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1ST LATAM MEETING ON GREEN AMMONIA AND POWER-to-X

Competitive Off-Grid Photovoltaic Green Hydrogen Production

TALCA UNIVERSIDAD CHILE

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LARI

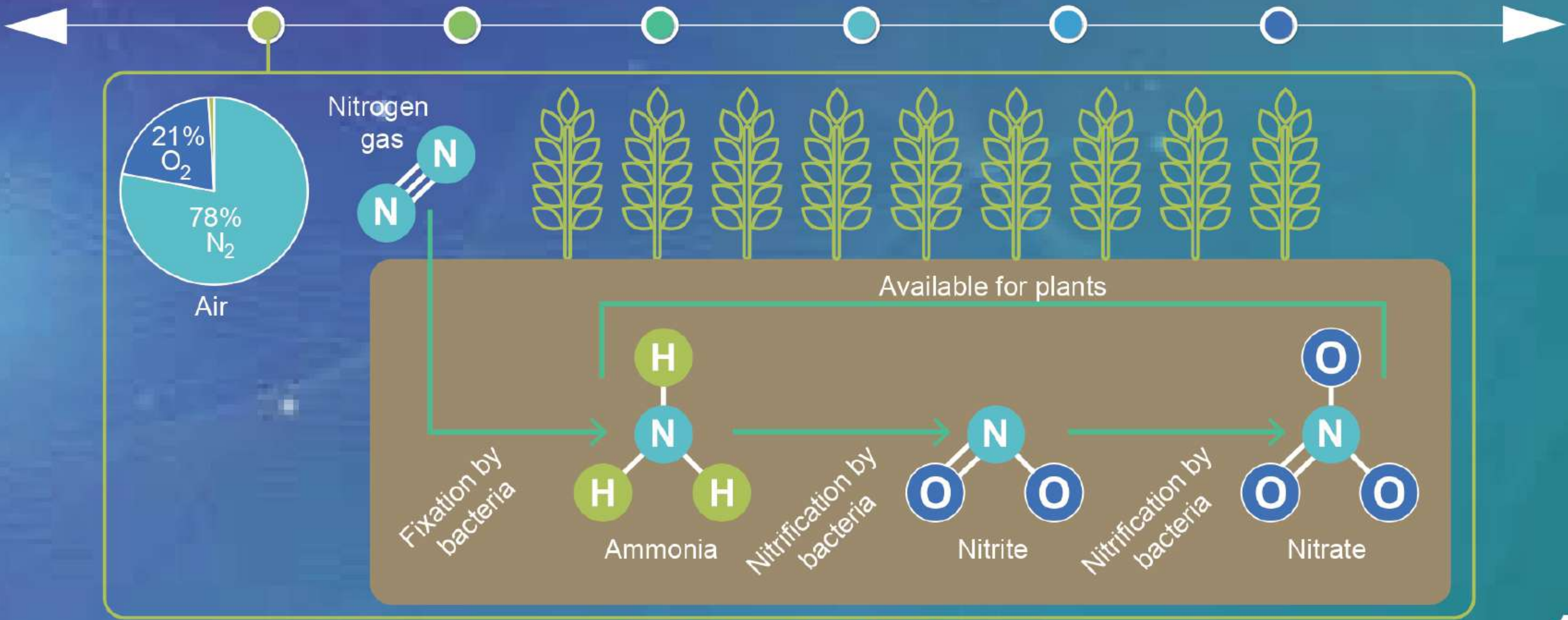
January 11, 2024

Outline

- Introduction
- Hydrogen
- Green hydrogen
- Barriers
- Research

Introduction

Microorganisms have fixed nitrogen in the soil for centuries to make it fertile



Introduction

In 1898, Sir William Cookes predicted the Earth's population would outpace wheat supply by about 1931

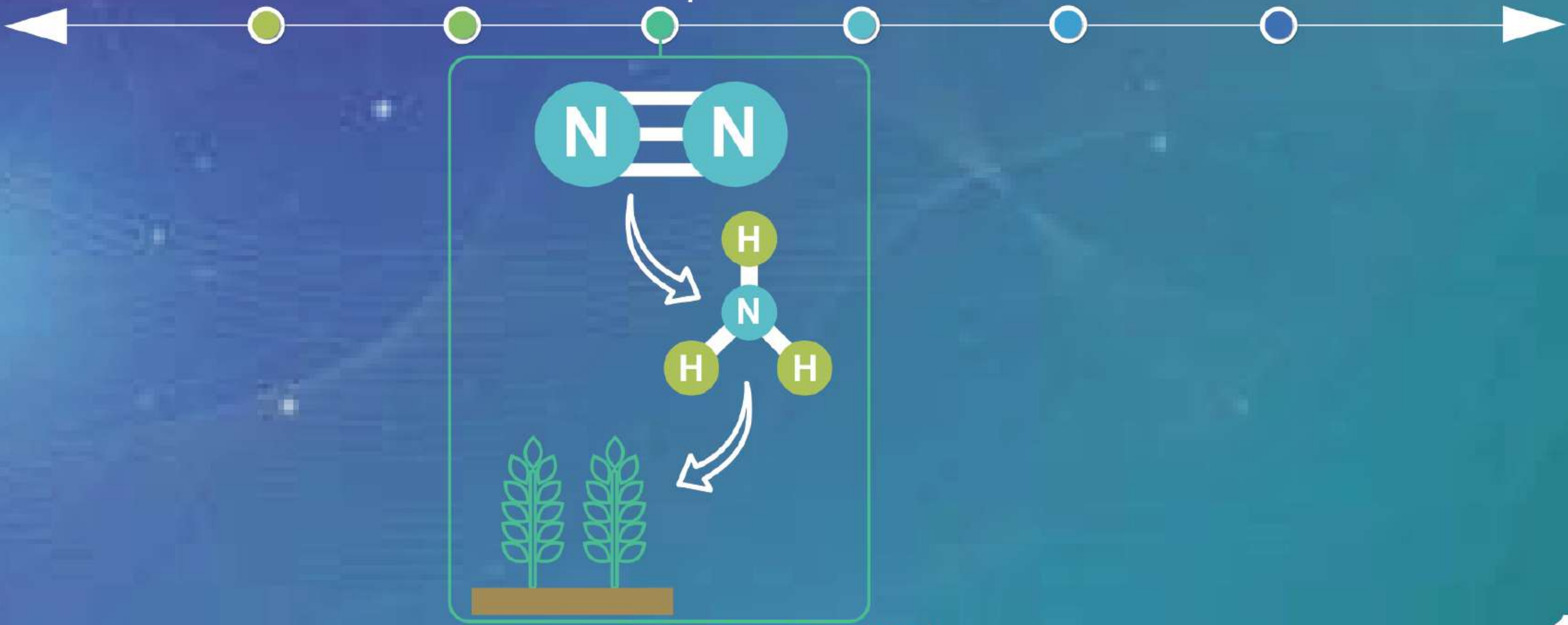
1898
Sir William Cookes

1900
1.6 billion people

2023
8 billion people

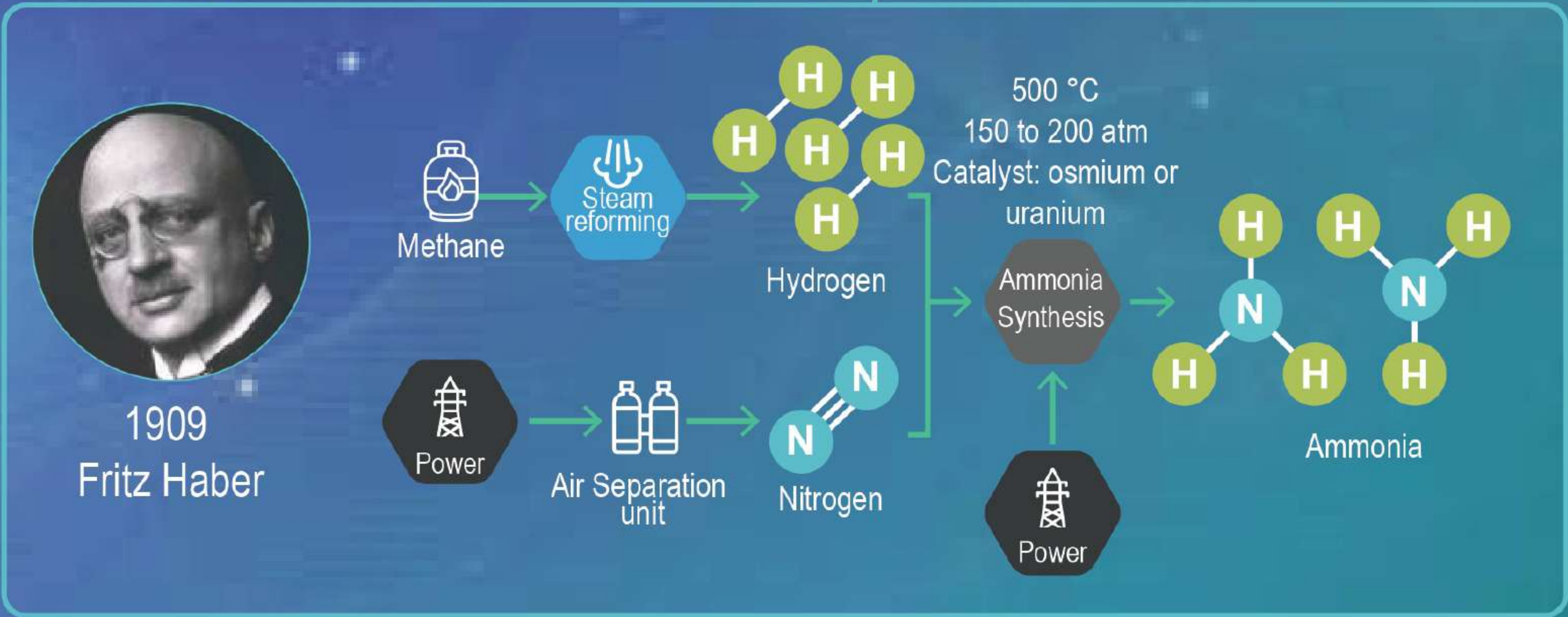
Introduction

Atmospheric Nitrogen exists as Diatomic Nitrogen (N_2), an exceedingly stable triple-bonded molecule.



Introduction

In 1908, Fritz Haber discovered how to synthesize ammonia by combining atmospheric nitrogen with hydrogen under high pressure and heat with a catalyst.



Introduction

In 1913, Carl Bosch helped commercialize a process for industrial-scale production of ammonia.

1913
Carl Bosch
BASF

500 °C
150 to 200 atm
Catalyst: osmium or uranium

Ammonia Synthesis

Fritz Haber

450°C
200 atm
Catalyst: Iron

Ammonia Synthesis

Carl Bosch

Introduction

Haber-Bosch process produced ammonia for cheap and abundant fertilizers to meet 20th-century population demands.

