TÉCNICO LISBOA

1: Renewable Hydrogen Production

2: Hydrogen storage and distribution

3: Hydrogen end uses

- Transport applications
- Clean heat and power

Hydrogen supply chain

Strategic Research Challenges

Clean Hydrogen Brokerage

6th of April 2022

Clean Hydrogen Partnership

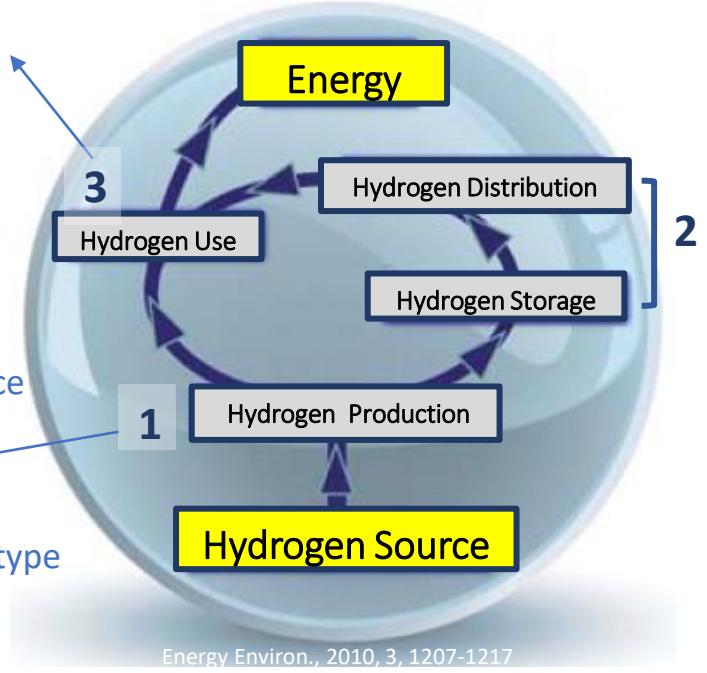
Ongoing research, topics of interest:

- The impact of clay as wall material on thermoelectric power generation and flame–wall interaction
- Thermoelectric power generation from Biogas+H2 flames: influence of Flame-Wall
- Experimental and Kinetic Investigation of Stoichiometric to Rich NH3/H2/Air Flames in a Swirl and Bluff-Body Stabilized Burner
- Numerical Investigation of the Impact of H2 Enrichment on Lean Biogas/Air Flames: An Analytical Modelling Approach
- H2 enrichment impact on the chemiluminescence of biogas/air premixed flames
- Interchangeability analysis of biogas and hydrogen blends, European Biomass Conference and Exhibition Proceedings

- Use of green H2 for the recovery of CO2
- Recycling of CO2 in the form of natural gas,
- Dimethyl ether/DME (alternative to LPG and, mainly, to diesel)
- Dimethyl carbonate/DMC (electrolyte - lithium batteries)

- Aspects of Hydrogen and Biomethane Introduction in Natural Gas Infrastructure and Equipment

- Transport systems and storage
- Catalytic H2 and C1-molecule activation
- Methanol, formaldehyde and formic acid reforming at low temperature



- Large-scale H2 underground storage (HUS)
- Acid-catalysed liquefaction converts feedstock, including those with high moisture, into bio-oils (BO)

- Green Hydrogen Production
- Intermittent wind resource to produce cheap green H2
- Hydrogen production from alcohol reforming in a microwave ‘tornado’-type plasma

Energy Environ., 2010, 3, 1207-1217

Modelling and experimental validation of **an alkaline electrolysis cell** for hydrogen production

Thermodynamic analysis of hydrogen production via **sorption enhanced chemical-looping reforming**

Offshore hydrogen-wind production models:

- competitiveness analysis,
- techno-economic analysis on Hydrogen production from the WindFloat Atlantic offshore wind farm;
- Intermittent wind resource to produce cheap green H2

