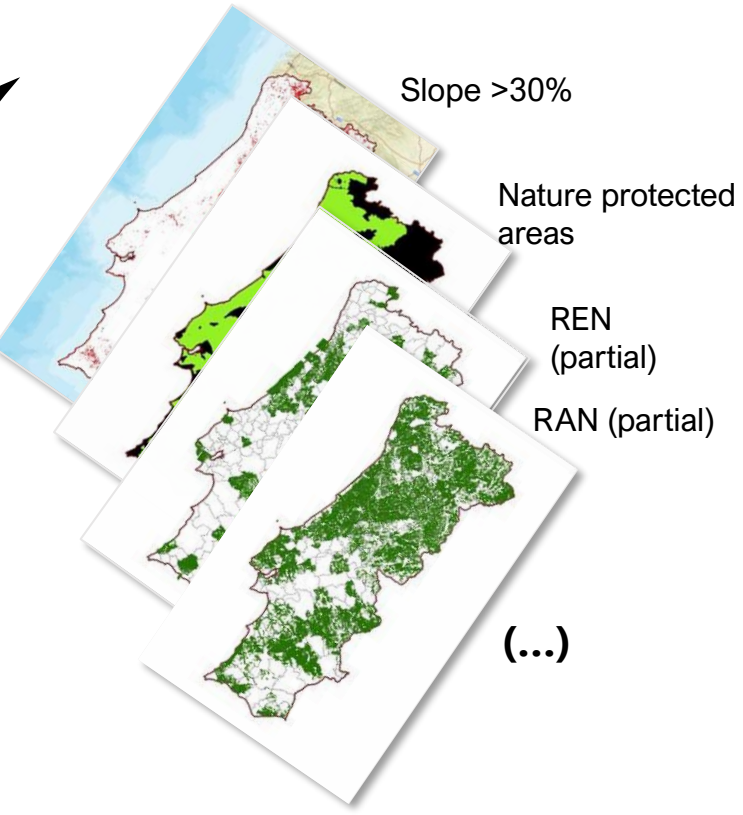
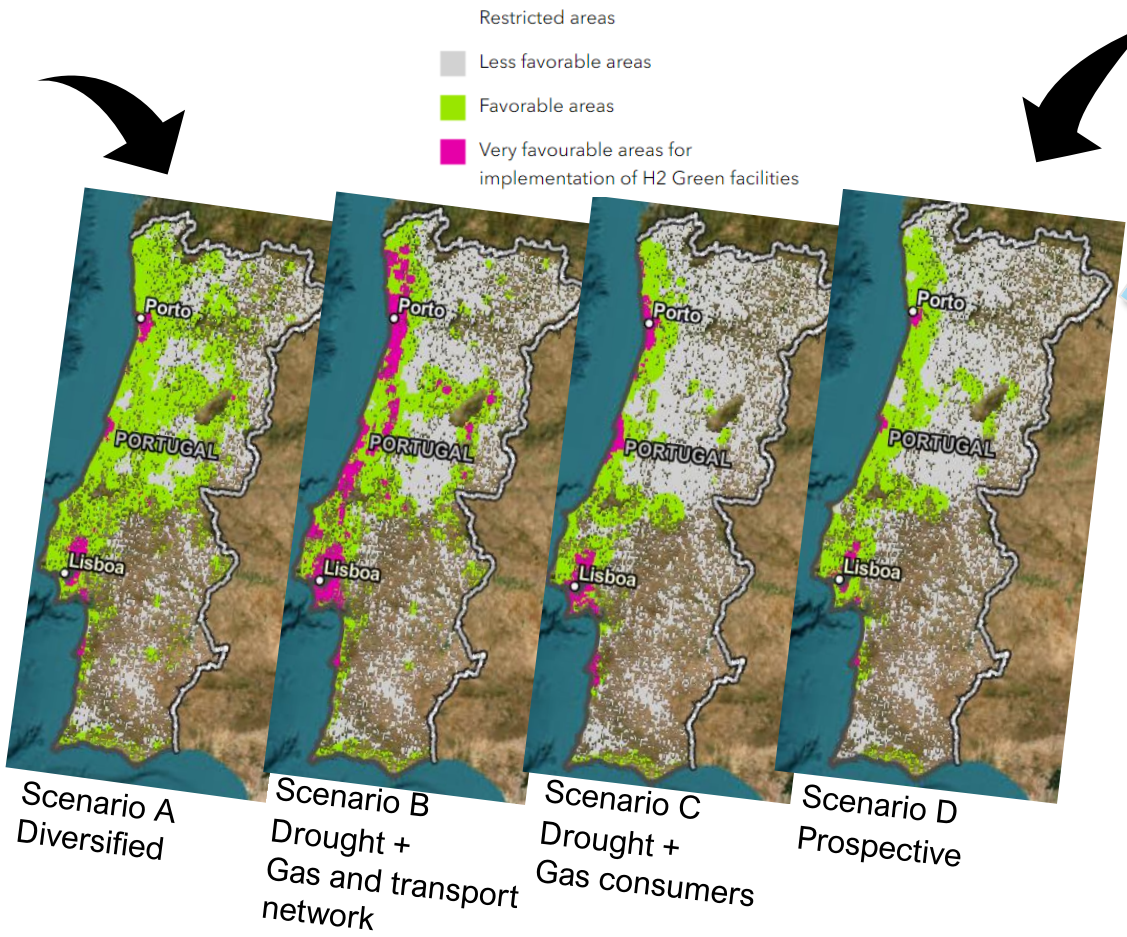
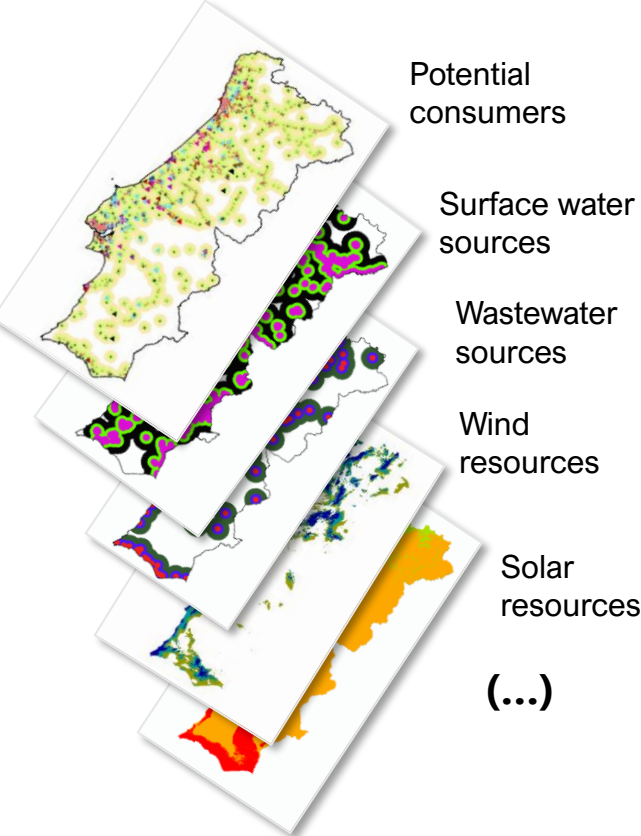
**Water availability and water usage solutions for electrolysis in hydrogen production.** S.G. Simoes, J. Catarino, A. Picado, T.F. Lopes, S. di Berardino, F. Amorim, F. Gírio, C.M. Rangel, T. Ponce de Leão, Journal of Cleaner Production, 315, 128124 (2021). <https://doi.org/10.1016/j.jclepro.2021.128124>

Policy briefs

# Inside the H<sub>2</sub> Atlas

## Water, energy, market

## Land use restrictions





<http://www.lneg.pt>



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