Capstone Project
IAHE - Green Hydrogen Policy Observatory
Business Case and Policy Recommendations

Sciences Po - PSIA

Master in Advanced Global Studies (2022/2023)

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Capstone Overview

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Green Hydrogen Policy Observatory of the International Association for Hydrogen Energy (IAHE)

- Understand the G2B and B2G dynamics by developing case studies on key stakeholders in large-scale green hydrogen businesses and policies, aiming to provide actionable recommendations to policymakers in countries with green hydrogen potential but without a national hydrogen strategy.

  (1) The Kingdom of Denmark - Plug Power
  (2) The Federal Republic of Germany - Enapter A.G.
  (3) The Kingdom of Morocco - CWP Global
  (4) Australia - InterContinental Energy

November	January-March	February-March	April-May	May
Kick-off meeting	**Research**	**First Draft**	**Final Decks**	**Policy Manifest**
Held to establish scope, align expectations, and understand the consultancy problem to solve.	Literature review of hydrogen regulations, policies, and strategies in the selected countries. Large-scale projects and stakeholders identified.	First document that collated the reviewed information for each country. First deck draft sent to our academic advisor for review.	Consultancy questions, analysis, and narrative established for ensuring coherence across case studies.	*Do's and Don'ts* for GH2 policy making based on lessons learned from case studies.

Weekly Meetings

II Green Hydrogen (GH2): An Overview

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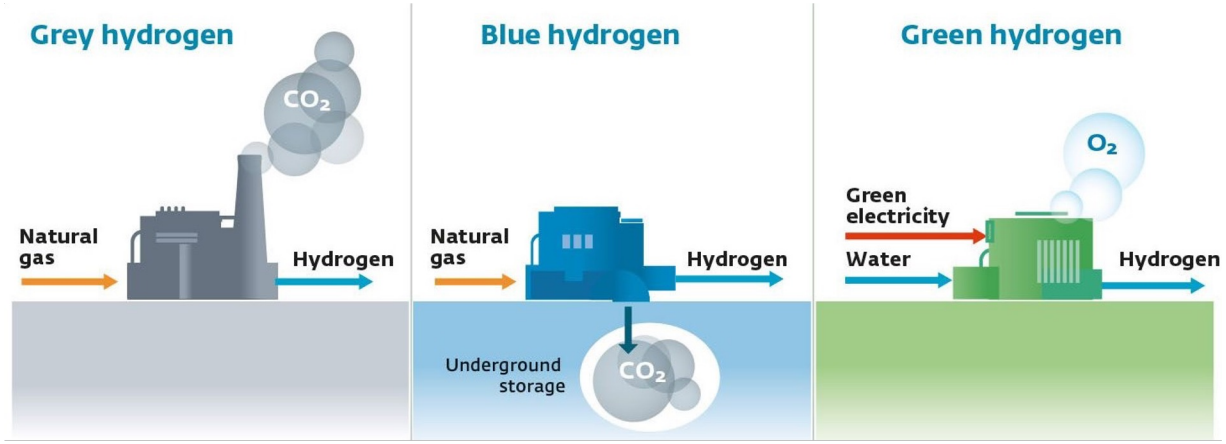
Green Hydrogen: Decarbonization Potential

Sources of Hydrogen

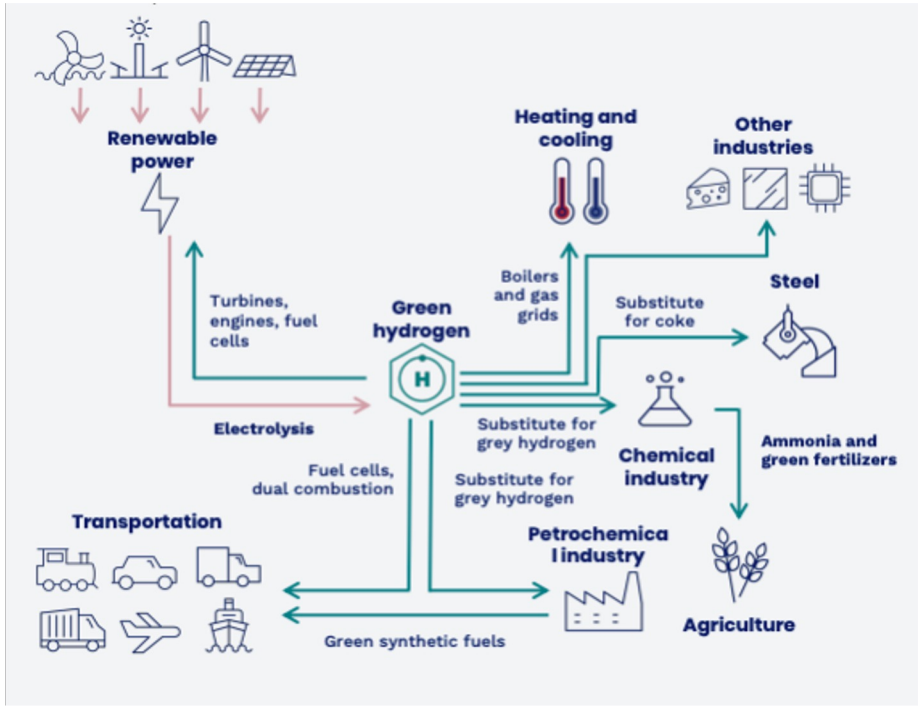


$0.7-1.6/kg **$1.2-2.1/kg** **$3.2-7.7/kg**

Source: The World of Hydrogen, IEA

- Hydrogen (H2), the simplest and most abundant element in the universe, is used as an energy carrier and has the potential to contribute to achieving the Net Zero Emissions Scenario by 2050 (IEA, 2022).
- “Green" hydrogen refers to a clean energy vector produced using renewable energies through electrolysis process, emitting only water steam. It is expected to become more competitive than other forms by 2050 (IEA, 2022).

Decarbonization Potential of Green Hydrogen



Source: Chile’ National Green Hydrogen Strategy

- Green Hydrogen (GH2) and its derivatives play a central role in addressing climate change and achieving net zero targets, particularly in hard-to-decarbonize sectors like industry and long-distance transport. The current production of low-emission hydrogen is around 0.6 Mt, less than 1% of global hydrogen production (IEA, 2022).

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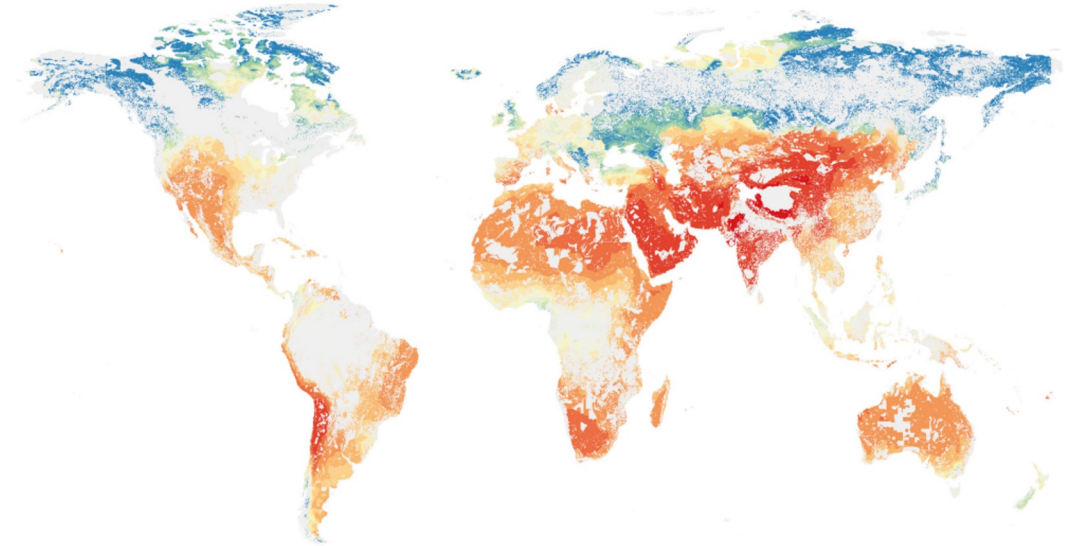
Green Hydrogen: Global Market Perspective

Countries with a Green Hydrogen Potential

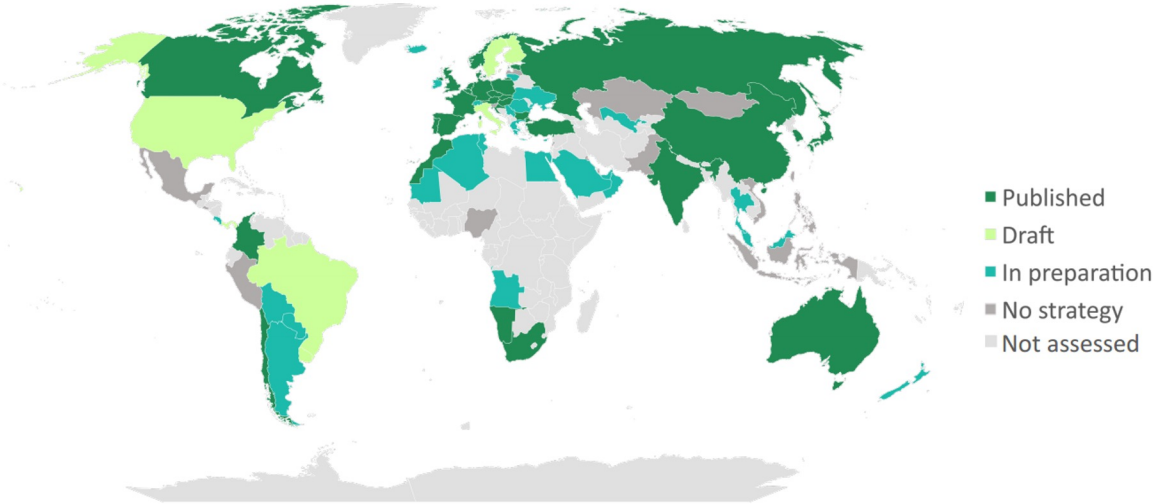


Source: Global Hydrogen Review 2022. IEA.