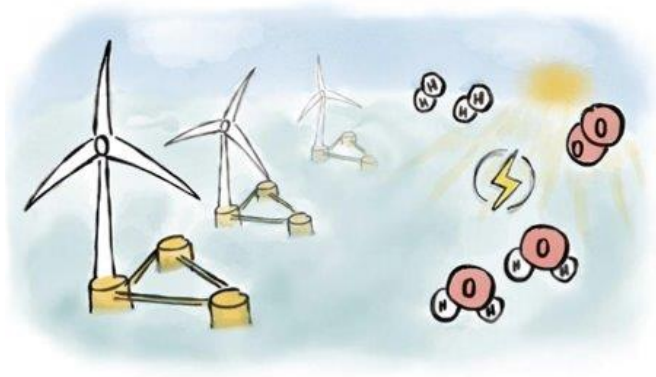
Selective and Mild Hydrogen Production using **Water and Formaldehyde**

Bioinduced Room Temperature **Methanol Reforming**

Wastewater treatment and H2 production

Case study: **Hydrogen production from the WindFloat Atlantic**

- Only Offshore, FOWF in PT
- Off-the-shelf electrolizer (PEM)
- Wind potential from resource assessment
- 2 sizes OWF, w/o O2 production

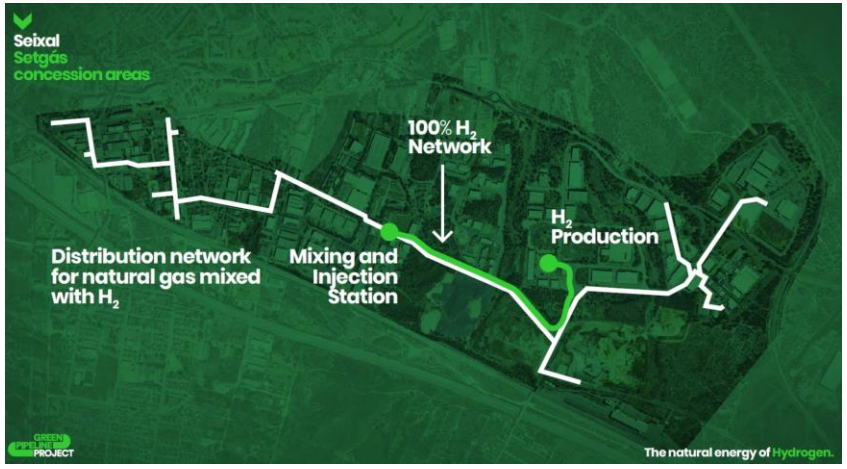


- Matching H2 production with curtailment events (REN)
- 2 scenarios (night, +afternoon)
- Mapping H2 production cost
- Hydro/Wind Plant Power Ratio 35% appears optimal

Hydrogen distribution feasibility assessment.

- Aspects of Hydrogen and Biomethane Introduction in NG Infrastructure and Equipment.
- Innovative approach based on the acid-catalyzed liquefaction of biomass and wastes to create a value chain that includes H2 production/ storage.
- Characterization of inverse diffusion flames with methane and hydrogen.
- Energy distribution through electrical powerlines and gaseous pipelines in Portugal (NG and Hydrogen).

H2 injection in Natural Gas pipelines.



Green Pipeline Project

- The Green Pipeline Project is a pioneering project in Portugal that, for the first time, will **introduce Green Hydrogen into the Natural Gas network.**
- Taking place in a closed network in Seixal, it will **distribute a mixture of Hydrogen and natural gas to around 80 consumers in the residential, non-residential and industrial sectors.**
- The **mix will contain 2% Hydrogen initially, and gradually increase to 20%** within 2 years

Chemical carriers

- Methanol, widely used in the chemical industry, allows easy storage and transport, scale effect and industrial application;
- Hydrogen-Powered Long-Distance Transportation for Portugal

Durability and corrosion of hydrogen transport systems

- Auto-ignition of spontaneous **hydrogen leaks**;
- Development of a **H2 Resistive Gas Sensor** based on Carbon Nanotubes synthesized by Biogas Flames

Large-scale H2 underground storage (HUS)

Core flooding lab and a chemical lab to perform tests on H2 flow under porous rocks and/or caprices

- Analysis of H2/CH4 mixtures to analyse potential segregation of H2 at different storage pressure conditions.
- Potential H2 diffusion on salt-rock - H2 storage in salt-rock caverns alongside natural gas.
- H2 flow under reservoir rocks and storage associated effects of ageing for the longest periods and several storage/production. In particular, H2 flow on caprocks, to access the efficiency of trapping mechanisms.

