FGV EUROPE

Latin America Hydrogen Market Development: strategies and opportunities focusing on Brazil

OCTOBER 12th 2023

INDEX

1. ABH2 – BRAZIL HYDROGEN ASSOCIATION

HYDROGEN ENERGY IN BRAZIL

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1975 — First Fuel Cell Developed in Brazil -Aïda Espinola

1984 — Creation of the Hydrogen Laboratory at Coppe/UFRJ

labH2 Laboratório de Hidrogênio COPPE . UFRJ

1995 — MCTIC

Ministry of Science, Technology and Innovation begins its work on the topic of Hydrogen Energy

1998 — Implementation of the National Hydrogen Energy Reference Center (CENEH)

2002 — Science, Technology and Innovation Program for the Hydrogen Economy (ProH2/PROCAC)-MCTI

2003 — Creation of IPHE w/ Brazil as a cofounder. Partnership IPHE MME/MCTI

IPHE

2004 — Creation of Rede PaCOS

2005 — Roadmap for Structuring the Hydrogen Economy in Brazil -MME

Roteiro para Estruturação da Economia do Hidrogênio no Brasil

2010

- Launch of Coppe/UFRJ Hybrid Electric-Hydrogen Bus

2015 — Hydrogen buses prototypes (3 units) -EMTU/SP

2017

AB H2 ASSOCIAÇÃO BRASILEIRA DO HIDROGÊNIO

- Strategic Agenda for CT&I in the Brazilian electricity sector MCTI/CGEE
- Creation of the **Brazilian Hydrogen Associaition**

2018

- Science, Technology and Innovation Plan for Renewables and Biofuels 2018-22 MCTICT.
- 22nd World Hydrogen Energy Conference-WHEC2018

PLANO DE CIÊNCIA, TECNOLOGIA E INOVAÇÃO PARA ENERGIAS RENOVÁVEIS E BIOCOMBUSTÍVEIS

WHEC 2018

2019 — 1st Brazilian Hydrogen Congress

2020 — National Energy Plan 2050 MME/EPE

PNE2050 PLANO NACIONAL DE ENERGIA

2021

- NT-003/2021 Bases Consolidation of the Brazilian H2 Strategy
- Hydrogen hubs in Brazil
- PNH2 Directives

2022

- Meetings in thematic chambers for PNH2 study points
- Bills of Laws
- Hydrogen Gigaprojects and MoUs

2023

- Launch of the Triennial Plan of the National Hydrogen Program
- Hydrogen Gigaprojects and MoUs
- 3rd Brazilian Hydrogen Congress
- Natural Hydrogen discovery in Maricá, RJ

PNH2 Programa Nacional do Hidrogênio

AB H2 ASSOCIAÇÃO BRASILEIRA DO HIDROGÊNIO FOR ALL OPTIONS OF PRODUCTION AND USE

HYDROGEN ENERGY: WORLD HYDROGEN STRATEGIES

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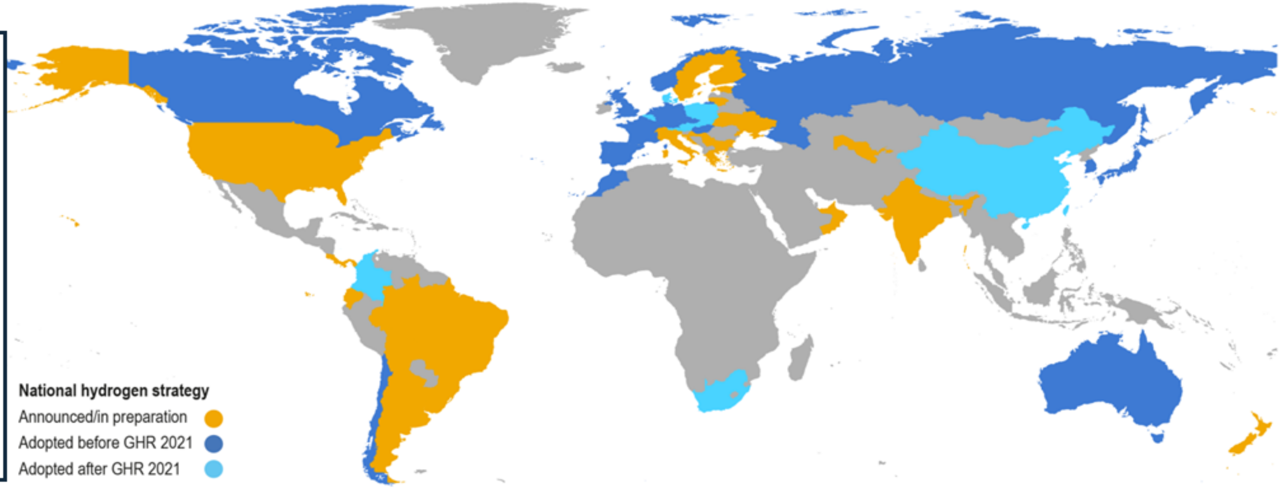
National Hydrogen Strategies

- Long-term commitment to the development of the hydrogen economy
- Strategies to leverage the economy
- Local development of value chains
- Decarbonization



International Energy Agency; Global Hydrogen Review 2021; 2021
International Energy Agency; Global Hydrogen Review 2022; 2022 (Julho)
2023 available from October

Brazil launched its first hydrogen strategy in 2005

MME - Ministério de Minas e Energia (2005). Roteiro para Estruturação da Economia do Hidrogênio no Brasil. (Coordenação geral: MME - Ministério de Minas e Energia; Integração Técnica: MCT - Ministério de Ciência e Tecnologia; Operação: LACTEC/UFPR; Sub-coordenações: UNICAMP, CENPES, COPPE/UFRJ e INMETRO).