33 countries have published a national hydrogen strategy

Hydrogen Europe

Data as of 09/05/2023



Source: Hydrogen Europe

- The global GH2 market is expected to reach 400+ million tons by 2050 (IRENA, 2022).
- The GH2 economy has significant potential and expected to make up 18% of global energy demand by 2050 (Hydrogen Council, 2017), generating 30 million jobs, and creating USD 2.5 trillion in annual revenue worldwide (CIC Energigune, 2023).
- 33 countries, accounting for over 90% of the world's GDP, have developed strategies for expanding hydrogen use (Hydrogen Europe, 2023).

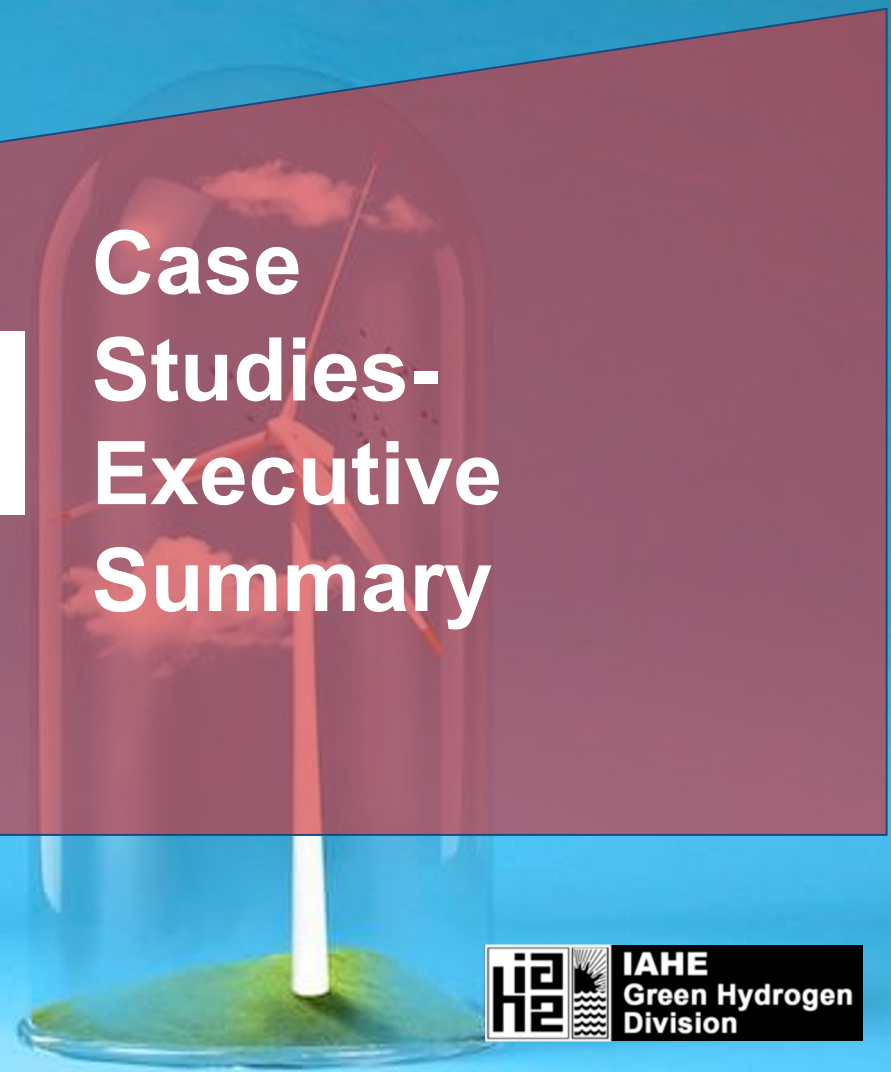
1. What is the stated objective of the country in question with respect to GH2?

2. What political and regulatory responses did the country have in order to achieve the stated objective? How did the private sector influence the development of these responses?

3. How did the private sector respond to the initiatives put forth by the country?

4. What does the company in question do? In developing a large-scale GH2 project, what factors motivated the company in question to choose the country?

II Case Studies- Executive Summary



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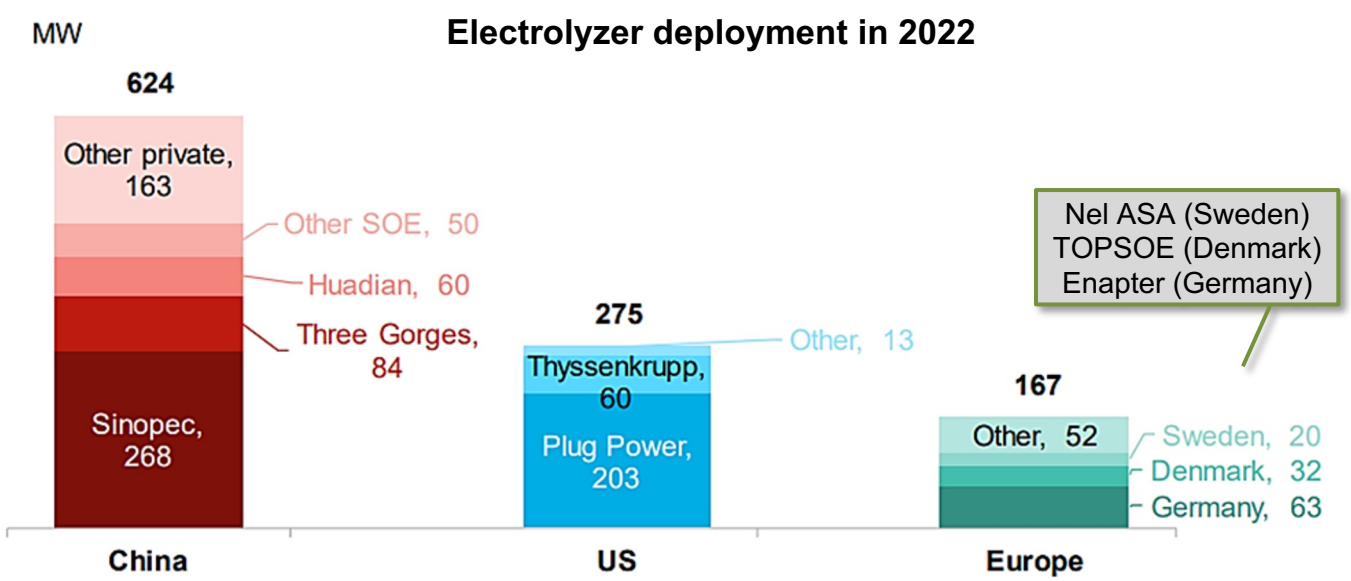
Case Studies Snapshot

- The global H2 market consists of seven major countries and regions that vary in policies, access to cheaper renewable energy, and local industry
- Europe has the potential to be a competitive region in hydrogen production and consumption, but is expected to rely on imports from outside of Europe. This ambition is supported by a strong policy framework, especially higher carbon price, and matured local industry. Denmark and Germany are adjacent European countries that lead in the field of electrolyzers production in Europe. The following case studies deal with a mature American electrolyzer manufacturer (Plug Power) in Denmark and a German early-stage manufacturer (Enapter) in Germany.
- In the third case, Morocco's development of hydrogen hubs is studied through the lens of access to cheaper renewable energy and key export markets such as Europe.
- The last Australian case is similar to Morocco. Australia is developing numerous regional hydrogen hubs and aims to export H2 to East Asia.

#	Countries / Regions	Features	Production	Consumption
1	China	Dominant supplier of VRE and Electrolyzers	High	High
2	US	Great attractor with IRA (preferential tax)	High	High
3	EU	Regulatory leader	Middle	High
4	Middle East and Africa	H2 supplier	High	Low
5	Australia	H2 supplier	High	High
6	East Asia	H2 consumer	Low	High
7	South America	H2 supplier	High	Middle



Source: BloombergNEF 2022.