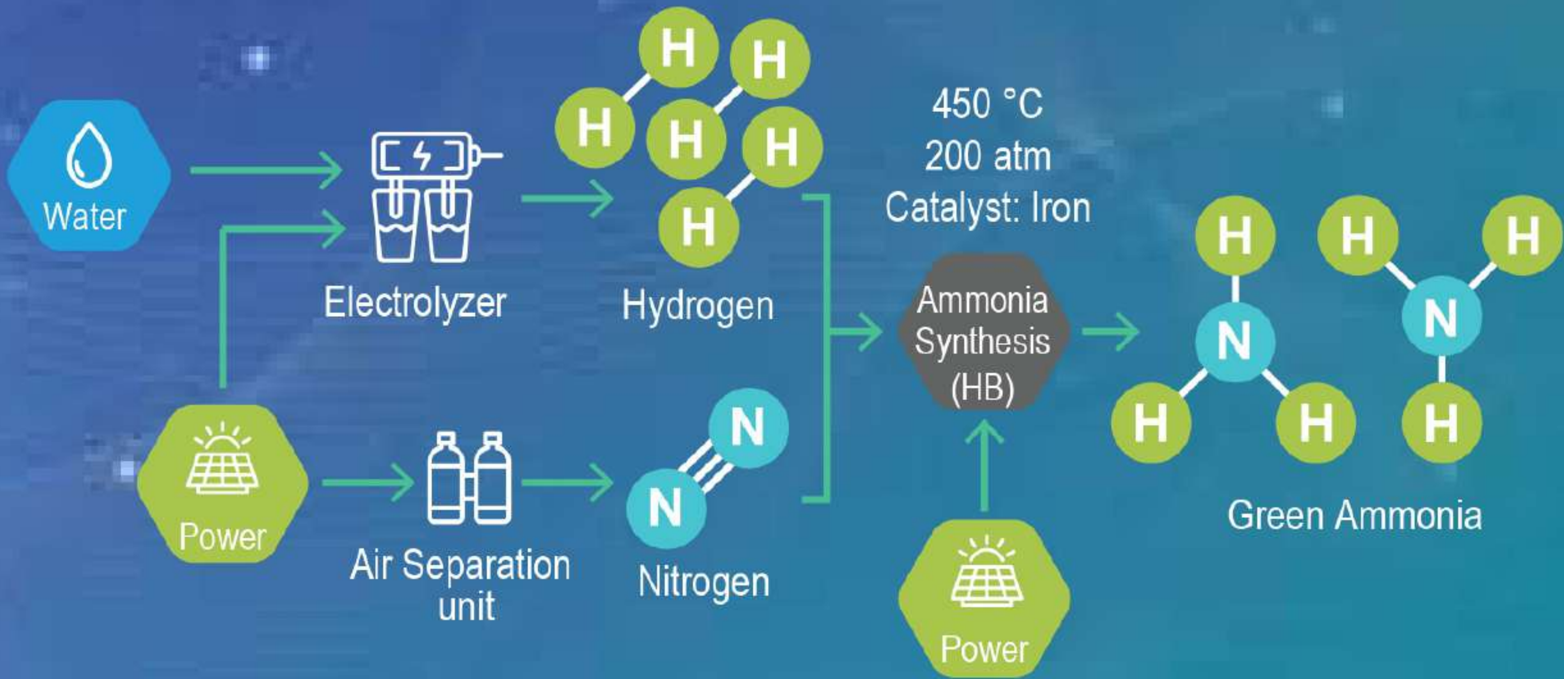
1918
Fritz Haber
Fixation of nitrogen from the air

The Nobel Prize in Chemistry

1931
Carl Bosch
Contributions to chemical high-pressure methods

Introduction

Replacing conventional ammonia with green ammonia made from renewable hydrogen offers an early opportunity to decarbonize the chemical industry.



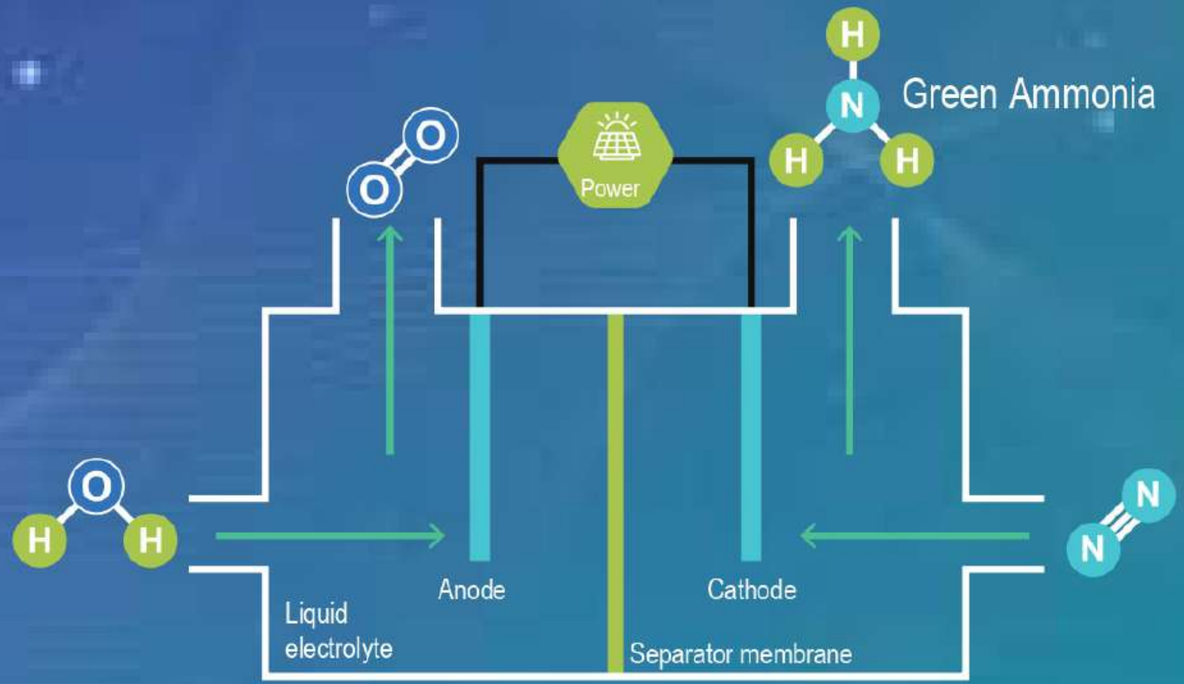
Introduction

The Haber-Bosch process has been the dominant nitrogen fixation procedure for over a century. However, A wide range of novel ammonia production processes has been researched, such as:

- Electrochemical
- Photochemical
- Plasma-based
- Chemical looping
- Biological

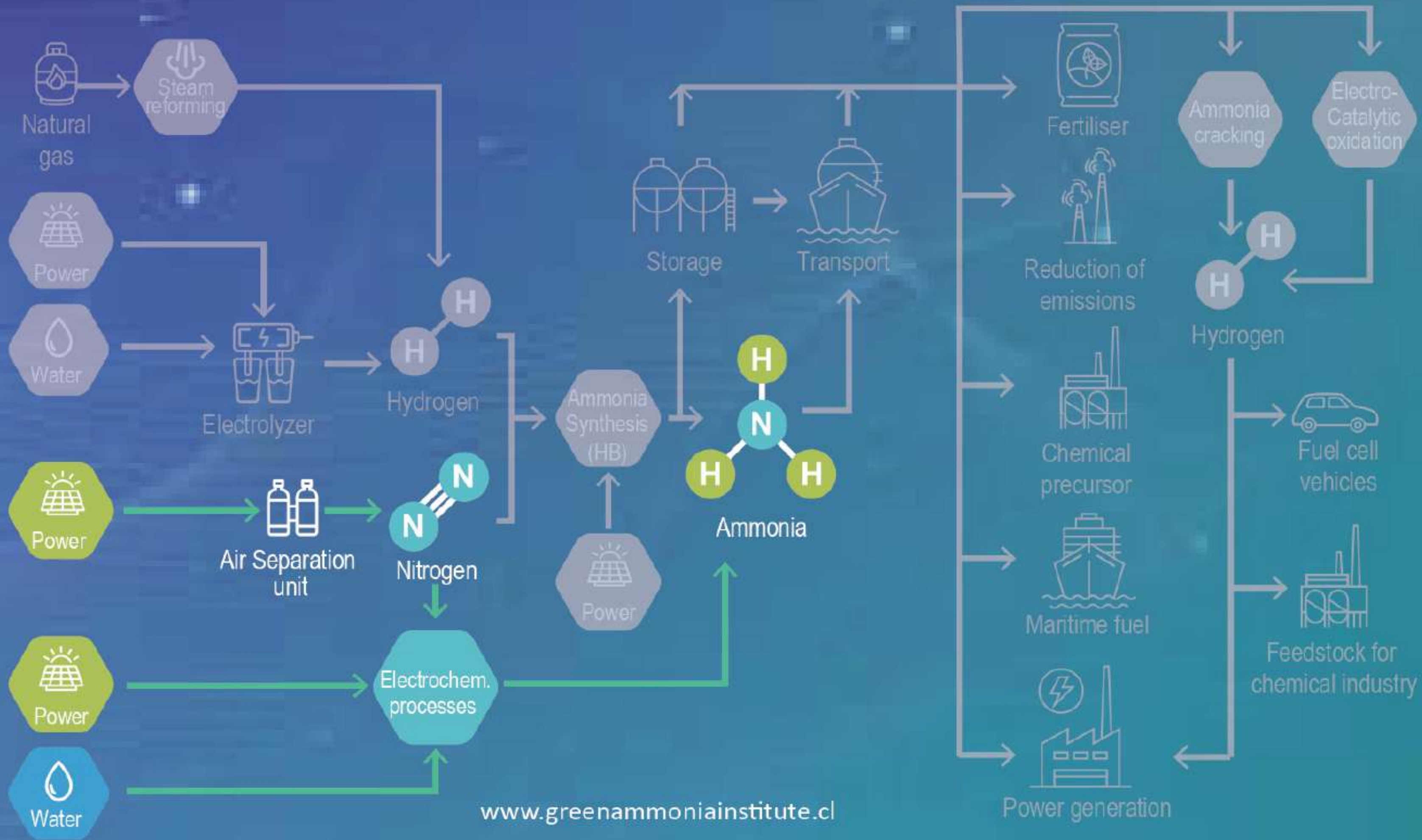
Introduction

Electrochemical ammonia synthesis has been a subject of extensive research in recent decades. It has the potential to create ammonia directly from water and nitrogen.