Project in collaboration

Long-distance hydrogen delivery with liquid organic hydrogen carrier systems

Transport applications

Clean heat and power

Modelling and experimental validation of **hydrogen recirculation in PEM fuel cells**

Assessing the **social acceptance of hydrogen for transportation** in Portugal: Focus on target population for a potential hydrogen economy

Green hydrogen and oxygen developments in Portuguese Economy in the context of **vehicle refueling stations.**

The introduction of hydrogen and biogas in the energy mix: The technological challenges of low emissions, safety and efficiency

Thermoelectric power generation: Impact of H2 on biogas flame-wall interaction; influence of Flame-Wall Interaction; the impact of clay wall material;

Numerical Investigation of the Impact of H2 Enrichment on Lean Biogas/Air Flames: An Analytical Modelling Approach; impact on the chemiluminescence of biogas/air premixed flames

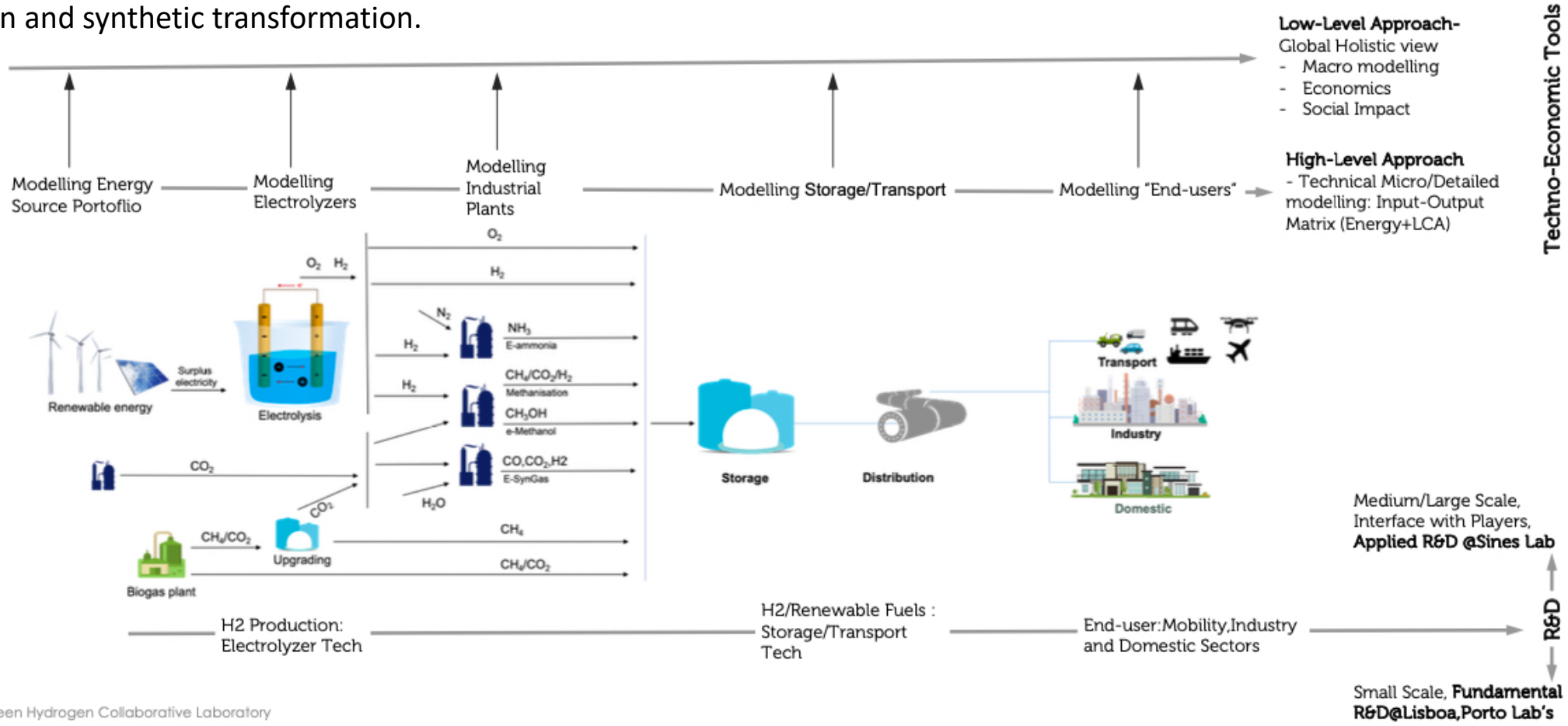
A Modelling and Assessing Energy performance and Influential Factors of **Cargo Ships and Power By Gas turbines or Fuel cells**
Technological and economical assessment on **hydrogen energy conversion systems based in Fuel cells, Gas Turbines** in residential, industry, buildings and large-scale production