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European Policy Landscape

2017 - 2019

RED2
Clean Energy Package

32% RES

2020

EU Green Deal
Hydrogen Strategy

2x40 GW; 1 Mt by 2024, 10 Mt of renewable hydrogen by 2030

2021

Fit for 55 package

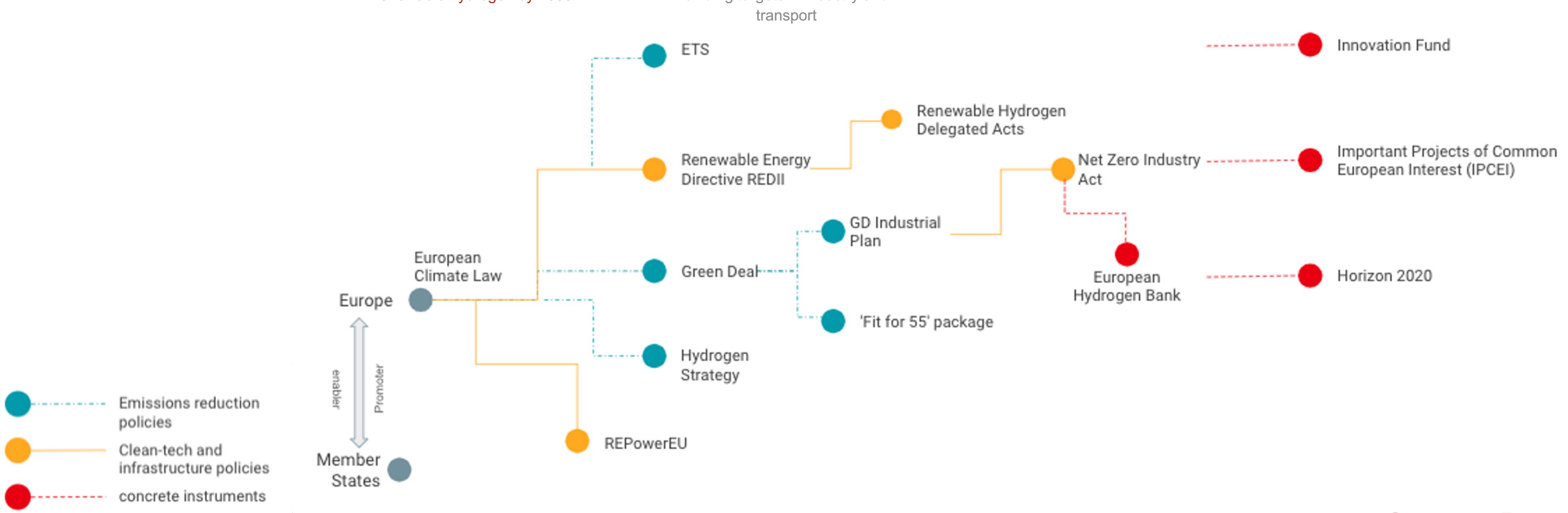
55% GHG, 40% RES, RFNBO's binding targets in industry and transport

2022

RePowerEU
Innovation Fund

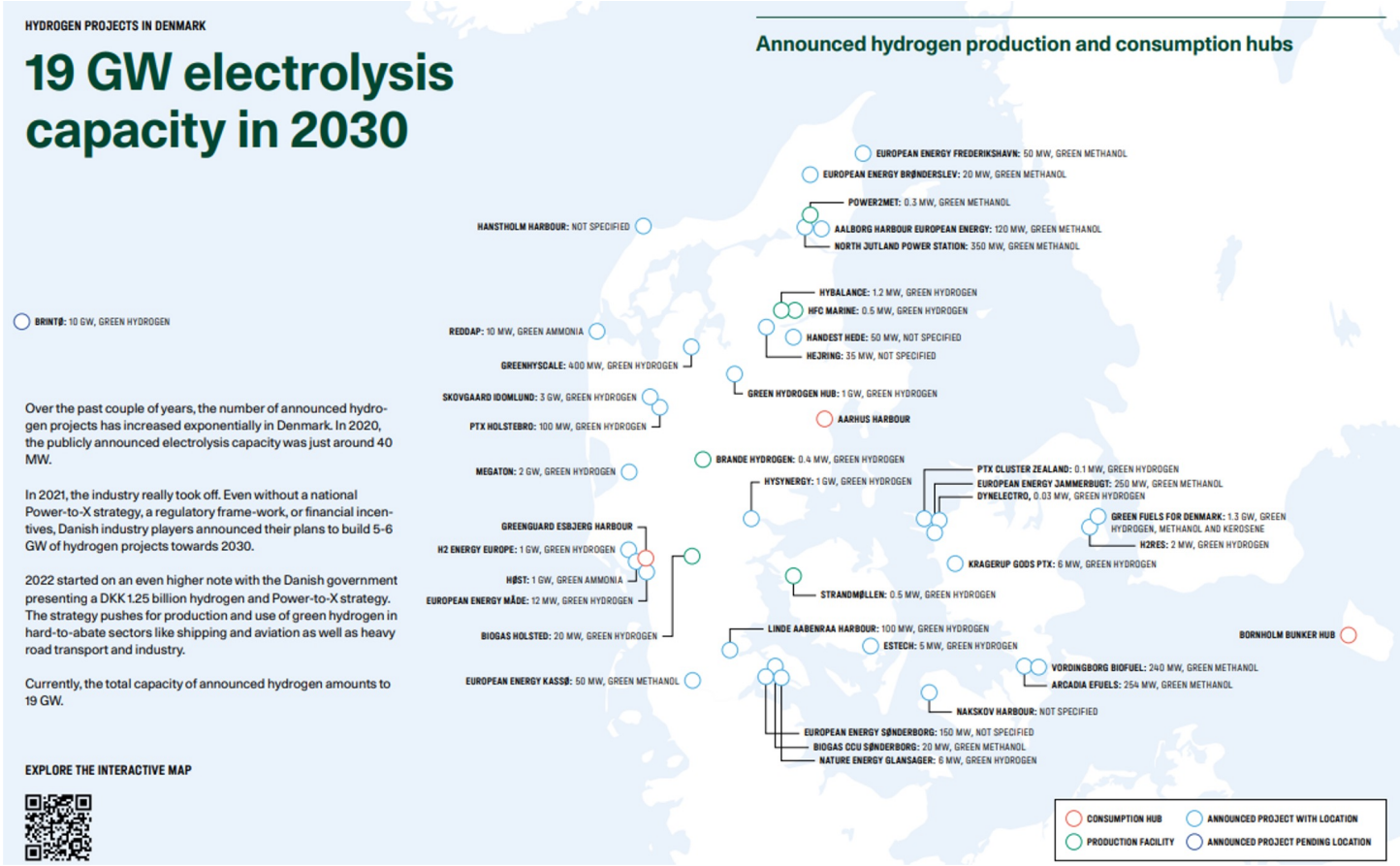
2023

Renewable Hydrogen acts
Critical Raw Materials Act
Net Zero Industry Act
H2Bank



Source: Authors' illustration

Case Study I: Denmark, H2 Energy and Plug Power



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Country Stated Objective

- Utilise Denmark's large wind resources to **align with the Danish Climate Act** (2020) to reduce GHG emissions by 70% by 2030 and achieve carbon neutrality by 2050
- GH2 and GH2 products key in sectors **where direct electrification has limited scope** (aviation, shipping, heavy transport, certain industry sectors)
- GH2 products to **compete on market terms** against fossil fuels, biofuels and foreign GH2 products in the long run with minimal external support
- Requisite raw materials, upstream and downstream infrastructure and financing to be secured to create an **export-led** market
- Raw materials as well as end products to be **adequately certified**

Political and Regulatory Responses

- Increase offshore wind (islands) and solar generation capacity and expand scope of distribution and transmission companies (Energinet, Evida)
- Establish differentiated, favourable electricity tariff systems to incentivize electrolysis close to power generation
- Build 4 to 6 GW electrolysis capacity by 2030 and promote the development and scaling of GH2 technologies
- Together with the EU, build common pipeline and storage infrastructure to provide flexibility and to access export markets
- Create EU-wide regulatory framework to promote demand for GH2 products (ReFuelEU Aviation, FuelEU Maritime, Agreement on Green Transition for Road Transport) and utilise surplus process heat in district heating
- Provide significant financial aid (~EUR 170 mn) through grants, subsidies, etc.

Private Sector Influence and Response

- Denmark boasts of over 70 companies within the hydrogen and CCUS value chain working on project development, R&D, consulting, production, etc.
- Active dialogue with the State and EU through State of Green (a public-private partnership between the Danish state and three leading Danish business associations), Hydrogen Europe and other industry associations
- As of 2022, private sector announced over 40 projects worth 19 GW of electrolysis capacity by 2030, including Europe's largest electrolyser plant. This is significantly higher than the national ambitions and includes other value chain projects such as green ammonia, methanol, kerosene etc.

STATE OF GREEN

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
Invest in Denmark

Hydrogen Europe

Company: Profile and Motivations

H2energy plug

- Plug Power, Inc is a US-based fuel cells, electrolyzer and liquifiers manufacturer along with H2 Energy, another key player in the GH2 value chain is building a 1GW electrolyzer plant in Esbjerg, Denmark
- The plant is expected to produce 100,000 MT of GH2 / year, equivalent to the fuel need of 15,000 heavy-duty trucks per day
- Entered into a JV with Hyundai to deliver hydrogen-based fleet and with Phillips 66 to build 250 hydrogen filling stations across Denmark, Austria and Germany
- Key factors for choosing the Esbjerg, Denmark include: (i) ideal geographic conditions (proximity to offshore wind, Germany's industrial cluster and pipeline development); (ii) Denmark's clear and stated ambition to expand offshore wind; (iii) Denmark's strong political support, transparency, approval efficiency and export ambitions; and (iv) "Invest in Denmark"'s continued support to H2 Energy on infrastructure, regulations and technical support

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Case Study II: Germany and Enapter A.G.