Introduction

1. Electrochemical production of NH3



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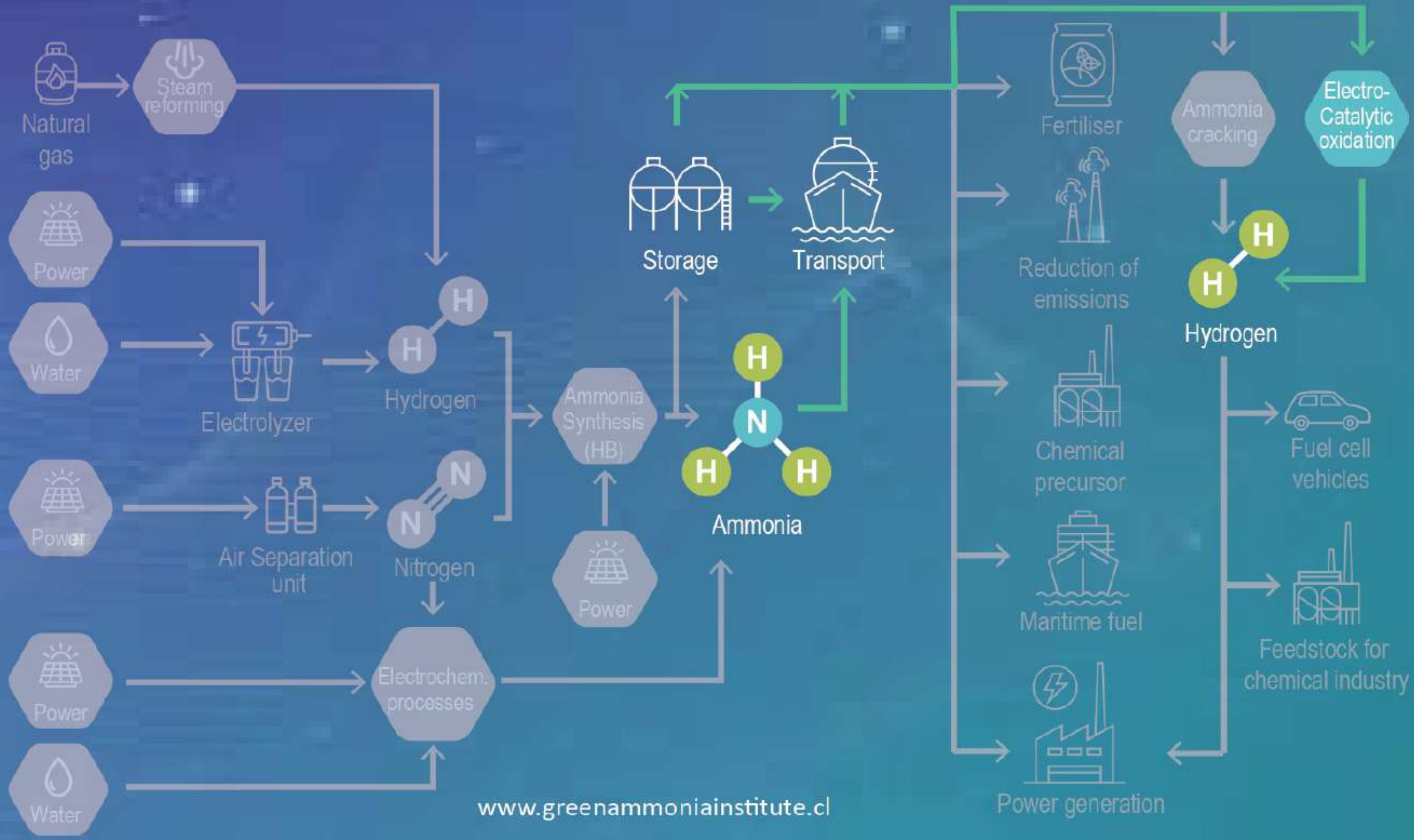
2. Production of H2 from NH3 electrolysis



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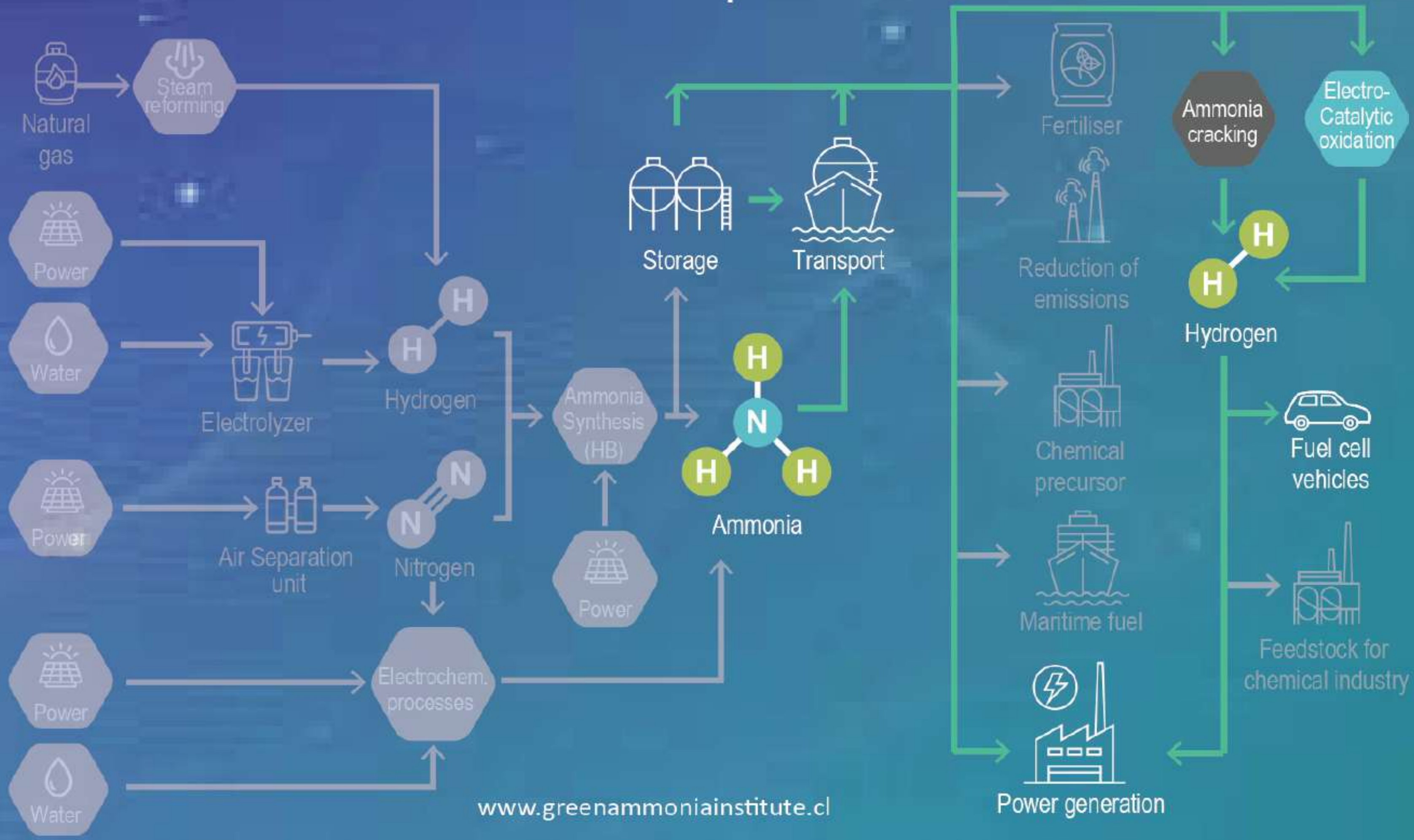
3. Design and prototypes of NH3 fuel cells and components



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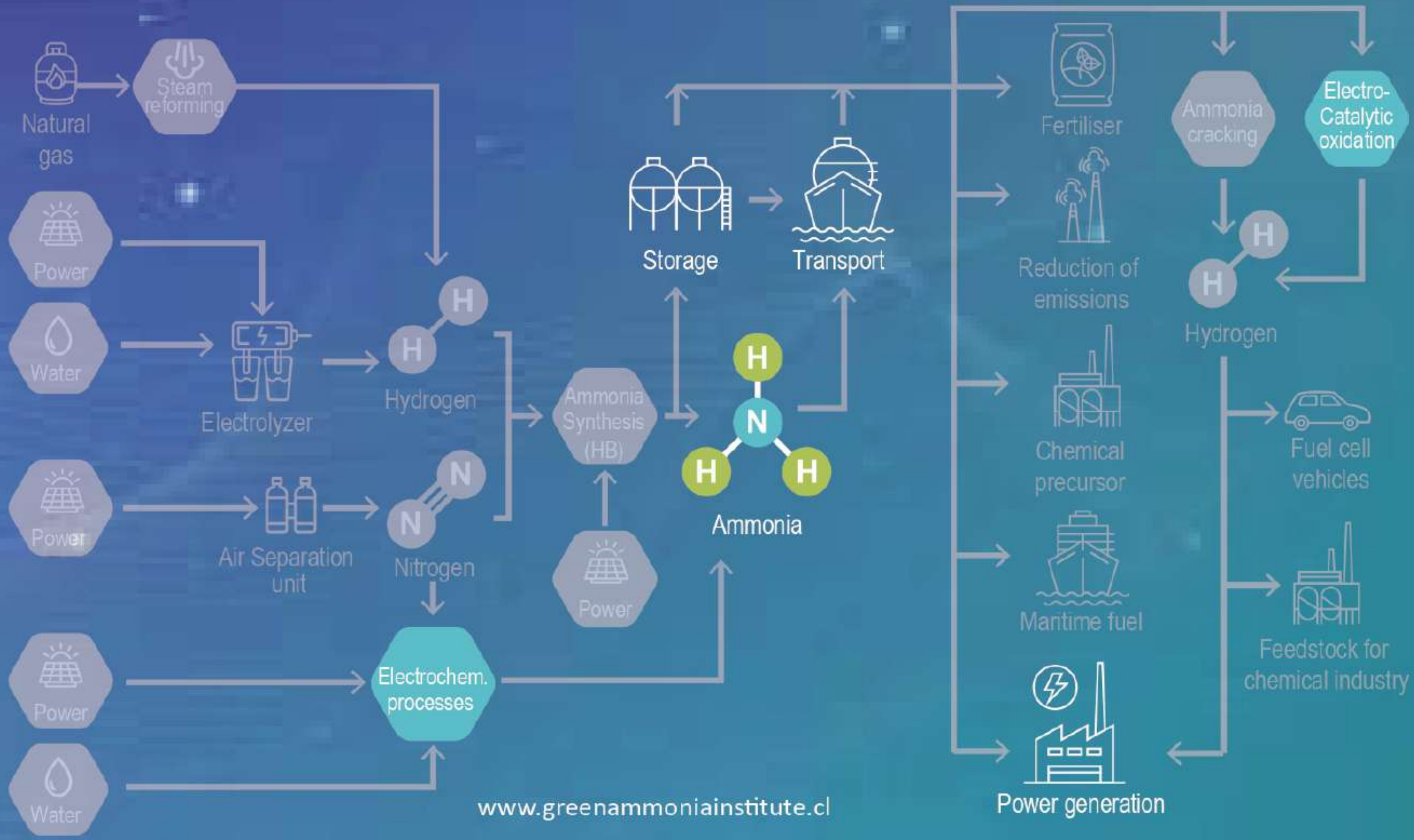
4. Corrosion and wear process



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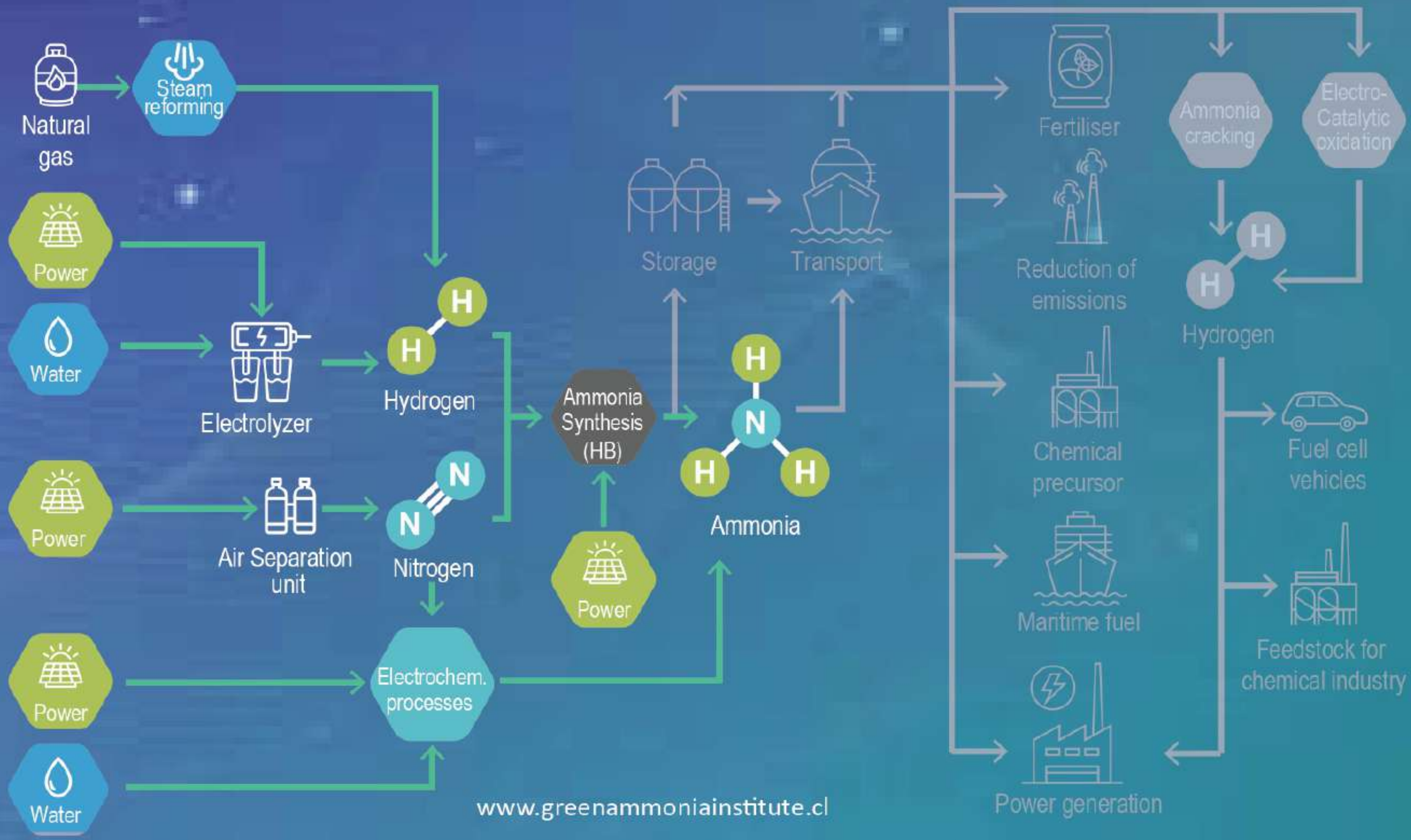
5. Green ammonia economy