Available Strategies

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FOR ALL OPTIONS OF PRODUCTION AND USE

THE ABH2

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Promoting the Hydrogen Value Chain in Brazil

- Development of the hydrogen network
- Contribution to hydrogen-related safety, codes and standards
- Advocacy and market regulation
- Research and professional training
- Industrial and scientific events
- Production and dissemination of information

AB H2 ASSOCIAÇÃO BRASILEIRA DO HIDROGÊNIO

FOR ALL OPTIONS OF PRODUCTION AND USE

COMPANY MEMBERS OF ABH2

bp	VALE	enel	NEOENERGIA	ENGIE	Cummins	COPEL Pura Energia	OXITENO
Eletrobras	UNIGEL	TOYOTA	SELCO	EDF renewables	Metalinox	MITSUBISHI POWER	Ponte Nova ENERGIA
PORTO DO AÇU	SUAPE Complexo Industrial Portuário Governador Eraldo Gueiros	TOTAL eren	TUPY	comgas	Burckhardt Compression	Gas Energy	Green Tech
eneva	aes Brasil	AGROZOOTEC	Grupo energisa	CMS law-tax-future	PACTO ENERGIA	CM Campos Mello Advogados	NEXWAY EFICIÊNCIA
Alupar	CEMIG	ABB	Air Liquide	GAS FUTURO	varixx	SOUTO CORREA ADVOGADOS	WATT CAPITAL
AIR PRODUCTS	Tracel	H_2helium energy projects	SPIC BRASIL	Trench Rossi Watanabe	HYDROBRAS	INSTITUTO SENAI DE INOVAÇÃO BIOMASSA	INSTITUTO SENAI DE INOVAÇÃO ENERGIAS RENOVÁVEIS
Hytron	TNS TENNESSINE	sandech Engineering & Management	ROLIM Rolim, Viotti, Goulart Cardoso Advogados	RINA	Rosseti Engenharia	GEMÜ	Solarig
PRF Gas Solutions	greenyellow	PÖYRY	WOLFTANK LATINOAMÉRICA	IATI	ctdut	ied	Creation
NORSUL	DIFERENCIAL ENERGIA	WHITE MARTINS	HIGER	Nepomuceno Soares Advogados	hidrogen&sys	H_2Verde	ORION-E
singular ENERGIA	Vind Aerogeradores	ONH	CITLUX	SUNSET CAPITAL	MATTOS FILHO	solum	N&A CONSULTORES
hubz	H_2Brasil seguros	eidee	SLX	quinto	BAC BALTIMORE AIRCOIL COMPANY	DE NORA	ENERCORE TRADING
Parker							

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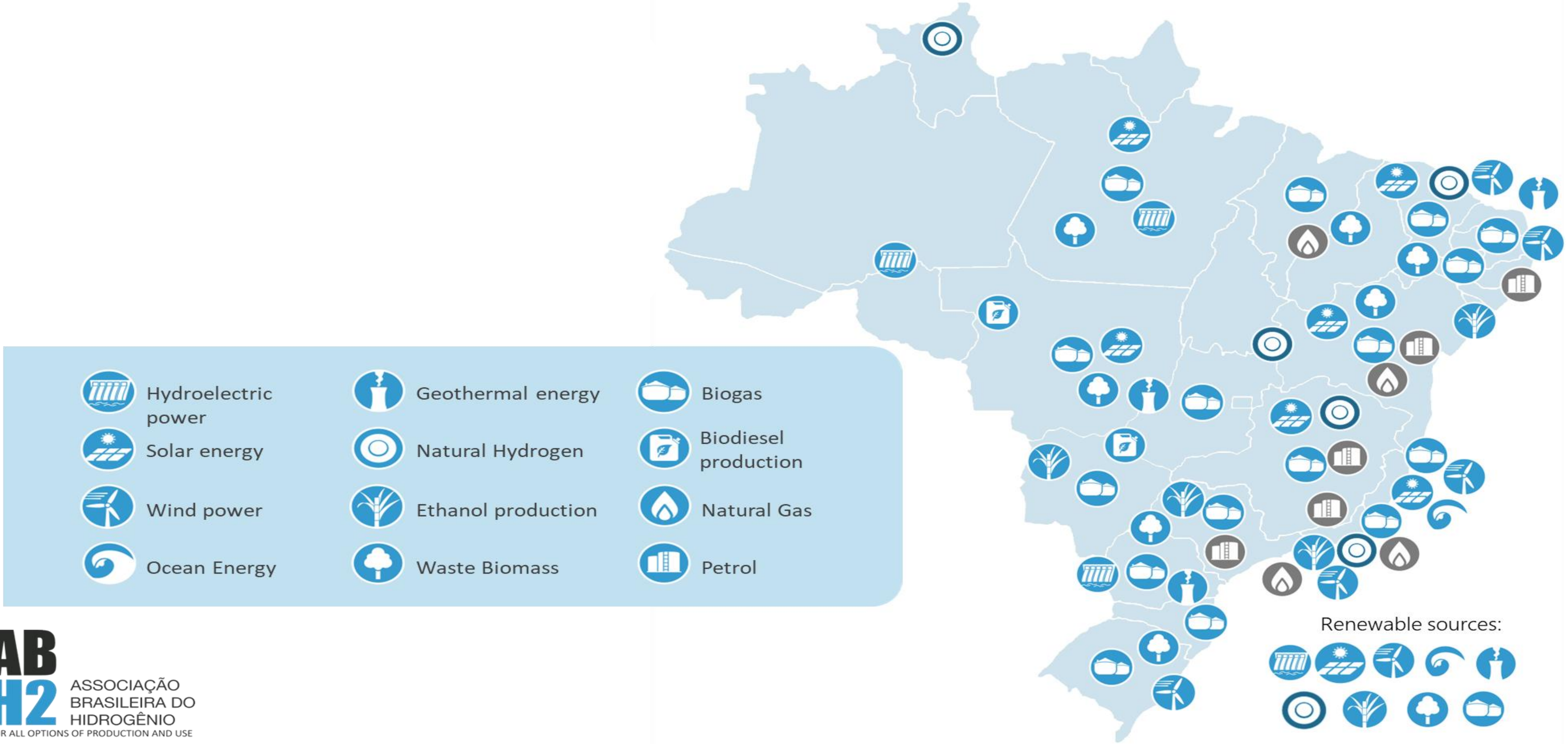
FOR ALL OPTIONS OF PRODUCTION AND USE