Enapter

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Country Stated Objective

◉ **Political profile:** Germany, a Federal Parliamentary Republic with 16 states (Länder), has a population of 84.3 million. It boasts a low corruption rate, a stable social economy, and a culture of innovation.

◉ **Climate-oriented government:** prioritized domestic climate policies, with renewables accounting for 45% of electricity generation in 2022.

◉ **GH2 Aim:** Germany aims to become the leading exporter of hydrogen technology across the entire green hydrogen supply chain.

◉ **GH2 Targets** 2GW electrolyser capacity by 2030, 5GW by 2050, and 10GW hydrogen production between 2030-2040 (domestic production+imports).

Key Figures *Source: Enerdata, 2022*

- Population: 83.4 million
- GDP: USD $4.479 trillion
- GDP growth rate: 2.89 %/year
- Energy independence: 35.3%
- 1º EU's largest economy and 4º worldwide

Political and Regulatory Responses

◉ **Early adopter:** First Member State to adopt a National Hydrogen Strategy (2020).

◉ **Innovation culture:** Create instruments to reduce initial risk, test prototypes, and promote the development of new technologies, such as, Regulatory Sandboxes, NIP, H2Giga and H2Global. Promote national and international consortiums (G2B and G2G) through energy alliances such as Clean Energy Partnership (CEP) and International Energy Partnerships (+30).

◉ **Corporatist approach:** The Federal Government holds primary responsibility for establishing energy policy legislation, while the Länder play a crucial role in shaping and implementing these policies.

Private Sector Influence and Response

◉ **Influence response:** Firms engage with governments to express their needs and influence regulatory responses, which encompass attractive programs addressing market failures (e.g. H2Global), a clear regulatory framework, and a stable environment for successful ventures.

◉ **Like-minded ecosystem**: Germany's innovation ecosystem and emphasis on clean energy created a perfect fit for Enapter, driving technological advancement and market demand.

Enapter

Company: Profile and Motivations

◉ **German Startup:** Enapter AG is a German energy technology company that specializes in manufacturing patented Anion Exchange Membrane (AEM) electrolysers.

◉ **Unique technology:** AEM electrolysers offer significant cost advantages, being 75% less expensive than PEM or Alkaline technologies. They are modular in design and produce high-purity hydrogen at a level of 99.9%.

◉ **Enapter Campus:** Currently has 7 major projects in progress, with the Enapter Campus in Saerbeck being the flagship. This renowned facility secured €14.9 million in government funding to produce over 100,000 high-efficiency AEM electrolyser modules per year and collaborate on technology development with Münster University.

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Case Study III: Morocco and CWP Global

CWP GLOBAL

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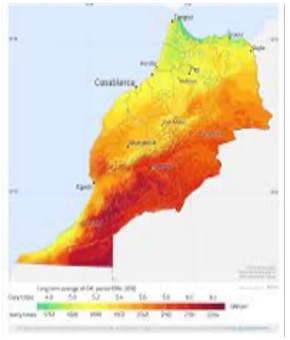
Country Stated Objective

- In recent years, **the Kingdom of Morocco has taken steps to position itself as a global leader in the clean energy transition**: it aspires to have 52% of installed electric power capacity using renewables by 2030. The country is rich in renewable resources.
- Morocco aims to **leverage its extensive renewables potential** to become a key exporter of GH2 to Europe to support decarbonization efforts, while exports via pipeline are expected from 2035 onwards.
- **Improve energy security and reduce import dependence**: Morocco is a major fertilizer producer and imports 1.5-2mn t/yr of ammonia which could be replaced by domestic green hydrogen production.



Political and Regulatory Responses

- **Morocco published a national hydrogen strategy in January 2021 i**n line with its country objectives to harness renewables potential for decarbonization goals and to increase energy security.
- The **King has final authority over key energy policy legislation.** Main state actors include Moroccan Agency for Sustainable Energy (MASEN) and Moroccan Ministry of Energy, Mines, and Sustainable Development (MEMDD).
- The country has been **active in establishing geopolitical alliances and preliminary offtake agreements** with potential importing countries: Portugal and Morocco signed an MOU in 2021; Morocco-Germany Energy Alliance established in 2020; several free trade agreements but most significantly with the EU.

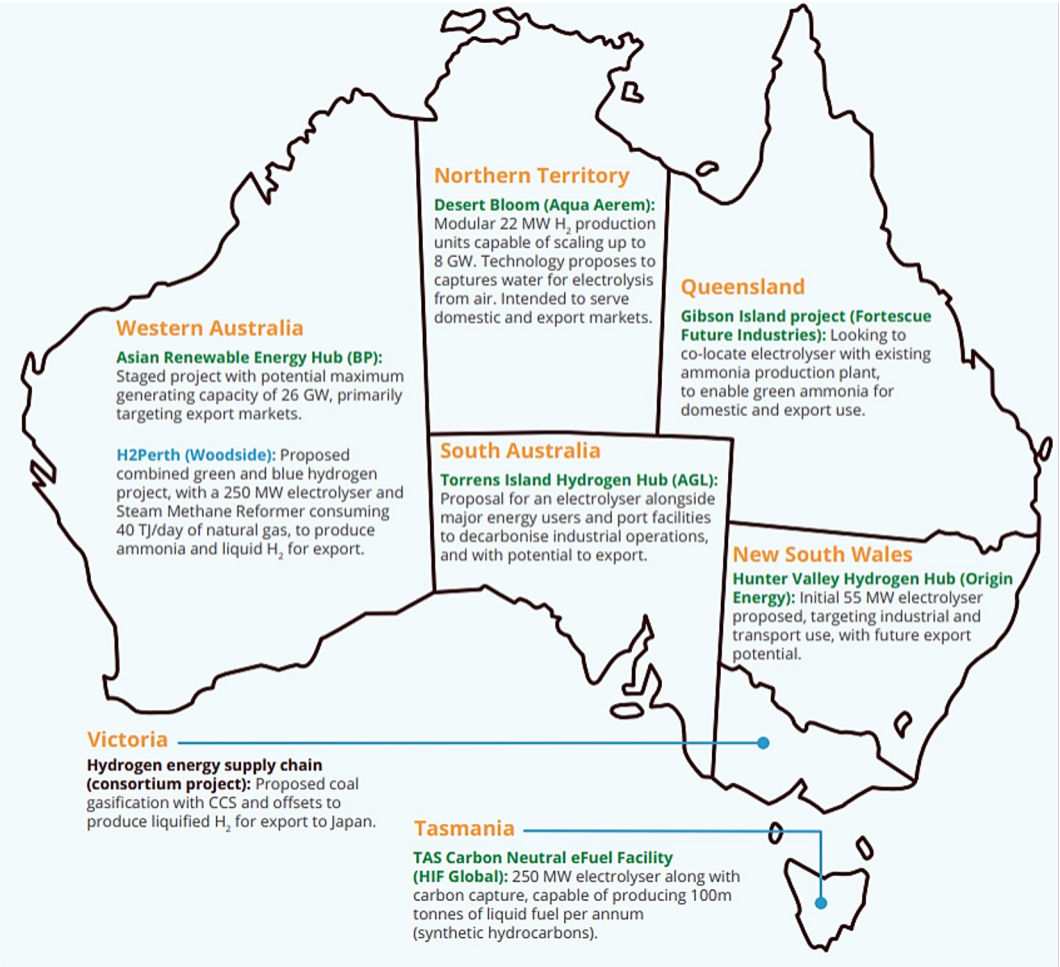
Private Sector Influence and Response

- **Private sector influence is more limited in scope**; the Kingdom of Morocco directs and encourages most private sector investment through high green hydrogen production potential, low regulatory barriers and limited directives through its national strategy.
- **Firms engage with key government ministries and largely state-owned industry stakeholders**, such as fertilizer giant OCP.
- CWP Global **undertook 2 year survey** of planned site in collaboration with Moroccan officials and relevant industry stakeholders.
- Most private sector hydrogen projects are in the early or demonstration phase.

Company: Profile and Motivations

- **CWP Global develops large-scale renewables** and hydrogen energy projects around the world, and one of the global pioneers of ultra-large scale green hydrogen hubs with 170+GW under development.
- The AMUN project in Tan Tan, Morocco is the country's first large-scale green hydrogen project initiated in 2019 with installed **15 GW capacity wind and solar**. Designed in three phases, it is expected to provide Morocco with the first million tons of green hydrogen and ammonia by 2028.
- CWP has partnered with Hydrogenious LOHC Technologies to **explore transporting 500t/day of green hydrogen directly to Europe as a feasibility study** (4 May 2023).