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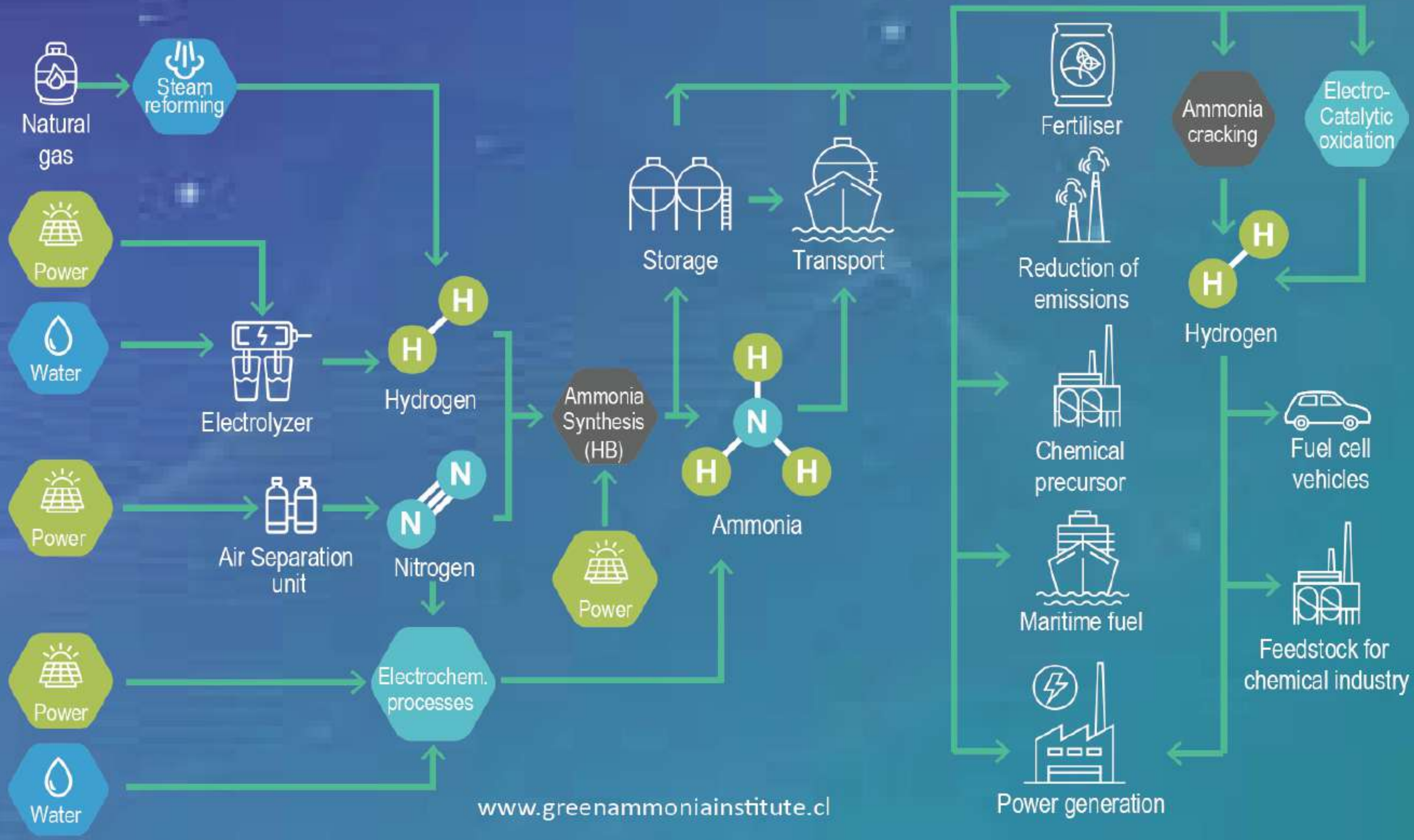
5. Green ammonia economy



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Hydrogen

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H 75%

The **most abundant** substance in the universe

H 1.00784 u

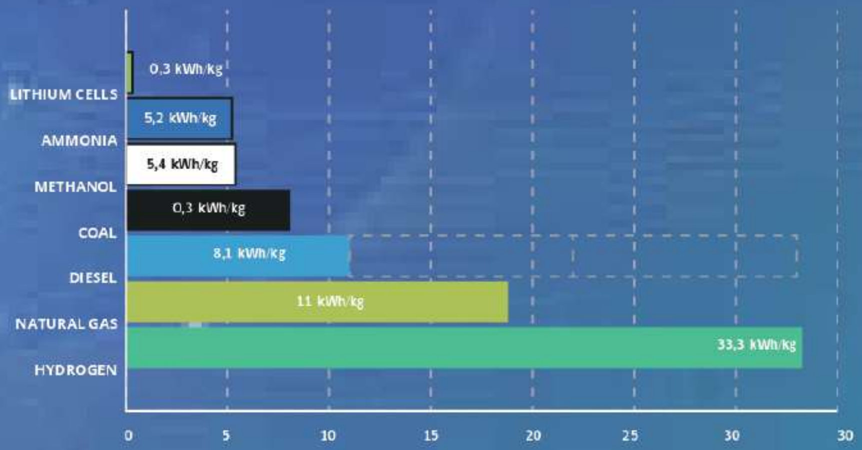
The **simplest and lightest** chemical element that exists

H_2O 71%

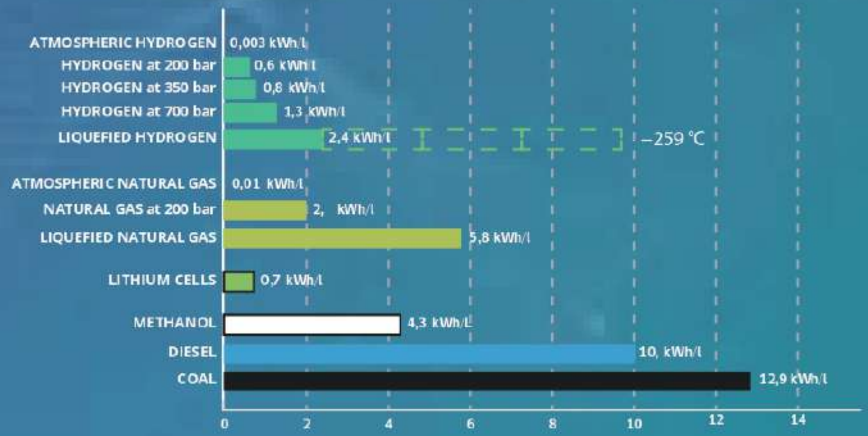
Present in the **most abundant component** of the earth surface

Methane CH_4
Butane C_4H_{10}
Gasoline C_7H_{16}
Diesel $C_{12}H_{26}$

Found **combined with carbon** in fossil fuels



The highest **energy density** per unit **mass**



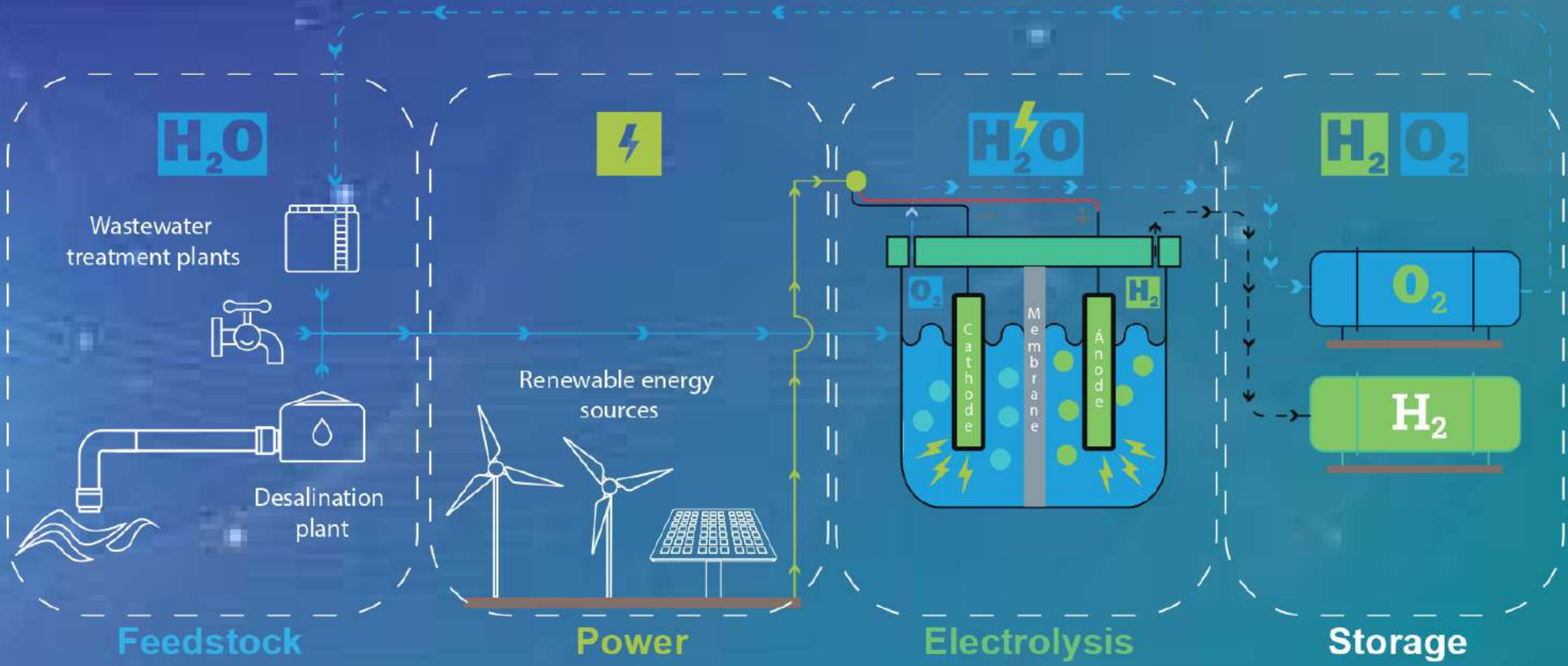
A very low **energy density** per unit **volume**

Source: National Green Hydrogen Strategy Published by the Ministry of Energy, Government of Chile

Hydrogen

Source: IRENA, Hydrogen from renewable power. Technology outlook for the energy transition, Sep. 2018

Green hydrogen



Sources: Australia's National Hydrogen Strategy 2019; Green Hydrogen Strategy, Government of Chile, 2020.