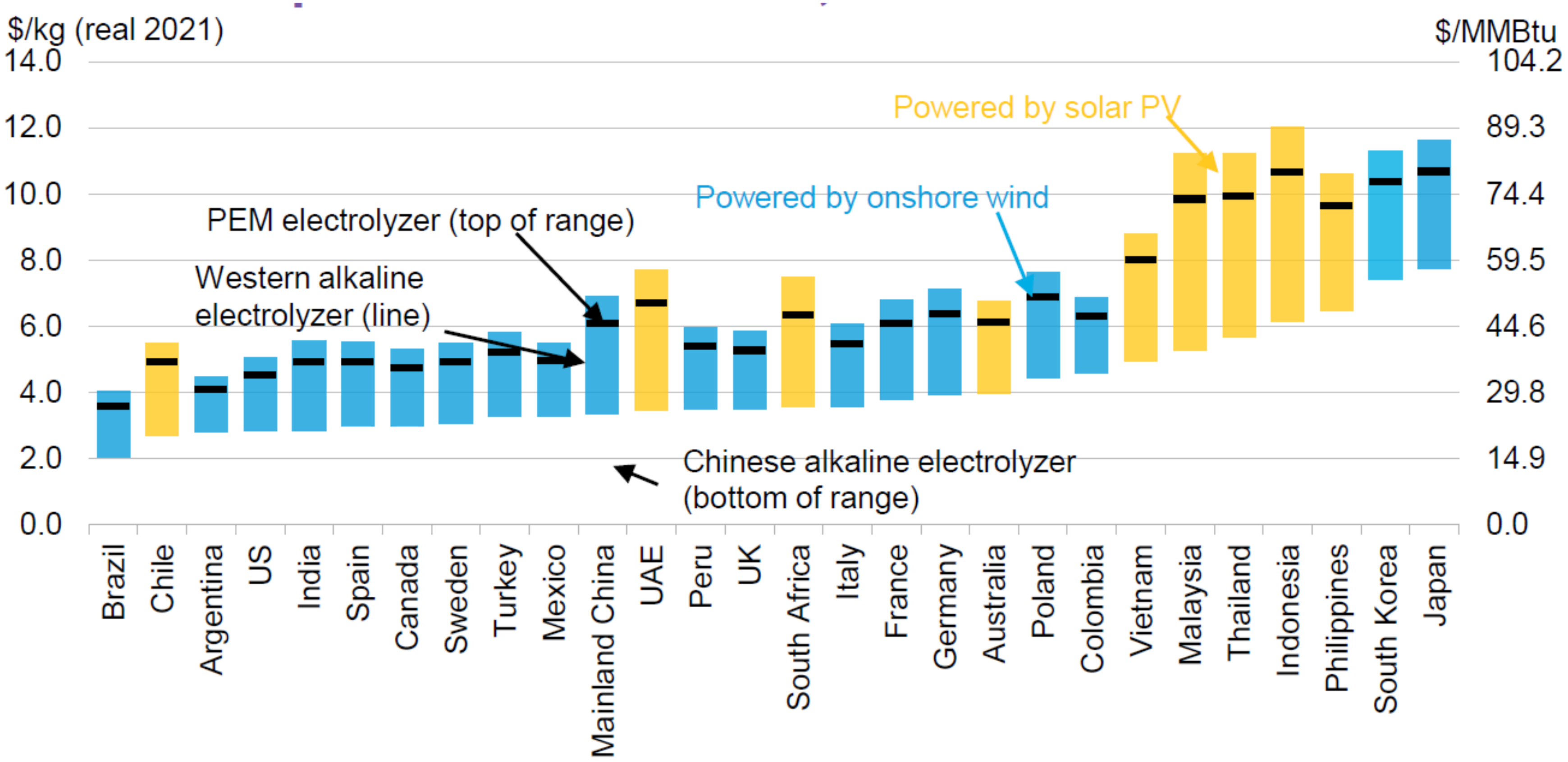
2. BRAZIL HYDROGEN MARKET AND H2 CASES

POTENTIAL FOR H2 PRODUCTION IN BRAZIL



ASSOCIAÇÃO BRASILEIRA DO HIDROGÊNIO
FOR ALL OPTIONS OF PRODUCTION AND USE

LEVELIZED COST OF HYDROGEN FROM CHEAPEST AVAILABLE RENEWABLE POWER IN 28 MARKETS, 2022



Source: BloombergNEF. Values at the bottom show cheapest hydrogen using a Chinese alkaline electrolyzer, values atop the range show cheapest values using a proton exchange membrane electrolyzer, and black lines show cheapest values using a Western alkaline electrolyzer. Electricity source is either solar or wind, whichever is cheaper. MMBtu is million British thermal units.

- **Brazil operates onshore wind projects with some of the highest capacity factors in the world**
- **Partly as a result, it has the world's lowest potential levelized cost for zero-carbon hydrogen at $2.01-4.05/kg**