Case Study IV: Australia and InterContinental Energy



InterContinental Energy

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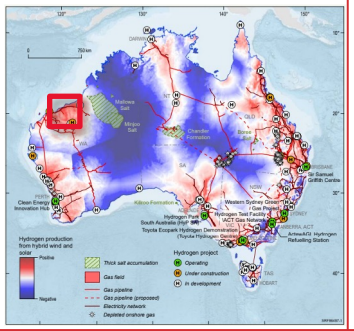
Country Stated Objective

- Australia is one of the most ideal area for the production of green H2 due to its massive land, high-quality wind, solar and hydro resources, domestic demand for hydrogen, and infrastructure (pipelines and ports), and aims to be a major global player in production and export by 2030
- A revised version of the national strategy is to be published in 2023 in accordance with the hydrogen market shift since 2019



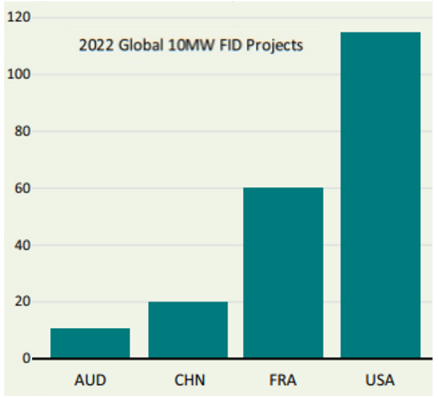
Political and Regulatory Responses

- Primal components of the national strategy (2019) are Regional H2 Hubs, where cross-sectoral actors are co-located, and Partnerships with high-H2-demand countries
- Financial support of AU$ 41.4 billion (€25 billion) for ca. 100 projects is an integral part of the H2-preferential policies

Totals (as of Jan 2023)	Number of PJ	H2 specific (AU$Billion)	H2 eligible (AU$Billion)	Combined (AU$Billion)
Commonwealth	36	1.6	27.1	28.6
States &Territories	72	4.7	8.1	12.8
Total	108	6.3	35.2	41.4

Private Sector Influence and Response

- Australia has a total of 106 (as of Dec 2022) active projects, but only ten are operating, 12 are under construction, and the rest haven't passed FID (final investment decision)
- The government recognizes that its industrial development is advancing but falls behind the other countries not only in investment but also in other perspectives, such as cost-competitiveness, transport, electricity generation, or local H2 consumption
- Prior to the national and regional H2 strategy in 2019, InterContinental Energy had an interaction with the Australian government proposing a project with 6GW renewable energy and exporting power cable to Singapore and Indonesia, when it was established in Singapore in 2014



Company: Profile and Motivations

- InterContinental Energy, founded in Singapore in 2014, is a developer pioneering large-scale green fuel hubs.
- The Australian Renewable Energy Hub (AREH) project proposes construct and operate a large-scale wind and solar hybrid renewable energy facility, developed in phases up to 26GW of renewable energy and 1.6Mt of H2 production
- Project acknowledgments from the governments and the Regional Hydrogen Hub scheme have been a tailwind for the project. However, time-consuming administrative procedures, particularly environmental assessment, have been a challenge, and the rejection of the referral in 2021 highlighted the discrepancies between the Commonwealth and State governments

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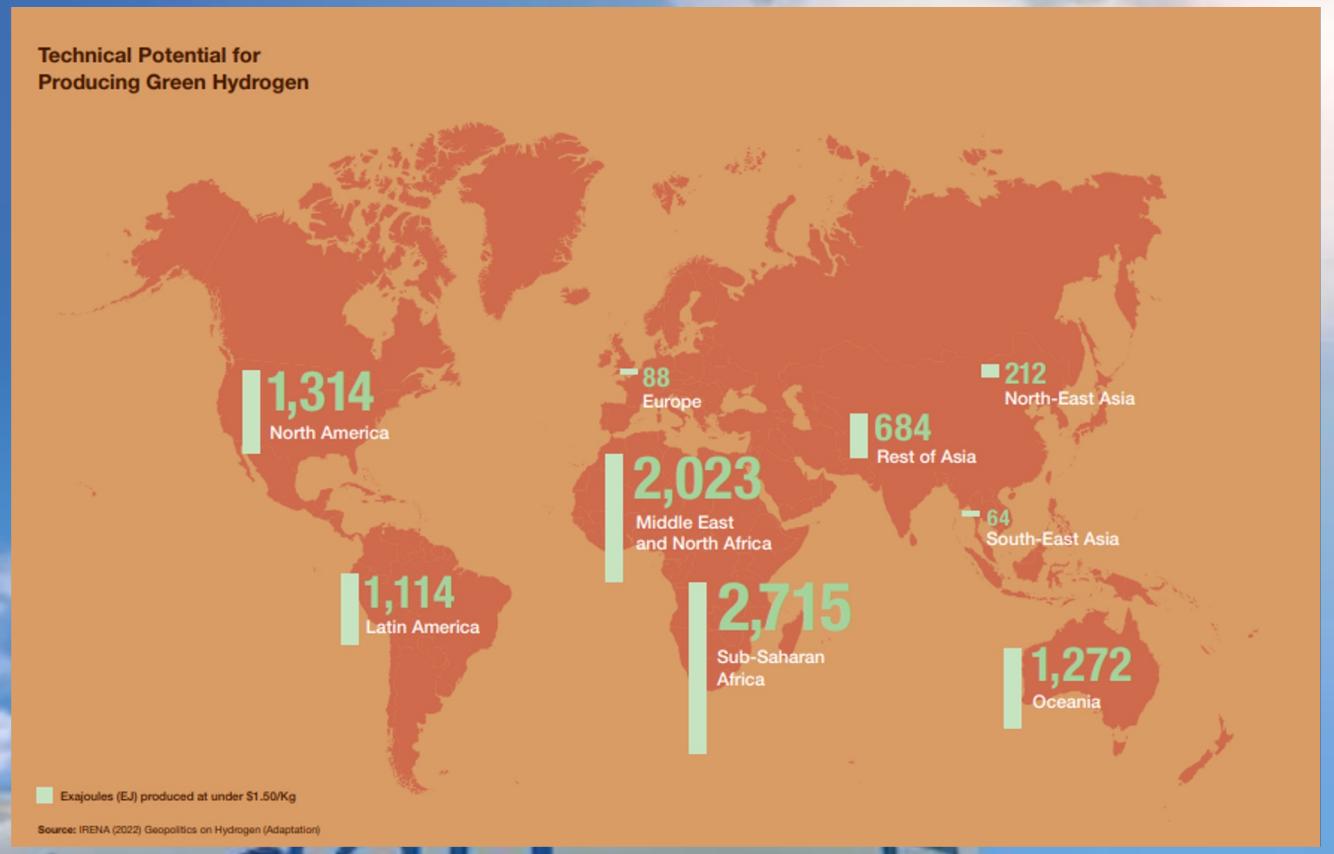
IV Policy recommendations

For countries with GH2 potential, but no policy framework yet



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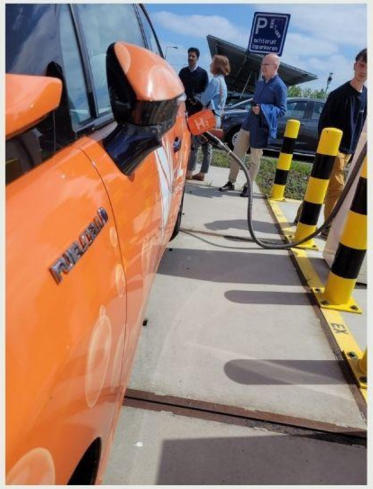
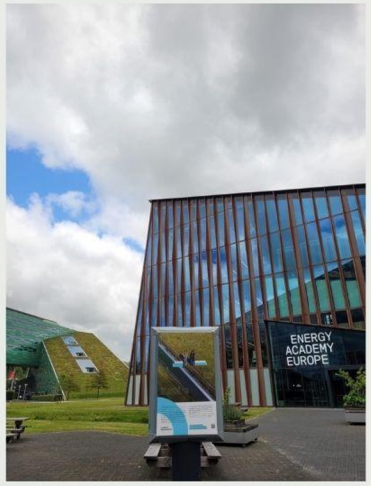
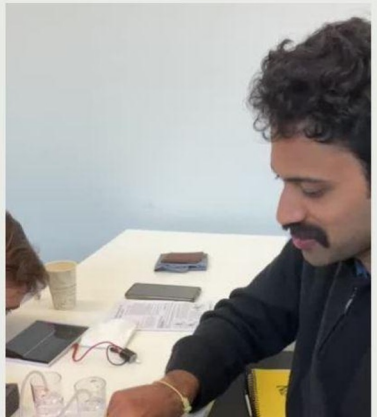
Policy recommendations to facilitate the large-scale green hydrogen project