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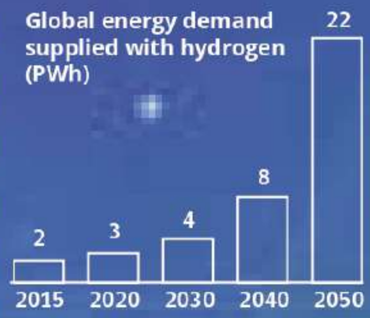
Green hydrogen

Limitations on carbon emissions

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

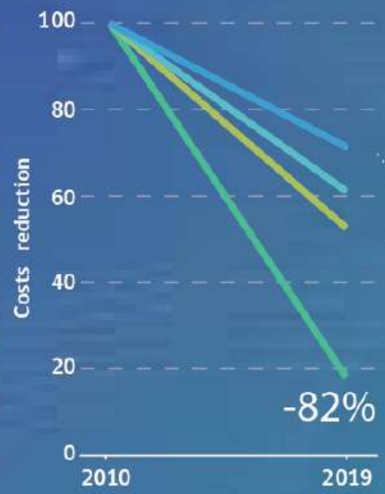
The demand for H2 would grow up to 10 times



$2.5 billones
Total hydrogen market

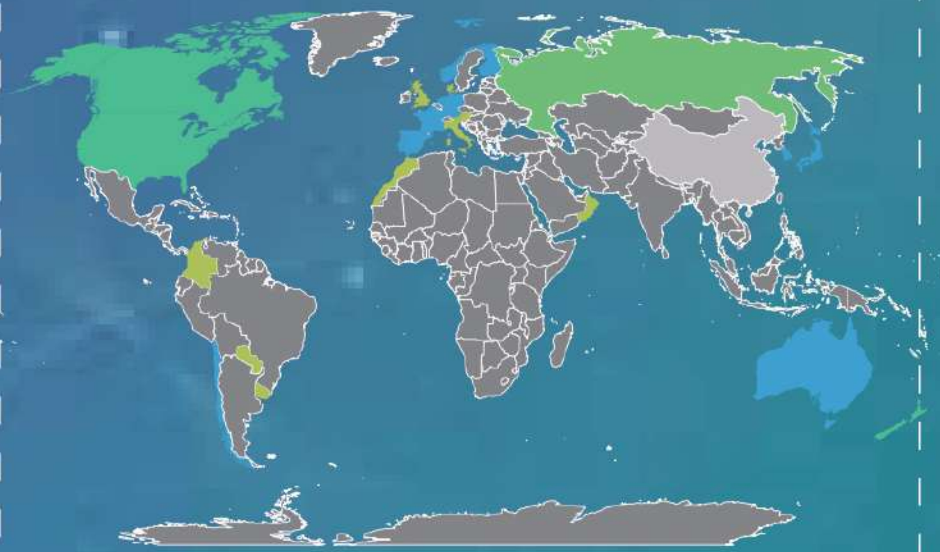
30 millions
New jobs

Renewable Energy Cost Reduction



Photovoltaic	-82%
Concentrated solar power	-47%
Onshore wind	-39%
Offshore wind	-29%

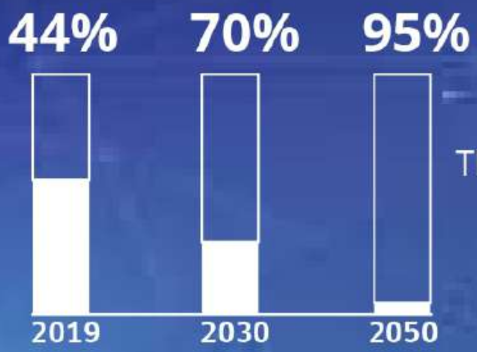
International strategies



- Strategy available
- Upcoming strategy
- Roadmap
- Vision document
- R&D programms

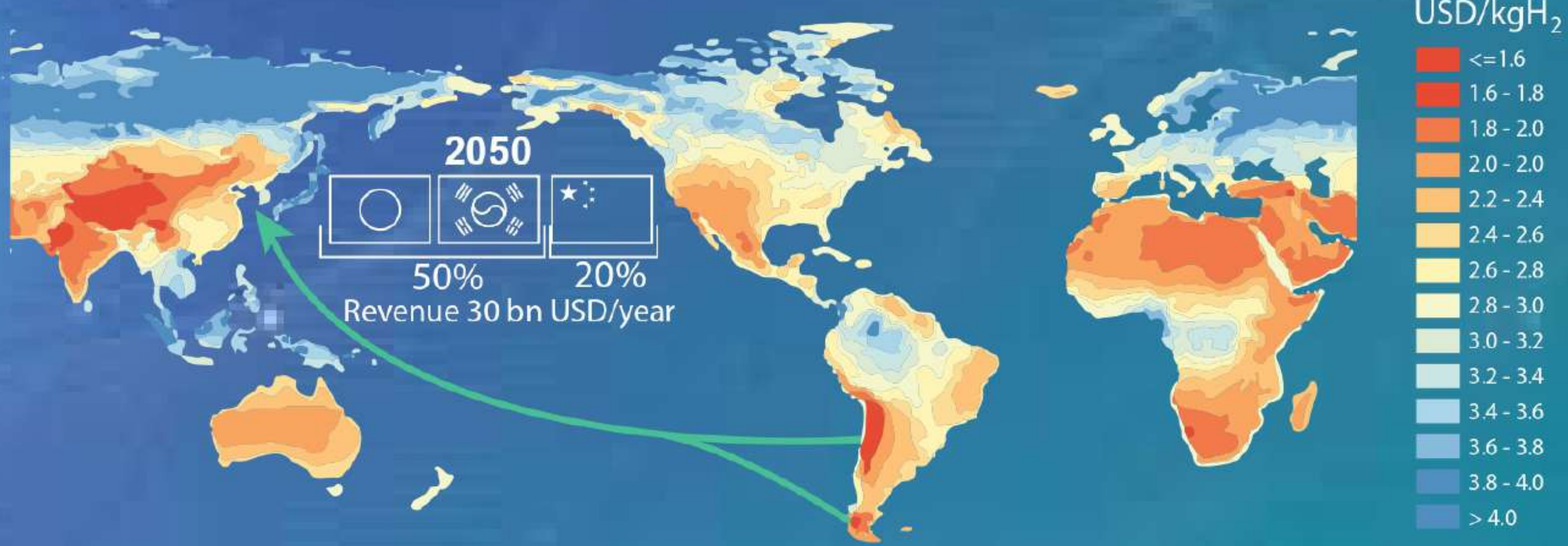
Sources: Green Hydrogen Strategy, Government of Chile, 2020; IRENA (2020), Renewable power generation costs in 2019. McKinsey & Co; Hydrogen scaling up, Hydrogen Council November 2017; Tecnologías del hidrógeno y perspectivas para Chile, 2018

Green hydrogen



The future of the generation of the electrical matrix is renewable

Chile's renewable potential v/s installed electricity capacity



Long term Hydrogen costs from hybrid solar PV and onshore wind systems

Sources: The Future of Hydrogen, IEA, 2019; Green Hydrogen Strategy, Government of Chile, 2020.

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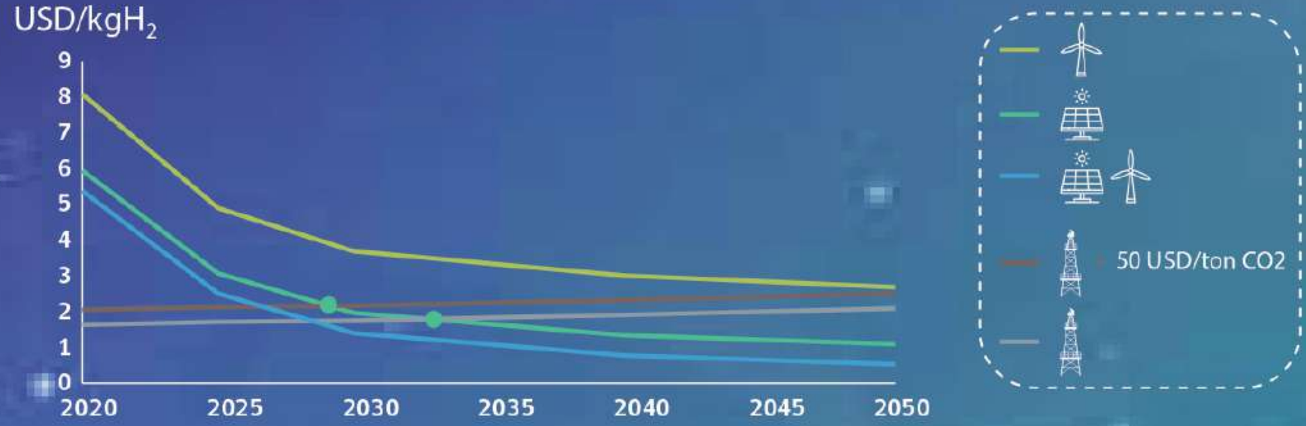
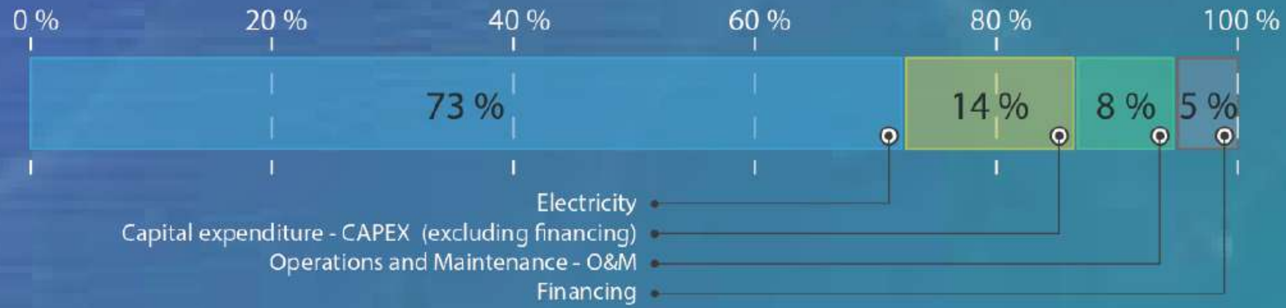
Barriers



Green H2 production is not yet economically competitive

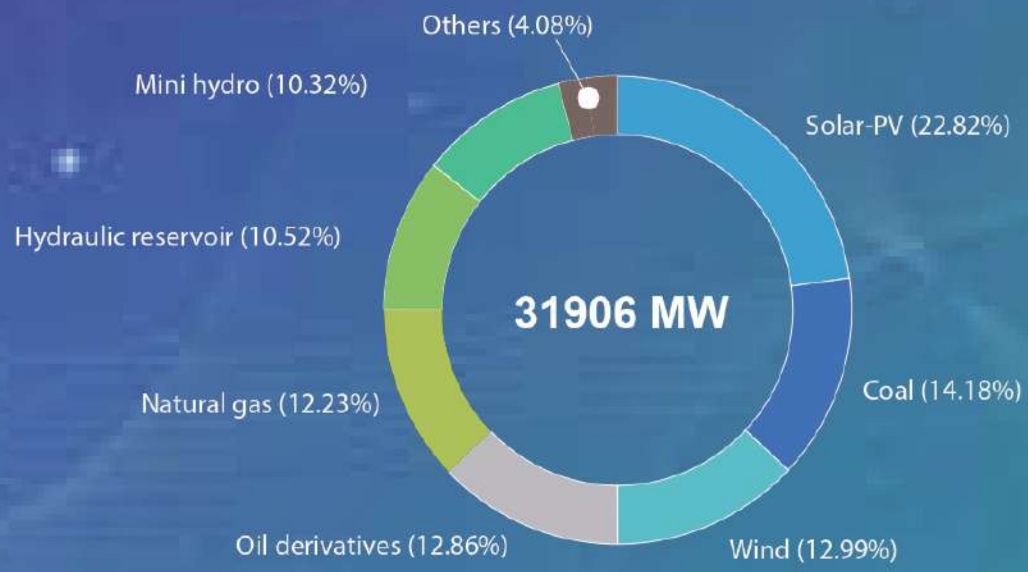


Main cost drivers (%) for green hydrogen in 2019

Sources: Green Hydrogen Strategy, Government of Chile, 2020.; IRENA (2020), Renewable power generation costs in 2019. McKinsey & Co; Hydrogen scaling up, Hydrogen Council November 2017; Aliaksei Patonia and Rahmatallah Poudineh, "Cost-competitive green hydrogen: how to lower the cost of electrolysers?", 2022.