BRAZIL HAS RESOURCES TO DELIVER LOWEST COST AMMONIA TO EUROPE AND JAPAN

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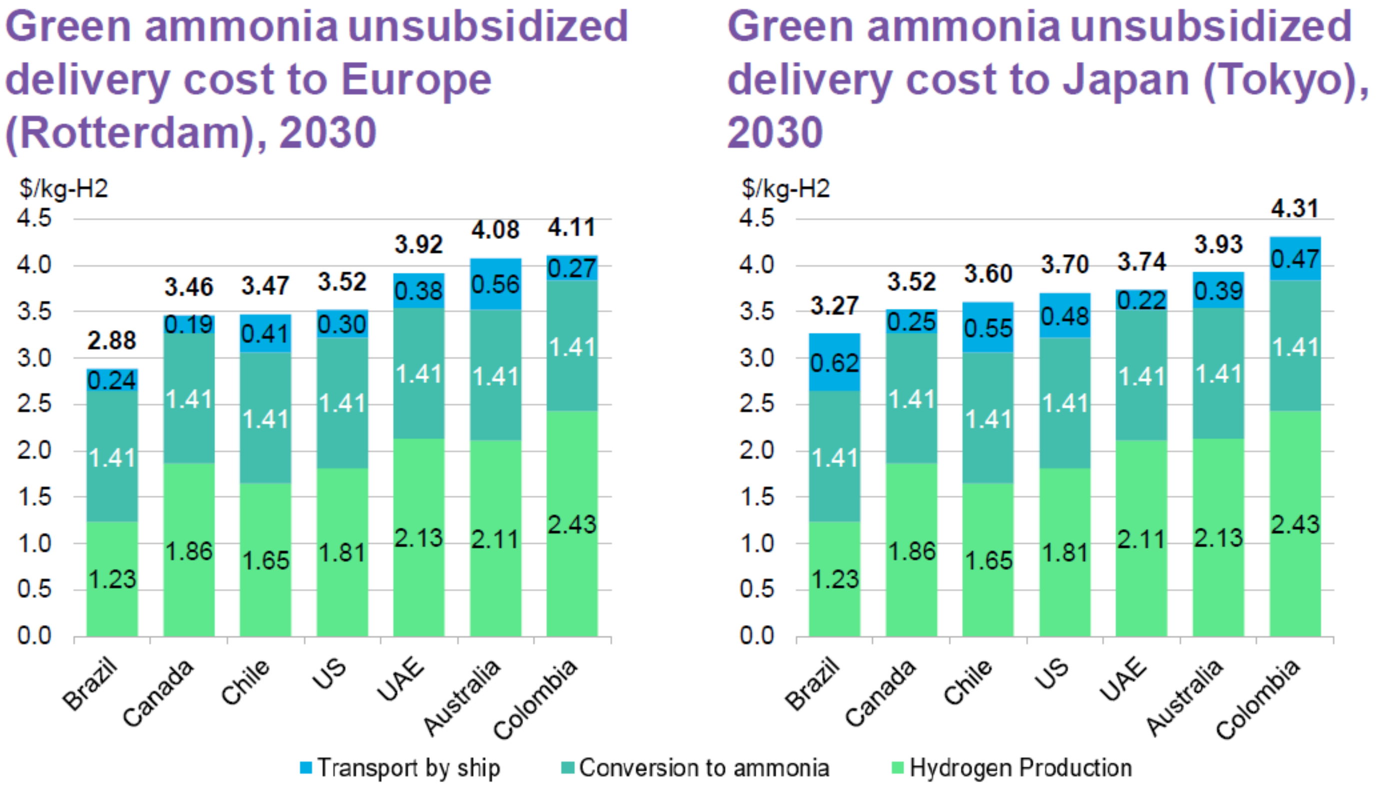
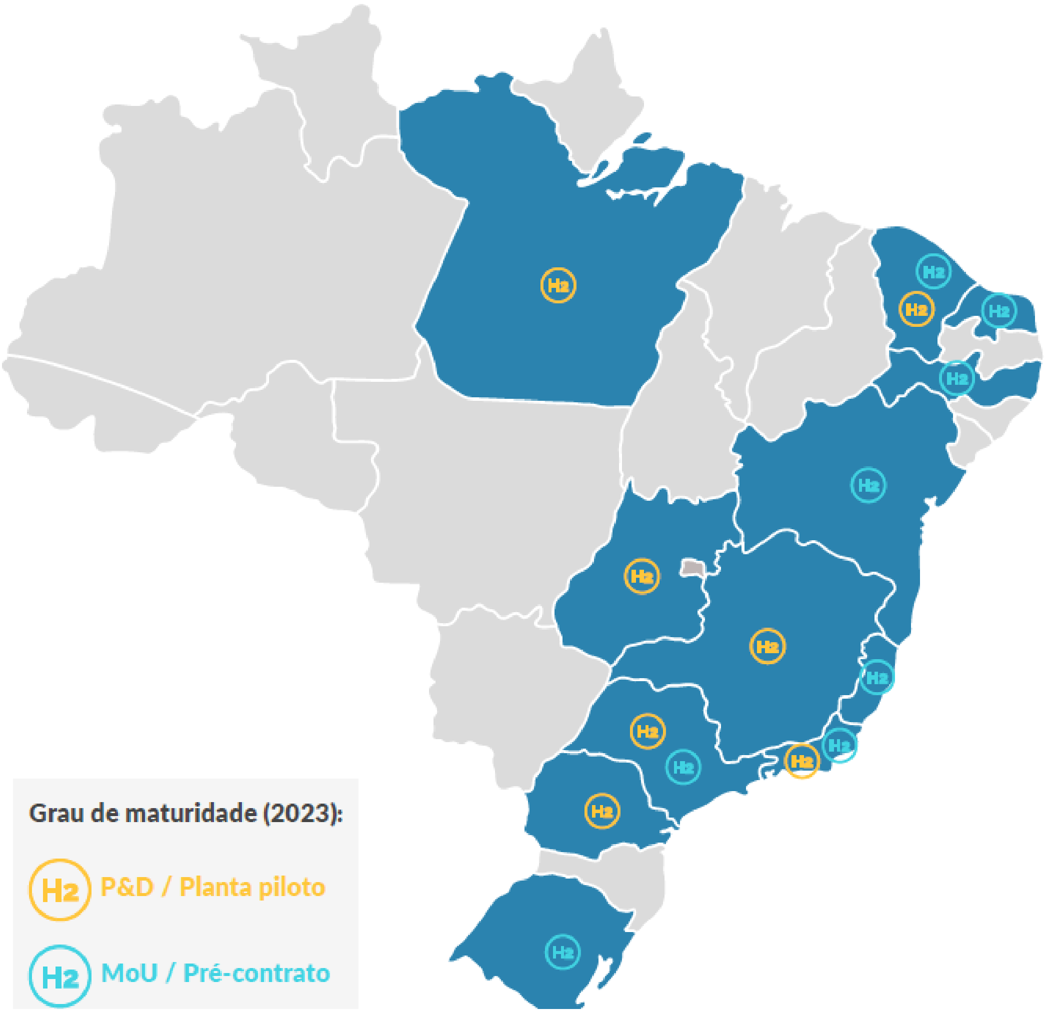