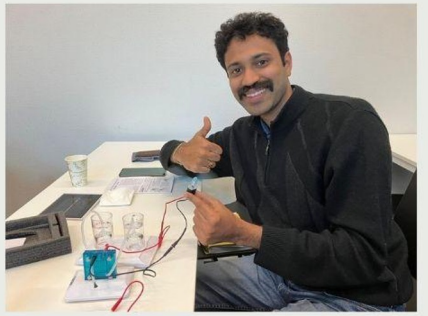
	The Do's	The Don't's
Government to Business	◉**Political risk mitigation:** Send clear political signal through robust, coherent and sustainable green hydrogen objective and policy framework as well as quantifiable and feasible targets and standards ◉**Market risk mitigation:** Create appropriate financial (e.g., preferential financing, taxation, electricity tariffs, etc.) and non-financial incentives (capacity building, value-chain partnerships) to engage relevant value chain actors ◉**Operational risk mitigation:** Transparent and reliable permits and licensing system, grid-access mechanism, land and water use regulations, product certification, additionality, social license to operate ◉**Financing risk mitigation:** Create favourable investment regulatory frameworks to attract the much-needed financing from financial institutions, development banks, etc. given the capital-intensive nature of GH2 ◉**Create markets:** Activate demand through regulation, financial and non-financial incentives, local and global trade partnerships	◉**Technology risk:** Refrain from creating discriminatory technology policies to avoid path dependency and risk of stranded assets ◉**Inadequate objective and policy:** Not setting clear objectives and targets and/or failing to ensure to address each critical part of the value chain with detailed action plan ◉**Bureaucracy:** Avoid complex and unclear operational mechanisms with respect to assessments, licenses, grants, incentives, etc. and an uncoordinated governance processes ◉**Market:** Avoid the alienation of affected industries and stakeholders to prevent disengagement and unintended consequences
Business to Government	◉**Proactive interaction:** With the Federal and regional governments directly or indirectly (through lobby groups, trade associations, etc.) to (i) provide practical technological, economic and operational perspectives; and (ii) to influence policymaking for risk mitigation ◉**Demonstration projects:** Develop and complete demonstration projects to gain operational experience at an early stage ◉**Eligibility and compliance:** Prepare robust and clear business plan to ensure eligibility and compliance with Government schemes and programs	

Trip to HEAVENN

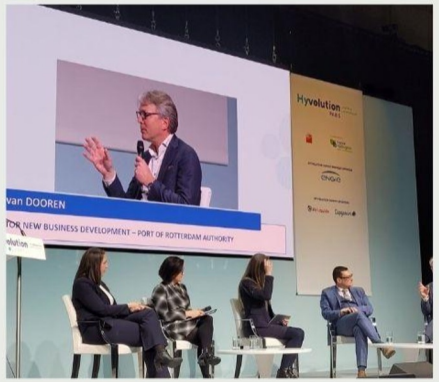








Hyvolution Paris and WHS 2023



V Appendix
Case Studies Deck

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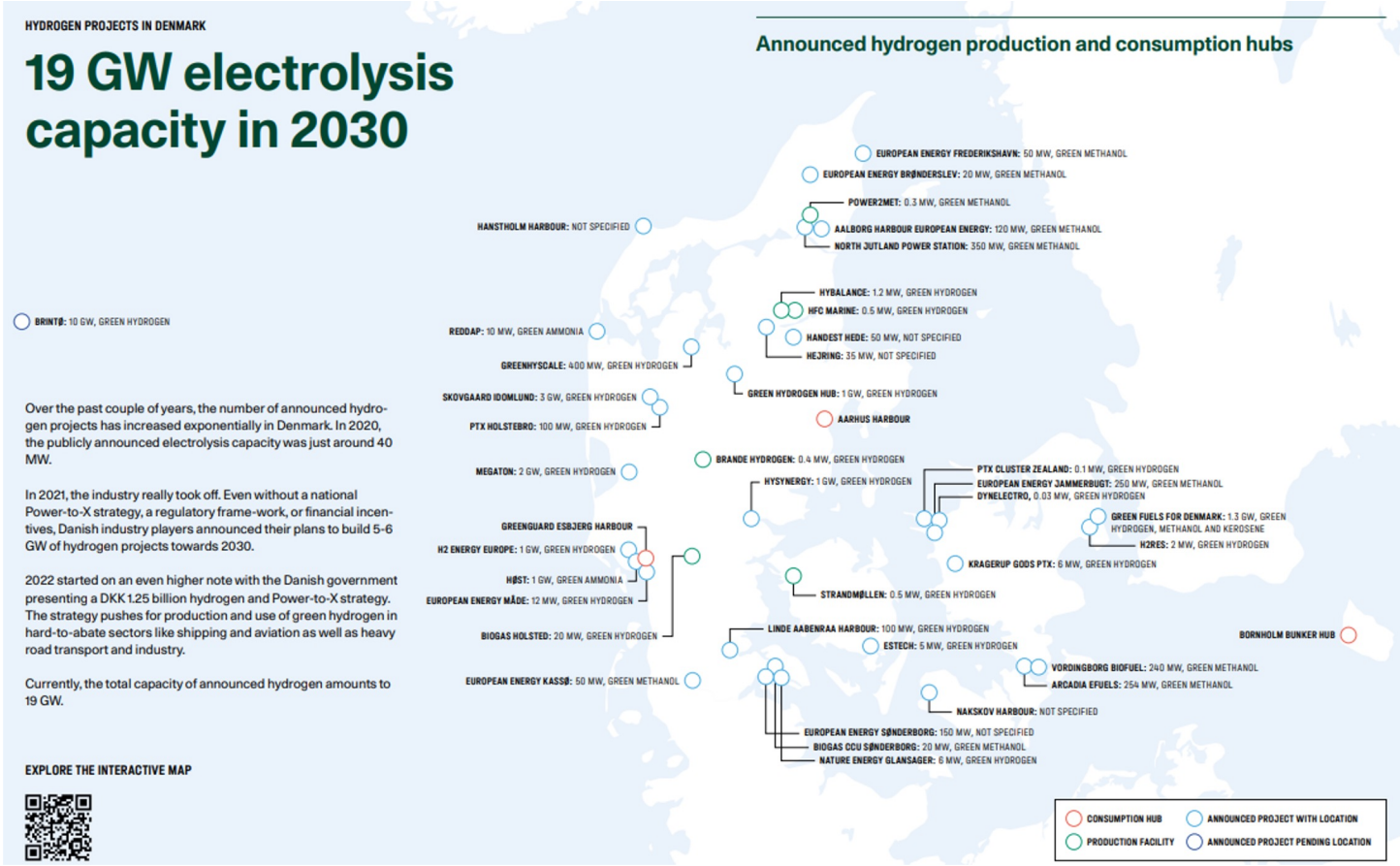
Case Study I: Denmark, H2 Energy and Plug Power



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European Policy Landscape

RED2+ Clean Energy Package

Hydrogen Strategy

2x40 GW; 1 Mt by 2024, 10 Mt of renewable hydrogen by 2030)

Fit for 55 package

55% GHG, 40% RES, RFNBO binding targets in industry and transport

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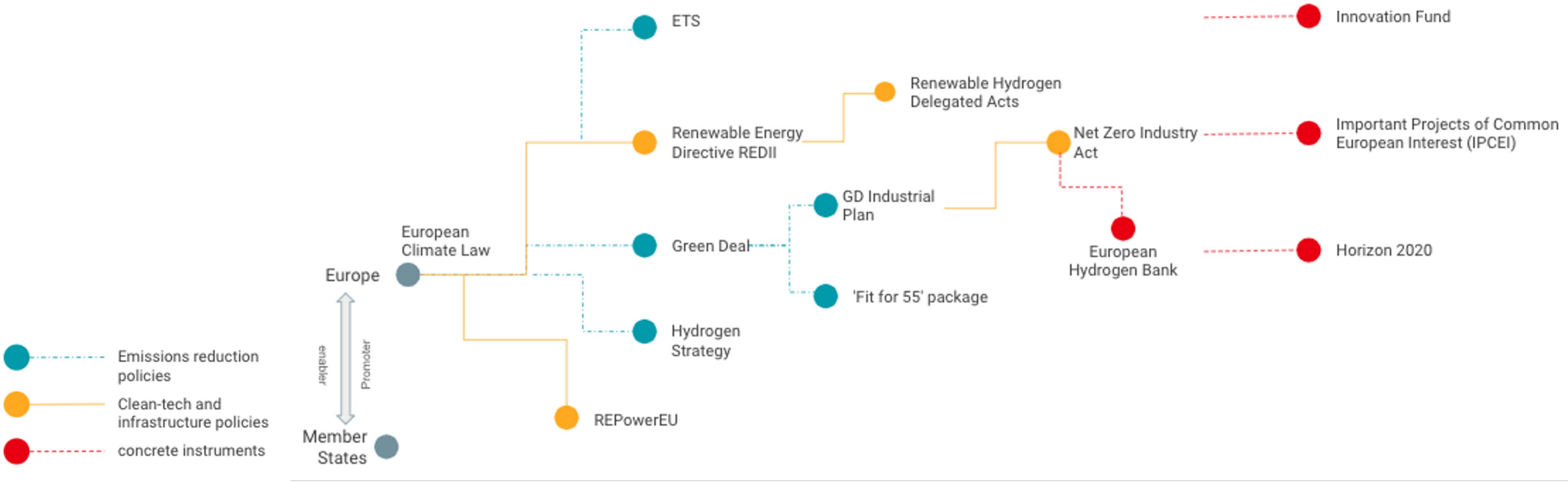