Research

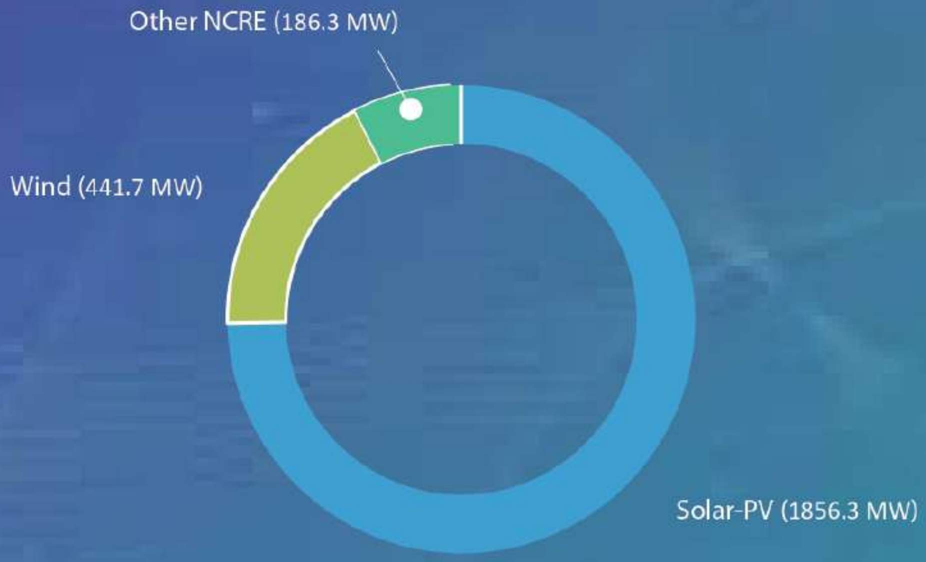
Total installed capacity



Source: National Energy Commission (02/05/2023)

Research

Projects under test



Source: National Energy Commission (02/05/2023)

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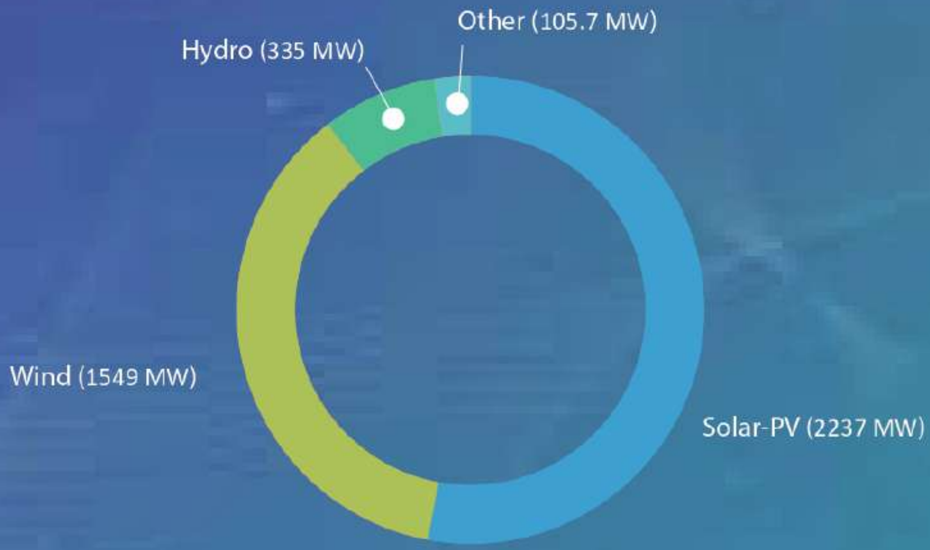
Generation plants under construction



Source: National Energy Commission (02/05/2023)

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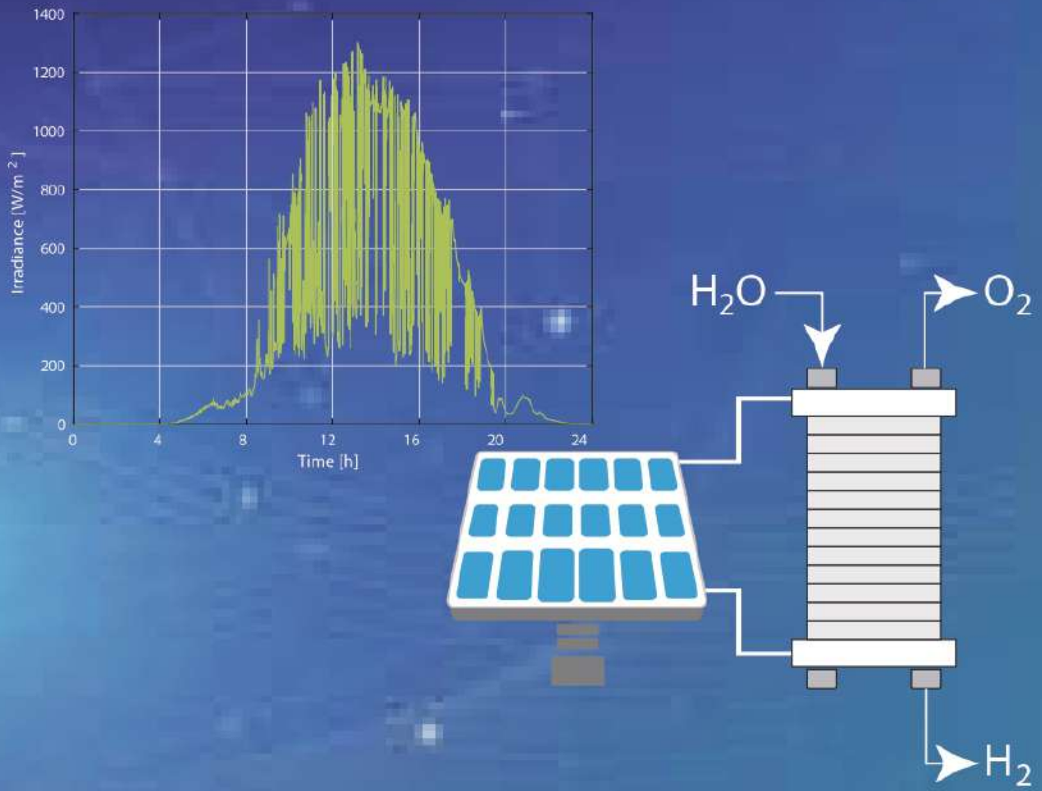

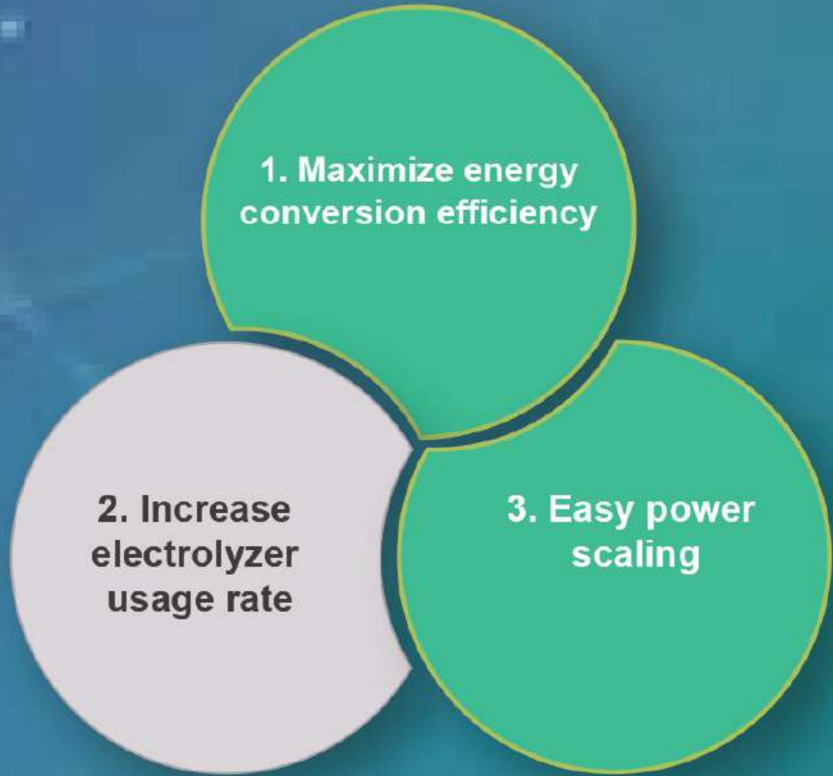

Source: H. Renaudineau, A. M. Llor, R. Cortés D., C. A. Rojas, C. Restrepo and S. Kouro, "Photovoltaic Green Hydrogen Challenges and Opportunities: A Power Electronics Perspective," in IEEE Industrial Electronics Magazine, vol. 16, no. 1, pp. 31-41, March 2022, doi: 10.1109/MIE.2021.3120705

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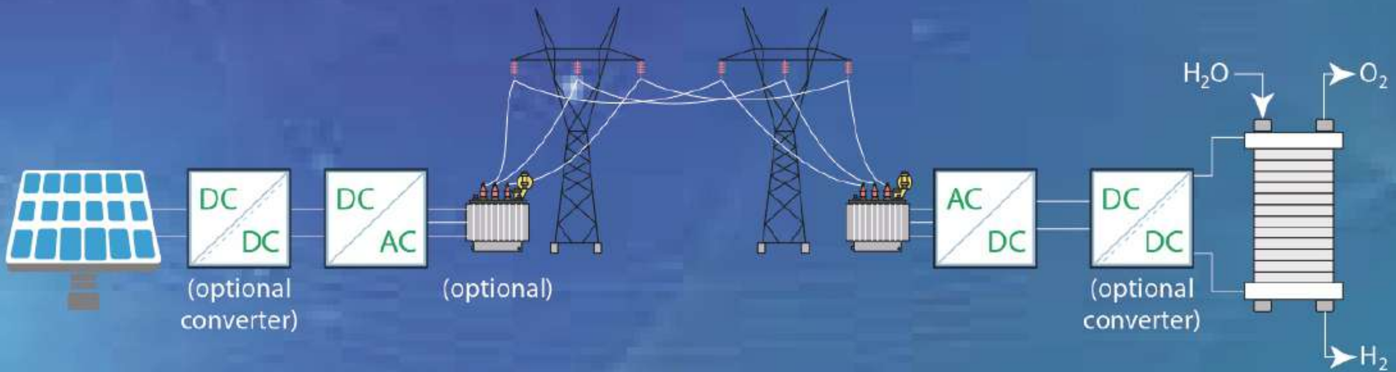