- **Projects in Latin America are likely to compete with projects in Australia, Canada, the Middle East and possibly the US for the mantle of lowest-cost provider;**
- **For delivery to key ports in Europe (Rotterdam) and Japan (Tokyo), BloombergNEF estimates projects in Brazil could by 2030 deliver the most competitive green ammonia in the world – without subsidies taken into account;**
- **Brazil ammonia delivered to Tokyo is also the most competitive globally, at $3.27/kg NH3, even with a considerably greater distance between the two ports;**
- **Much attention to date has focused on the port of Pecem in Brazil's Ceara state.**

Source: BloombergNEF. Note: Costs are in $ per kilogram of hydrogen. Ammonia contains 17.6% hydrogen by weight. Brazil exports from Pecem. Canada exports from Quebec to Rotterdam and from Vancouver to Tokyo. Chile exports from Antofagasta. US exports from Houston. UAE exports from Ruwais. Australia exports from Dampier. Colombia exports from Cartagena. Hydrogen production assumes levelized cost of hydrogen (LCOH) using western alkaline electrolyzer for each country.

ANNOUNCED HYDROGEN INVESTMENT IN BRAZIL



US$ 30 bilhões
em projetos de hidrogênio anunciados para o Brasil

O Brasil possui potencial técnico para produzir
1,8 gigatonelada
de hidrogênio por ano

Eólica offshore **350,4 Mt/ano**	Fontes fósseis **60,2 Mt/ano**
Biomassa **50,5 Mt/ano**	Nuclear **6,9 Mt/ano**

Eólica onshore + Solar + Hidrelétrica **18,1 Mt/ano**

Source: Plano de Trabalho Trienal 2023-2025, PNH2 – Ministério de Minas e Energia

COMPANIES AND INSTITUTIONS THAT HAVE ANNOUNCED HYDROGEN PROJECTS IN BRAZIL

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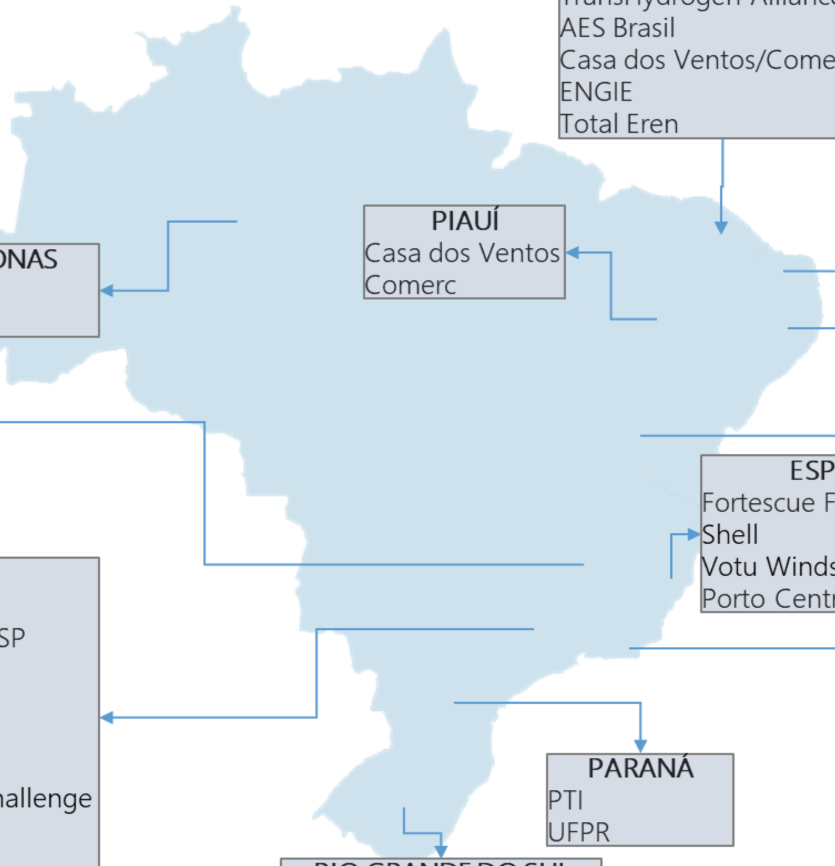
*Not an exhaustive list

- Total potencial for hydrogen production from renewables estimated in 19 Mton/H2 per year (EPE, 2023), increasing as new processes, routes and studies are developed.



CEARÁ
Pecém
EDP
Qair
Fortescue
Linde/White Martins
TransHydrogen Alliance
AES Brasil
Casa dos Ventos/Comerc
ENGIE
Total Eren

RIO GRANDE DO NORTE
Neoenergia/Iberdrola
Enterprize Energy
Nordex Acciona/Vieira
Enerfin
Voltalia

PERNAMBUCO
Suape
Qair
Neoenergia
Casa dos Ventos
Comerc

PIAUÍ
Casa dos Ventos
Comerc

AMAZONAS
SENAI
Eletronorte

BAHIA
UNIGEL
ThyssenKrupp
Nucera
Acker
Statkraft
Sowitec
Casa dos Ventos

MINAS GERAIS
Universidade Federal de Itajubá(UNIFEI)
GIZ Research Center Project
Atlas Agro

ESPÍRITO SANTO
Fortescue Future Industries
Shell
Votu Winds
Porto Central

SÃO PAULO
Repsol Sinopec Brazil
Gas Innovation Research Center USP
Cetiq Senai
Hytron / NEA
Fraunhofer
EMTU/SP
SAE Brasil & Ballard Student H2 Challenge
Raizen
YARA

RIO DE JANEIRO
Porto do Açu
Fortescue Future Industries
LINDE/White Martins
Shell
SPIC Brasil
Casa dos Ventos
Neoenergia
EDF Renewables
CSN
Coppe/UFRJ
Hydrogênio Maricá