Source: Authors' illustration

Denmark: Country Profile

- Denmark is a rich, modernised, urban country with a large coastline, access to significant offshore energy capacities
- The country has a high dependence on foreign trade to realise its economic growth potential with the primary trade partners being other EU countries (Germany, the Netherlands, Belgium, etc.) as well as other countries such as the U.S. and Russia

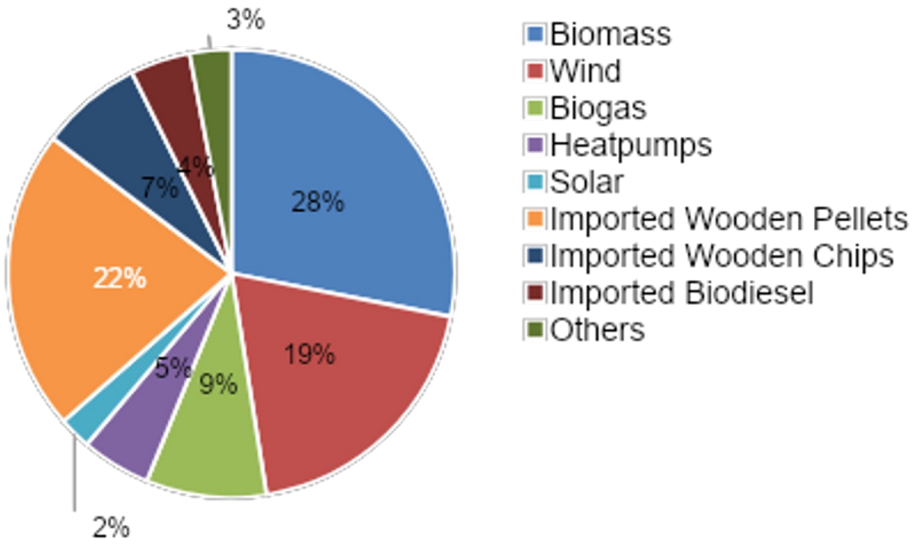
Demographic Profile	Political System
▪ The Kingdom of Denmark ("Denmark") is a country of 5.9 mn people (19% youth), and 2.8 mn households ▪ **Long life-expectancy**: 81.3 yrs (retirement age: 66 yrs) ▪ **High-income economy**: Per capita GDP is €50,010 (1.8x of EU) with 5.1% unemployment rate ▪ **Highly educated population**: 99% literacy rate, 46% above secondary education ▪ **Urban Population**: 88% population in urban areas	▪ A **constitutional monarchy** the Queen as the ceremonial head of state with limited powers and the Prime Minister as the Head of Government ▪ A representative parliamentary democracy. **Folketing** (Danish Parliament) is a multi-party structure, with elections every four years, and empowered to pass bills ▪ New Govts. unlikely to reverse past policies, which are based on joint political agreements across the spectrum. Relative weightage, however, subject to changes ▪ An **EU member country** and part of the **Schengen area**.
Geographic Profile	**Economic Profile**
▪ Located in the Scandinavian region of Europe with the Copenhagen as the capital city ▪ Characterised by a **large coastline** (7,300 km) with direct access to North Sea and Baltic Sea ▪ Comprises of **406 islands** (only 70 inhabited) ▪ Shares a land-border with Germany to the South and is in geographic proximity to Norway, Sweden, the Netherlands, the UK and Belgium ▪ Receives an average of 1,540 hours of sun a year and has access to large onshore and offshore wind resources	▪ Uses the Danish Krone (DKK) as the official currency, pegged to the € ▪ Characterised by high-tech agriculture, modern industry and high dependence on foreign trade ▪ Net exporter of food and energy ▪ Intra-EU trade accounts for 52% of Denmark's exports. Key partners are Germany (14%) and Sweden (9%). External key partners include the U.S. (11%) and Norway (6%) ▪ Key import partners include: Germany (22%), Sweden (13%), the Netherlands (9%), China (8%) and Norway (4%)

Sources: https://ec.europa.eu/eurostat/cache/countryfacts/
https://www.dst.dk/en/Statistik/emner/borgere/befolkning/befolkningstal
https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=DK
https://european-union.europa.eu/principles-countries-history/country-profiles/denmark_en

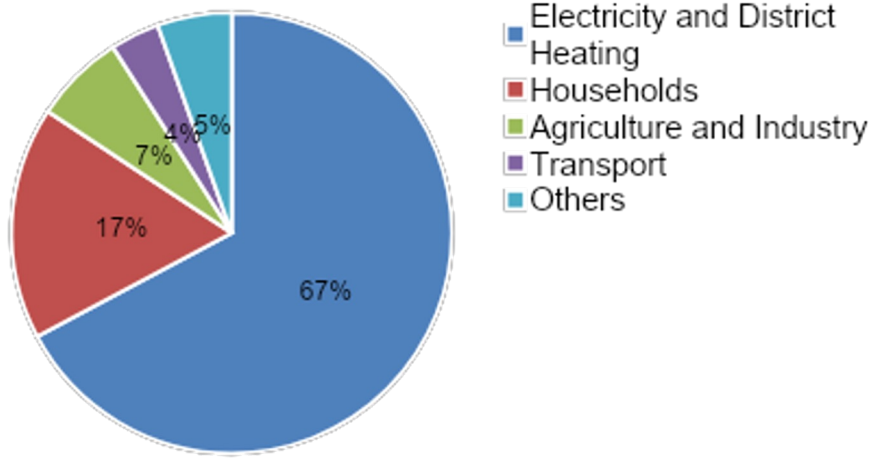
Denmark: State of Renewable Energy

- Despite a 3x increase in renewable energy production, Denmark continues to rely on imports to meet its consumption needs, which are dominated by electricity generation and district heating requirements
- These form important considerations when assessing the potential policies and commercial opportunities for green hydrogen

2021 Primary renewable nergy Sources: 299 PJ



2021 renewable energy Uses: 299 PJ



- Wooden pellets and chips import partners: North America and Russia
- Renewable energy covered 42% of the total observed energy consumption in 2021 (6% in 1990)
- Wind: Installed capacity of 7,021 MW and contributed to 43.6% of the domestic electricity supply
- 53% of the wind power production was onshore and 47% was offshore. Top 10 municipalities contributed 52% of the wind power

Sources: https://oec.world/en/profile/bilateral-product/crude-petroleum/reporter/dnkhttps://european-union.europa.eu/principles-countries-history/country-profiles/denmark_en
http://www.bioenergy-machine.com/wood-pellet-market-in-denmark.html

Denmark: Supply Chain and Competitive Advantages

- Denmark and the EU's aggressive net zero targets creates a market for PtX products in the EU region
- Value-added GH2 and PtX production will enable Denmark to capture untapped opportunities

Value Chain	Challenge	Opportunity
Renewable Power Generation	▪ Limited excess renewable energy capacity for use in electricity-intensive GH2 applications ▪ High cost of renewable electricity	▪ Excess Potential: Offshore wind potential > 40GW v/s projected use of 13 GW in a fully electrified Denmark ▪ Technology: Established domestic companies with 50+yrs experience such as Vestas, Siemens Gamesa
Green Hydrogen Production	▪ Low domestic GH2 demand ▪ Limited electrolysis capacity at scale ▪ High cost of electrolysis and GH2 production	▪ Extensive R&D experience across Danish universities ▪ Highest number of hydrogen-related patent applications globally ▪ Number of technologies ready to scale and industrialise
Storage and Transportation	▪ No existing hydrogen storage infrastructure ▪ No existing hydrogen transport infrastructure. Existing gas pipelines have competing uses until early 2040s ▪ High cost of building new infrastructure	▪ Use established existing gas infrastructure that could be partially retrofit and converted at scale for GH2 ▪ Experienced and established companies such as Energinet, Evida, Everfuel, etc. keen to explore opportunity
PtX Products and Usage	▪ Competition with cheap fossil fuels and 1st generation biofuels in the transport sector ▪ Limited availability and high cost of biogenic carbon for carbon-based PtX products	▪ Aggressive emissions reduction targets by 2050 implies curtailment of fossil fuels and 1st generation biofuels ▪ Key use case in sectors where direct electrification is not a solution: heavy road transport, aviation and shipping

National Strategy: Four Objectives

- Denmark's GH2 strategy is the mandate of the Danish Ministry of Climate, Energy and Utilities (created in 2015)

Objective 1: Alignment with the Danish Climate Act

- Denmark's strategy is to use regulations and regulatory frameworks to indirectly reduce the consumption of competing products (fossil fuels, biofuels, etc.) both at the national and the EU-level
- Fit-for-55 was a response by the EU to achieve its climate targets. Denmark has utilized the drafting efforts to enable regulatory conditions to spur the demand for PtX products across the EU
- With a strong access to renewable energy, Denmark is set to benefit from pro GH2 regulations at the EU-level

Objective 2: Regulatory Framework & Infrastructure

- Denmark aims to use time-based incentive mechanisms including subsidies, tax grants, low-cost investments to address the high production cost challenges across the value chain
- The Government is also resolute to increase the renewable energy production capacity
- Government to push for standardized carbon certification to attribute higher-value to PtX products