Electrodes to mount on an alkaline electrolyser

To build electrodes to mount on an alkaline electrolyser
Durability and corrosion of hydrogen transport systems

Catalytic H2 and C1-molecule activation

The use of methanol, aqueous formaldehyde (patent) and paraformaldehyde (patent) for low-temperature circular hydrogen storage/generation and synthetic transformation.

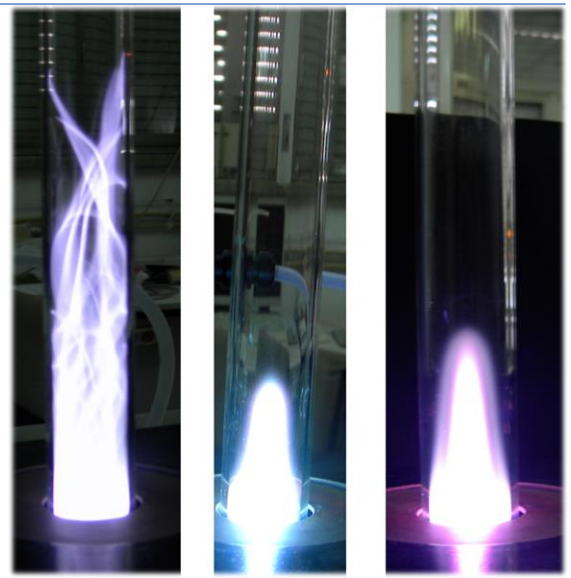


Acid-catalysed liquefaction converts feedstock, including those with high moisture, into bio-oils (BO) innovative approach based on the acid-catalysed liquefaction of biomass and wastes to create a value chain that includes H2 production/storage.

- Since the BO from acid-catalysed liquefaction is significantly more stable, its use as a reactant for SR could avoid catalyst coking, **boosting its efficiency and thus increasing the H2 production.**
- The aromatic scaffolds, like those present on BO, can be envisaged as Liquid Organic Hydrogen Carriers (LOHC). LOHC systems enable safe/efficient high-density H2 **storage** in an easy-to-handle oil, delivering high pure H2 with little loss.
- Many aromatics compounds have been proposed as LOHC. Liquefied biomass is to be studied as LOHC.

Hydrogen production from alcohol reforming in a microwave 'tornado'-type plasma

- Production of hydrogen-rich gas, form a microwave 'tornado'-type plasma with a high-speed tangential gas injection (swirl) at atmospheric pressure, applied to decompose alcohol molecules, namely methanol, ethanol and propanol.



Awards

Premio 2021 VEA GLOBAL
Fundación Hidrógeno Aragón, "Technological and economical assessment on hydrogen energy conservation systems in Gas Turbines" IN+, Edgar Fernandes e Rui Neto

NRW Returnee Award 2009
"*Molecular & Nanoscale Catalysts for Energy Storage & Synthesis"* Energy Research Program of Ministry of Science of NRW (Germany) CQE, Martin Prechtl

Ernst-Haage-Prize for Chemical Energy Conversion 2014
"Formaldehyde Reforming at low temperature" (Max-Planck Society), CQE, Martin Prechtl

Heisenberg Fellow 2015
"Catalytic Hydrogen Generation and Utilisation at Low Temperature using Water and Small Molecules as Hydrogen Source" (DFG), CQE, Martin Prechtl

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Patent
The use of aqueous formaldehyde and paraformaldehyde for H2 generation (Wastewater treatment and H2 production) CQE, Martin Prechtl

Thank you!

Clean Hydrogen Brokerage

6th of April 2022

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