PARANÁ
PTI
UFPR

RIO GRANDE DO SUL
LINDE/White Martin

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PORTO DE PECÉM – HUB H2V & EDP HYDROGEN INVESTMENT

pecem
COMPLEXO INDUSTRIAL E PORTUÁRIO

- **February 2021: launch of the Hydrogen Hub in the State of Ceará, Northeast of Brazil. A pioneer initiative that gathers Ceará Government, Industry Federation of Ceará (FIEC), Federal University of Ceará (UFC) and Pecém Port Complex (CIPP S/A).**

edp

- **R&D investment: R$ 42 M (EUR 7,7M)**
- **First hydrogen molecule produced in 2022**
- **3 MW solar plant**
- **250 Nm3/h hydrogen capacity**
- **Electrolyser 1,25 MW**
- **Partners:**
  - ✓ **Economic and market feasibility studies** GESEL
  - ✓ **Technical feasibility studies** IATI
  - ✓ **Electrolyser supplier** Hytron

Source: https://brasil.edp.com/pt-br/pd-pecem-h2v

CEARÁ HYDROGEN HUB’ COMPANIES

The Ceará State signed 33 MoU with companies investing in the Pécem Hydrogen Hub totaling about US$30 bi of investments

Source: OPORTUNIDADE DE TRANSFORMAÇÃO DA ECONOMIA DO CEARÁ ATRAVÉS DO HUB DE HIDROGÊNIO VERDE NO PECÉM, Estado de Ceará; https://www.ceara.gov.br/2023/10/06/governo-do-ceara-e-goverde-assinam-memorando-visando-producao-de-energia-e-amonia-verde-no-porto-do-pecem/

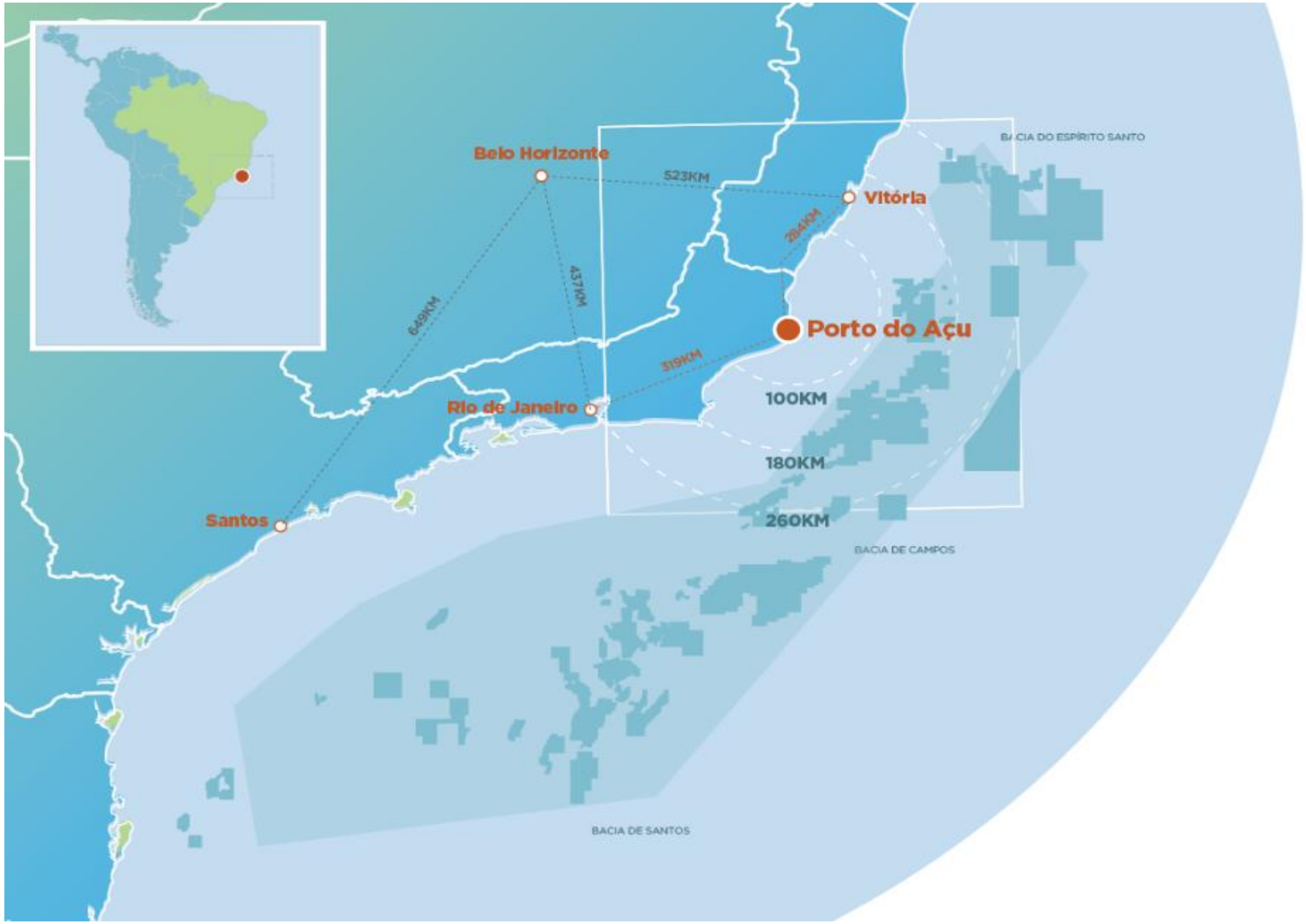
CEARÁ HYDROGEN HUB KEY COMPANIES

- **Key firms that announced investments in the Ceará hydrogen hub:**
  - **Enegix – US$ 5,4 billion investment, with an expected production of 600 million kg of green hydrogen per year;**
  - **GoVerde – US$ 3bi;**
  - **Linde/White Martins company;**
  - **EDF Renewables;**
  - **Casa dos Ventos;**
  - **Fortescue Future Industries Pty Ltd (FFI) – investment of US$ 6 billion;**
  - **Qair Brasil – investment of US$ 6.95 billion;**
  - **Transhydrogen Alliance Consortium – investment of US$ 2 billion;**
  - **AES Brasil – feasibility studies for green hydrogen production facilities, with an estimated investment of US$ 2 billion.**