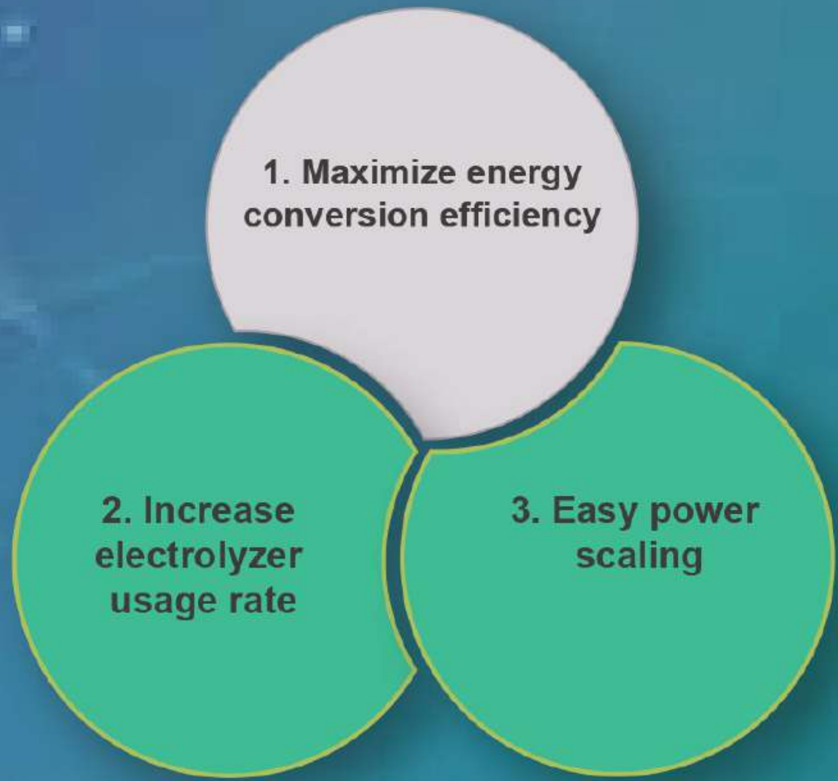

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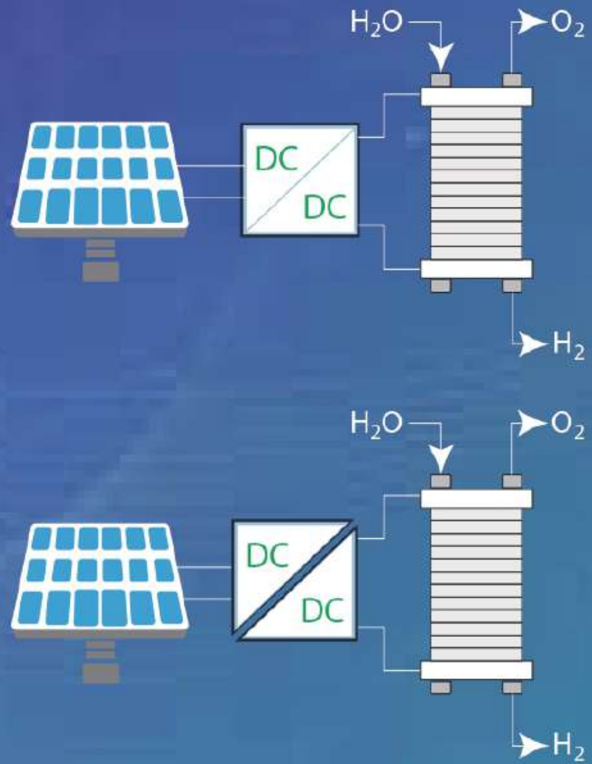

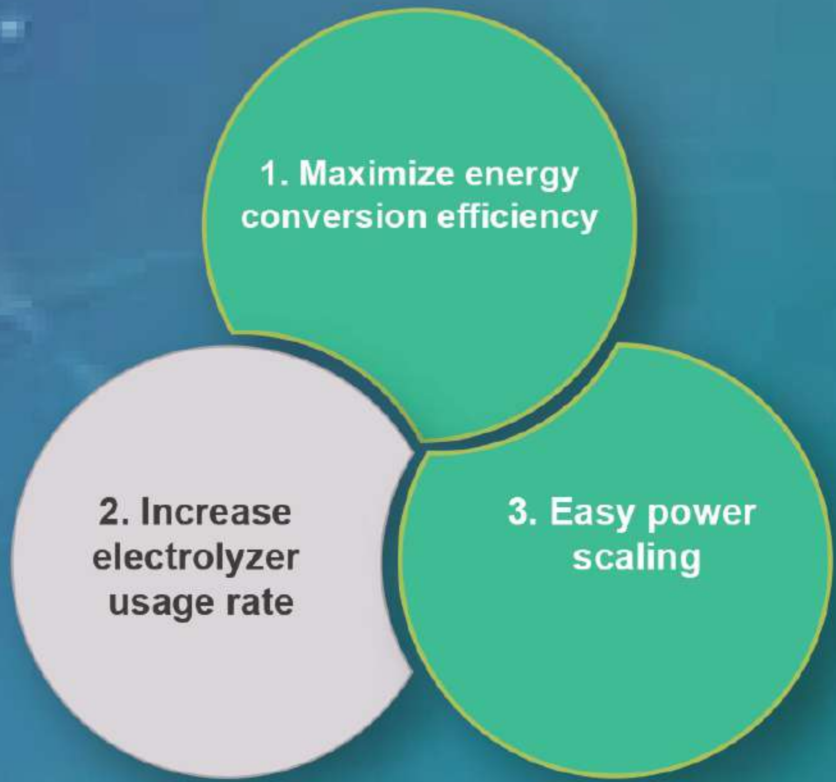

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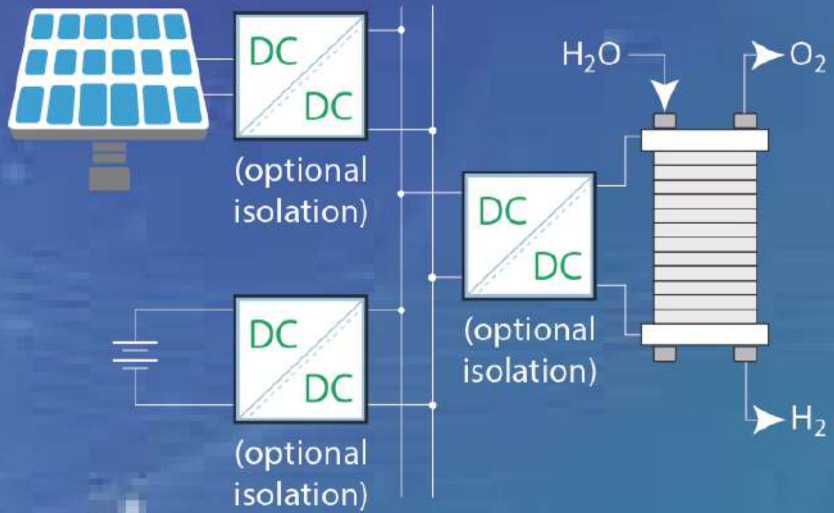

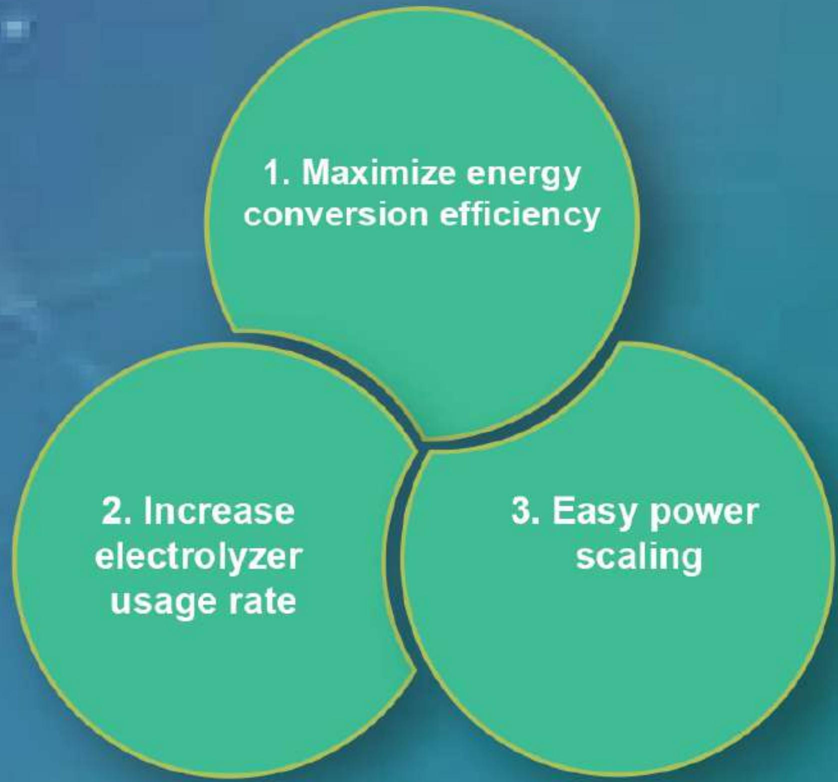

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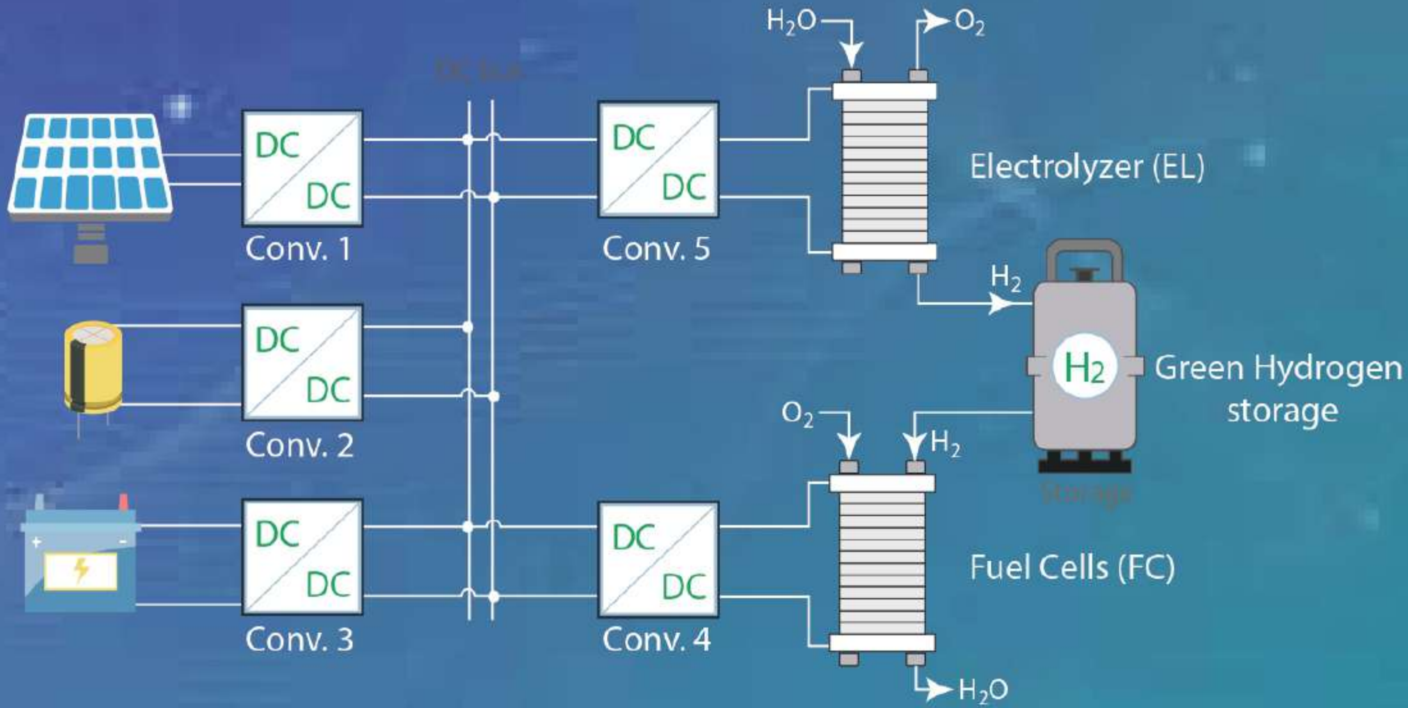
Research