- **CIPP has already signed three pre-rental contracts for the installation of Green Hydrogen industrial plants in the Export Processing Zone (ZPE). Together, the agreements will total US$8 billion by 2030. The companies are: Casa dos Ventos, Fortescue Future Industries and AES Brasil.**

Source: OPORTUNIDADE DE TRANSFORMAÇÃO DA ECONOMIA DO CEARÁ ATRAVÉS DO HUB DE HIDROGÊNIO VERDE NO PECÉM, Estado de Ceará; https://epbr.com.br/edf-renewables-analisa-construcao-de-planta-de-hidrogenio-verde-no-ceara/ ; FGV 2022; https://www.ceara.gov.br/2023/10/06/governo-do-ceara-e-goverde-assinam-memorando-visando-producao-de-energia-e-amonia-verde-no-porto-do-pecem/

PORTO DO AÇU



- **The largest private industrial port complex in Latin America;**

- **The only totally private port in Brazil, it is the result of investments totaling BRL 20 billion (EUR 3,67b), with planned investments of another BRL 22 billion (EUR 4b) over the next ten years.**

Source: https://portodoacu.com.br/en/about-port-acu/

KEY PLAYERS HAVE ALREADY JOINED AÇU PORT IN ANALYZING RENEWABLE PROJECTS

EDF renewables

Base eólica offshore

Planta de hidrogênio

Linde

Planta de hidrogênio

TotalEnergies

Base eólica offshore

SPIC

Base eólica offshore

comerc eficiência

casadosventos

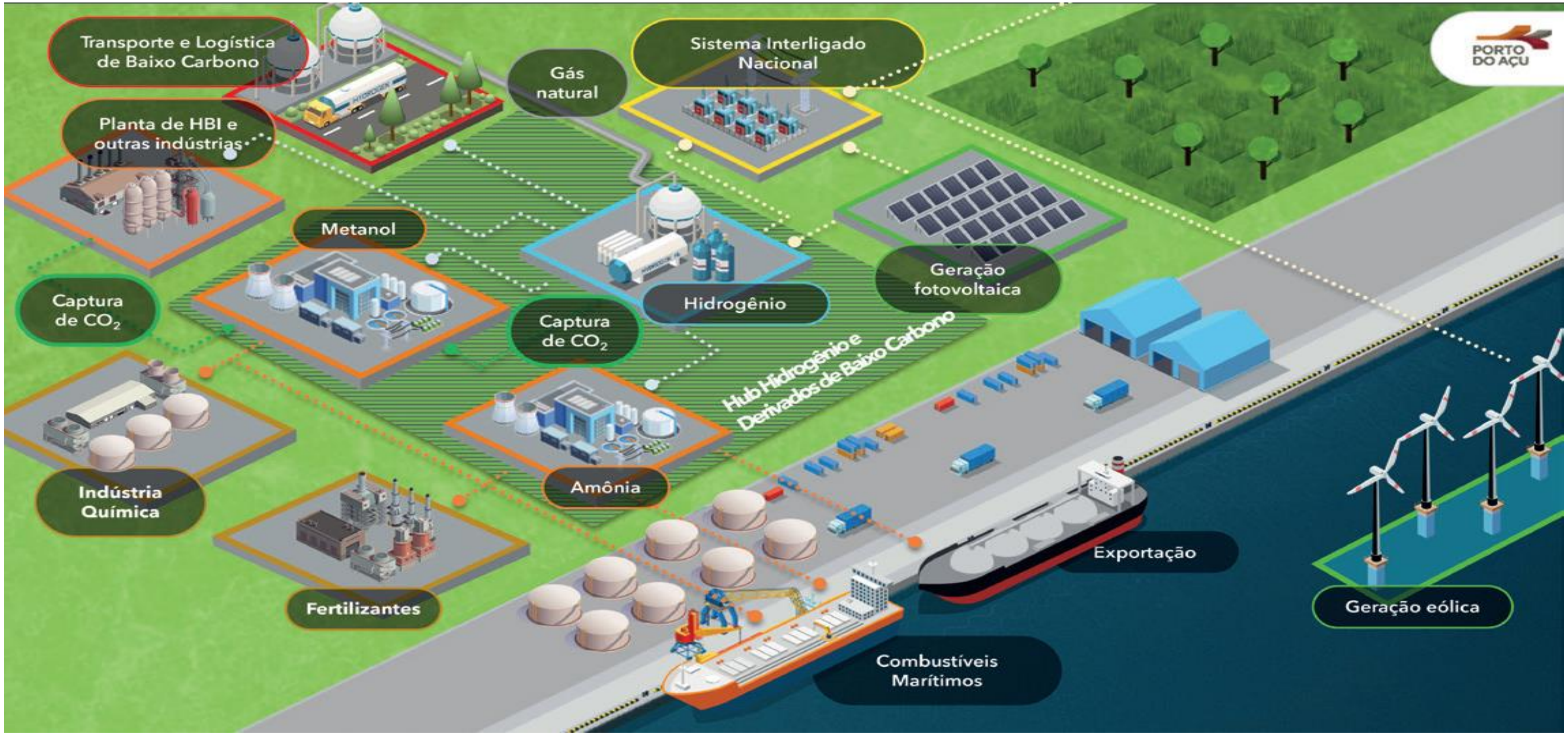
Planta de hidrogênio de larga escala (2GW)

NEOENERGIA

Base eólica offshore & planta de hidrogênio

HYDROGEN AND LOW CARBON DERIVATIVES AÇU HUB

- **Port of Açu is under environmental licensing process of a 100ha hydrogen hub up to 4GW of electrolysis**
- **Total investment of EUR 7,4bi (BRL 40bi)**



Source: Relatório de Impacto Ambiental Hub de Hidrogênio e Derivados de Baixo Carbono do Porto do Açu

HYDROGEN AND LOW CARBON DERIVATIVES AÇU HUB

The HUB's modular development model will allow the implementation of industrial units in a sequential manner as commercial demands are confirmed, ensuring uniformity of controls and safety measures mitigation aiming for better environmental performance. The HUB development is divided into four macro phases:

Description	Installed capacity of electrolyzers - MW	Hydrogen from electrolysis (renewable) - kton/year	Low carbon hydrogen (UGHs) - kton/year	Ammonia – kton/year	Methanol – kton/year
Phase 1	100	15,1	-	-	-
Phase 2	480	72,5	21,4	194	60
Phase 3	2.000	302,2	42,8	600	210
Phase 4	3.700	561,8	-	1.900	313,6

Source: Relatório de Impacto Ambiental Hub de Hidrogênio e Derivados de Baixo Carbono do Porto do Açu

ESTADO DE PIAUI – ZPE PARNAÍBA (PI)

- **Export Processing Zones are industrial districts where firms operates with fiscal benefit, freedom of exchange and simplified administrative procedures;**
- **Located on the coast of Piauí, ZPE Parnaíba occupies an area of 313.5 hectares.**

Announced low carbon hydrogen: R$ 50 b (EUR 9,1b).

Key Firms:

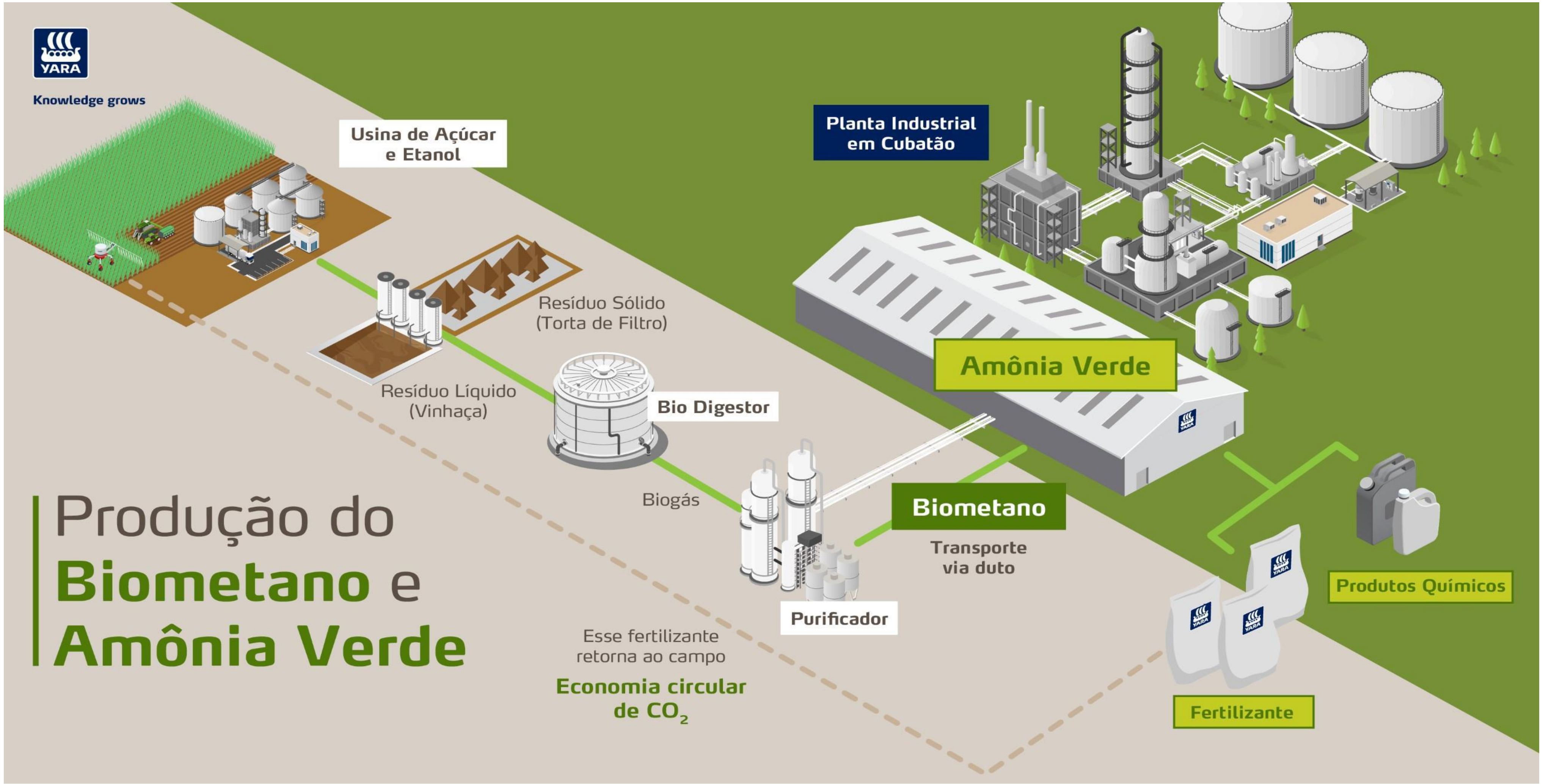
- **Solatio Energia (Spanish solar developer) combined investment of about BRL 30 billion (EUR 5.6bn) for electrolyser capacity of nearly 2.4GW.**

- **Solar Outdoor Media (Germany) billion investment. Plant with an installed capacity of 940 MW, potentially reaching 3 GW.**

Source: https://investepiaui.com/hidrogenio-verde/ ; https://antigo.pi.gov.br/noticias/investimento-em-hidrogenio-verde-no-piaui-sera-cinco-vezes-o-valor-que-uniao-europeia-anunciou-para-o-brasil/ ; https://canalsolar.com.br/piaui-produzira-hidrogenio-verde-com-usina-de-energia-solar/ ; https://epbr.com.br/piaui-mira-exportacao-de-amonia-verde/

YARA

Announced in 2021, biomethane supply contract with Raízen is the first step towards producing renewable ammonia, from 2024 (20k m³/d - 3% of demand from Cubatão, delivered by the network)



Source: Yara Brasil Produção de fertilizantes e o hidrogênio 05/09/2023

THANK YOU!

Marco Contardi
Senior Project Manager
Sustainability and Urban Development
E-mail: marco.contardi@eu.fgv.br