Research

ANID FONDECYT Regular No. 1231015 (2022-2026): Competitive Off-grid Photovoltaic Green Hydrogen production based on the Versatile Buck-Boost Power Electronics Building Block



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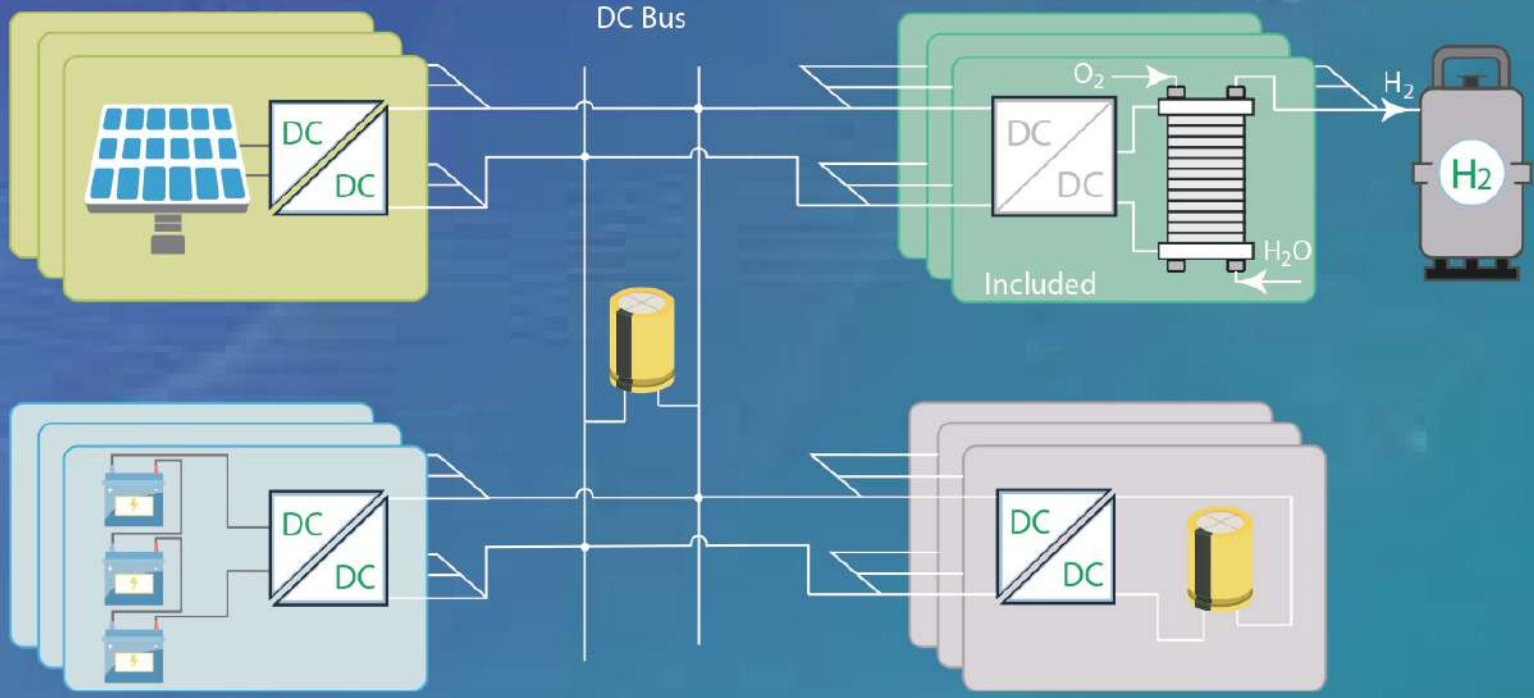
ANID Desafíos Públicos 2022 No. RP22I40005 (2022-2025): A hybrid system that utilizes a power building block for partial power processing ensures maximum conversion efficiency and electrolyzer utilization rate for green hydrogen production.



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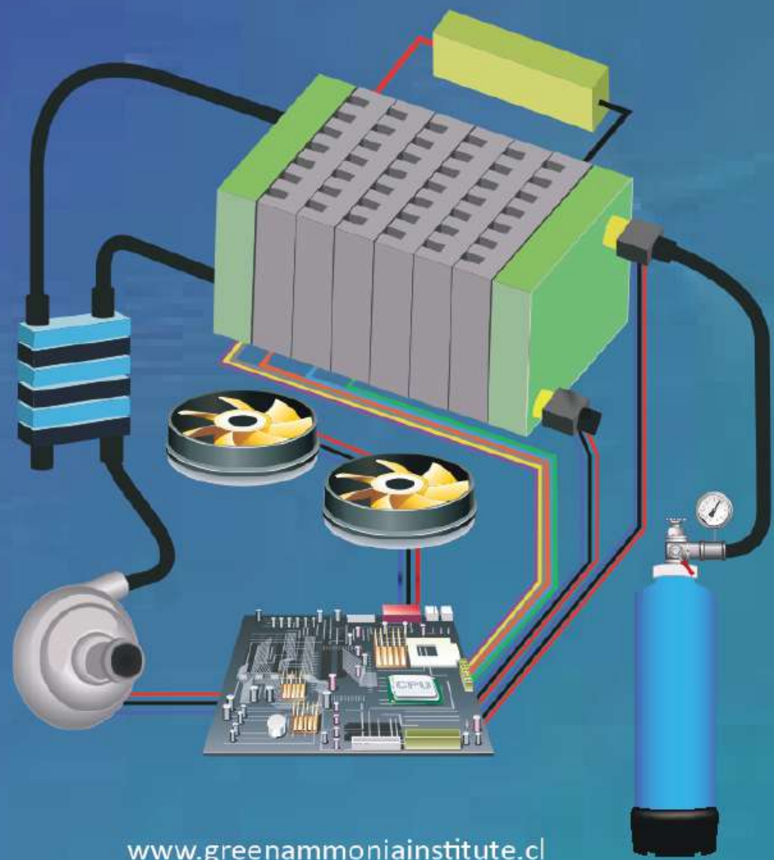
ANID Millennium Institute No. ICN2021_023 (2022-2032): Millennium Institute on Green Ammonia as an Energy Vector (MIGA)



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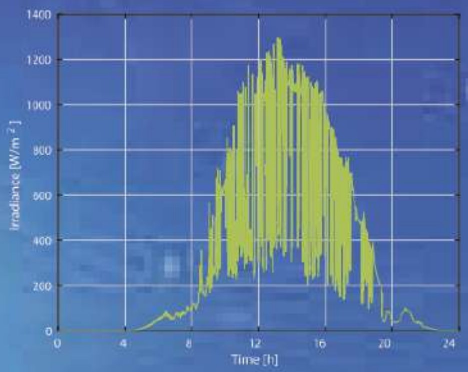
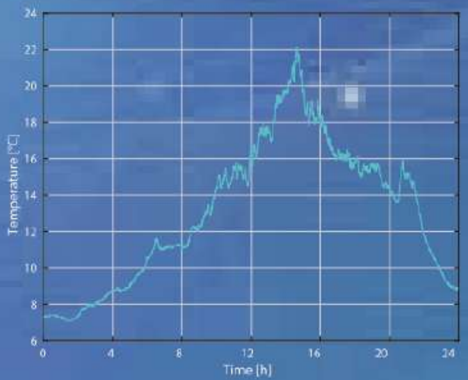
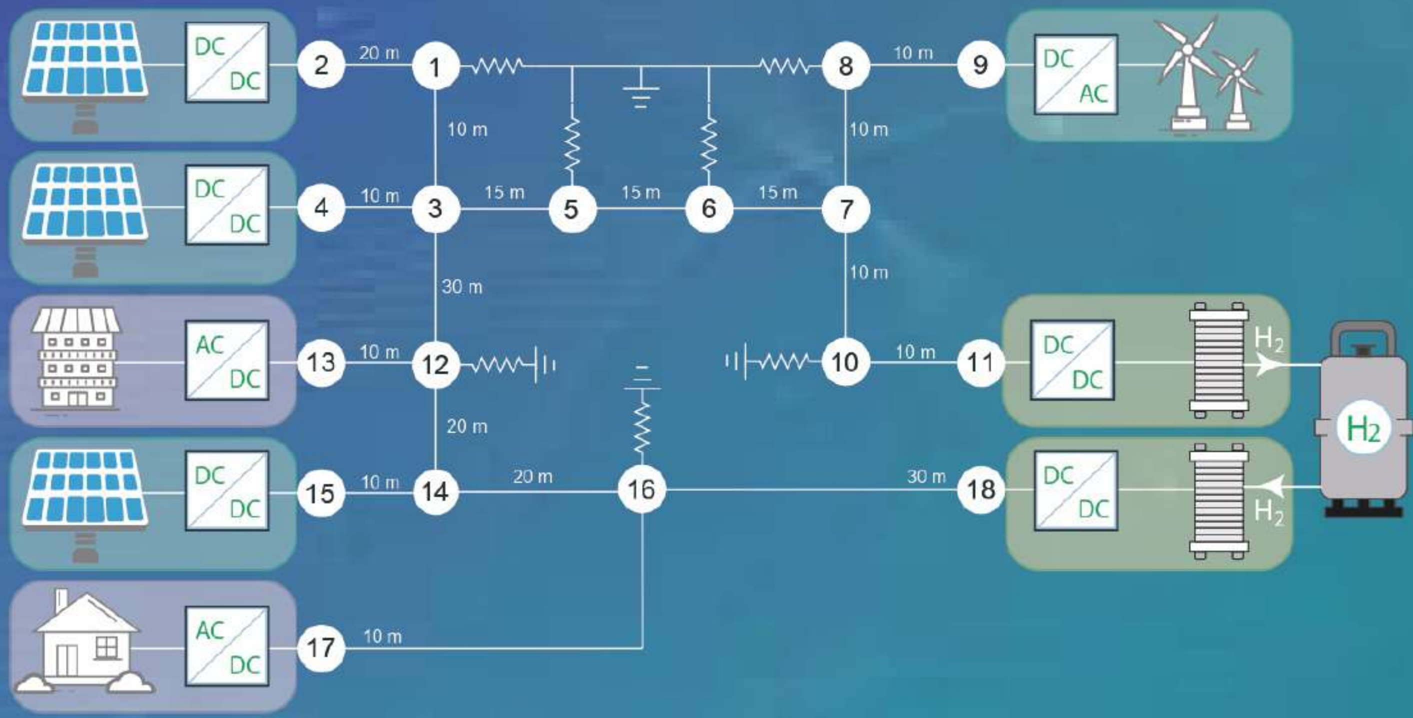
ANID Anillo de Investigación en Áreas Temáticas Específicas 2022 (2022-2025): Centre for Multidisciplinary Research on Smart and Sustainable Energy Technologies for Sub-Antarctic Regions under Climate Crisis







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