Objective 3: Integration with the Energy Systems

- By willing to modify the existing law and the electricity tariff structure by closely coordinating with regulators and different governance bodies, Denmark is able to provide strong market signals of commitment and long-term stability to attract investors and companies into Denmark
- Choice of an ideal location close to electricity generation is expected to have a significant, favourable impact on the cost of production for GH2 and PtX plants

Objective 4: Export of PtX products and tech

- As a result of Denmark's leadership in the sector, over 7GW in GH2 projects have been announced thus far across 20 different projects. DKK 1 bn will be made available through a tender process in support

Source: H2 Energy Europe, https://stateofgreen.com/en/news/new-strategy-kick-starts-denmark-production-of-green-hydrogen-and-e-fuels/2022, Teaser - Project Overview Green Hydrogen Esbjerg

Plug Power: Company Profile

- Plug Power continues to rely on funding support from marquee investors such as BlackRock and Vanguard to support its expansion and growth ambitions

Company Profile

- Plug Power, Inc. ("PP") operates end-to-end, integrated GH2 ecosystem, from the production, storage, and delivery to energy generation to help customers decarbonize their systems
- Incorporated in 1999, PP is headquartered in New York, USA
- Uniquely positioned as a comprehensive solutions provider, with an addressable market of electrolysers, GH2, fuel cells for transport and fuel cells for stationary power
- Total addressable market estimated ~US$2.2 trn
- In an effort to be a one-stop shop solutions provider, PP has used the bolt-on acquisition strategy to build a comprehensive, high-quality product profile: Cellex and General Hydrogen (2007); ReliOn (2014); American Fuel Cell (2018); EnergyOr (2019); United Hydrogen and Giner ELX (2020); JV with Hyvia and SK Group (2021); Applied Cyro Technologies and Frames Holdings B.V. (2021); Joules Processing (2022)

Key Financials

Particulars (US$ mn)	2019	2020	2021
Revenue	230	(93)	502
Net Income	(84)	(596)	(460)
Total Assets	660	2,251	5,950

Product Profile

- **GenDrive**: PeM fuel cell system, providing power to material handling electric vehicles
- **GenFuel**: Liquid hydrogen fueling delivery, generation, storage, and dispensing system
- **GenCare**: IoT-based maintenance and on-site service program for Gendrive fuel cell systems, GenSure fuel cell systems, GenFuel hydrogen storage and dispensing products and ProGen fuel cellengines
- **GenSure**: Stationary fuel cell solution providing scalable, modular Proton exchange Membrane (PeM) fuel cell power to support the backup and grid-support power requirements
- **GenKey**: Certically integrated "turn-key" solution combining either Gendrive or GenSure fuel cell power with GenFuel fuel and GenCare aftermarket service, offering complete simplicity to customers transitioning to fuel cellpower
- **ProGen**: Fuel cell stack and engine technology currently used globally in mobility and stationary fuel cellsystems, and as engines in electric delivery vans
- **GenFuel electrolyzers**: Modular, scalable hydrogen generators optimized for clean hydrogen production

Key Investors

BlackRock Vanguard

Source: https://seekingalpha.com/article/4604444-plug-power-stock-q1-2023-earnings-new-multi-year-lows-cautious-outlook-hold

H2 Energy: Project Overview

- The 1GW electrolysis project of H2 Energy, Plug Power and Denmark is a case of intersection of world-class technological capabilities meeting robust Government support to enable the creation of new markets in a rather nascent industry

Project Overview

- In 2022, H2 Energy ordered a 1GW PtX plant in Esbjerg, Denmark from Plug Power
- When installed, the electrolyser is expected to be the largest capacity installation to date and will play a critical role in the Danish energy supply chain
- The plant is expected to produce 100,000 MT of GH2 per year. Equivalent to the fuel need of ~15,000 heavy-duty trucks every day
- The implementation is expected to be completed by 2024
- H2 Energy is in JV with Hyundai to deliver a fleet of hydrogen-fueled trucks
- Entered into a JV with Phillips 66 to build ~250 hydrogen filling stations in Denmark, Austria and Germany (supplied with GH2 from Esbjerg)
- Plant built over 11 hectares bought by H2 Energy
- Proximity to North Sea's offshore wind production and to large industrial clusters in Germany key factors in H2 Energy's decision making

Key Success Factors

Ideal geographic conditions in Esbjerg

Denmark's stated ambitions to expand offshore wind energy

Denmark's strong political support, transparency, approval efficiency and export ambitions

"Invest in Denmark"'s continued support to H2 Energy with respect to dialogues on infrastructure, regulations and technical support

Project Location

- Esbjerg is one of the two key landing zones in Denmark

- Ideal place for pipeline development. 50km to road transport off-takers, 3km to port of Esbjerg and proximity to Germany and export markets

Source: H2 Energy Europe, 2022, Teaser - Project Overview Green Hydrogen Esbjerg

Case Study II: Germany and Enapter A.G.

Enapter

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Country Profile: a Political and Economic overview

Political profile

- Germany is a Federal Parliamentary Republic with 16 states (Länder).
- With a population of 84.3 million from which 19% are younger than 20 and 27% +60 (European Commission, 2023).
- The Federal Government develops energy policy legislation in cooperation with the Länder, who implements energy policies in their respective federated states (Bundesländer).
- Current government coalition, prioritize climate and renewable energy policies.

Regulatory framework is changing

- The illegal invasion of Ukraine has accelerated the adoption of energy transition legislation, highlighting the connection between clean energy, security, and sovereignty. Germany has been at the forefront, driving the implementation of low-carbon hydrogen regulations in Europe.
- Germany cannot be separated from its regional context, which follows a “top-down” and “bottom-up” approach. Europe's carbon-neutral goal by 2050. The convergence of the political landscape, decarbonization urgency, low renewable energy prices, and the growing focus on hydrogen have driven a transformative regulatory framework.

Economic profile

- Germany is known for its skilled workforce, strong capital stock, low corruption, and a culture of innovation.
- With a GDP of USD $4.479 trillion in 2022 (World Economics), Germany is Europe's largest economy and the fourth largest globally (KPMG, 2022). It holds significant influence in the Euro area, providing regional stability.
- Germany's central location in the middle of Europe brings with it a closely tied infrastructure network and access to strategic market routes.
- Main economic sectors: manufacturing industries including automotive, chemicals, metals such as iron and steel, electrical equipment, coal, ships, machine tools (World Atlas, 2017)
- Export markets: The US, France, the UK, China, the Netherlands and Belgium, among others (World Atlas, 2017).

Key Figures

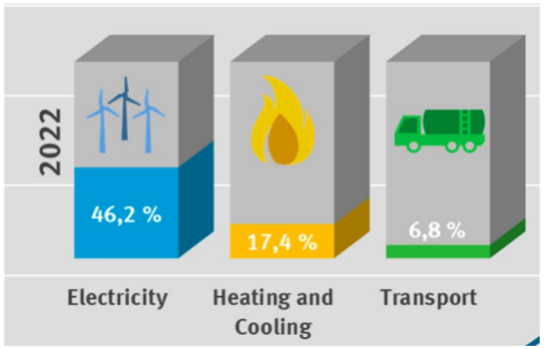
- Population: 83.4 million
- GDP: USD $4.479 trillion
- GDP growth rate: 2.89 %/year
- Energy independence: 35.3%
- 1º EU’s largest economy and 4º worldwide.

Source: Enerdata, 2022

Country Profile: Energy overview

- Germany is a net exporter of energy, and its imports have increased by 51.1% compared to 2021, according to Enerdata's report in 2022.
- In 2022, renewable energy sources (RES) accounted for 47% of final consumption. The electricity sectors as major responsible of this development.

Development of renewable energy shares for electricity, heat and transport (2022)

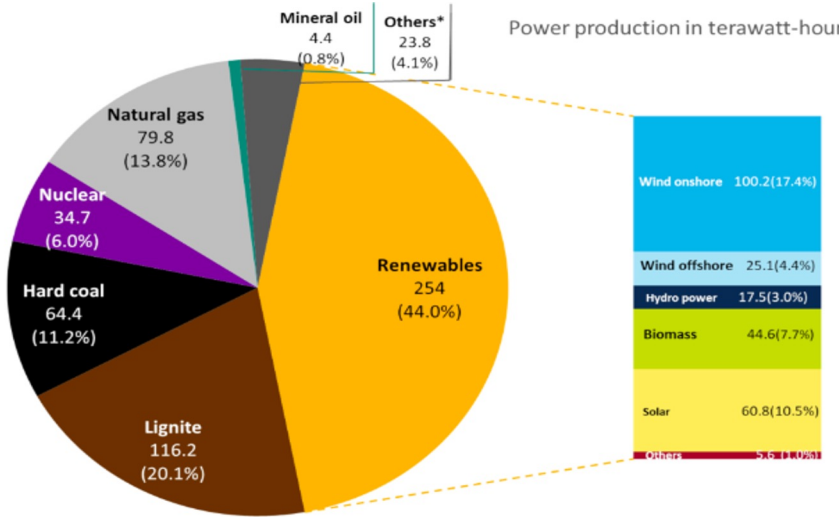


Source: umweltbundesamt, 2023

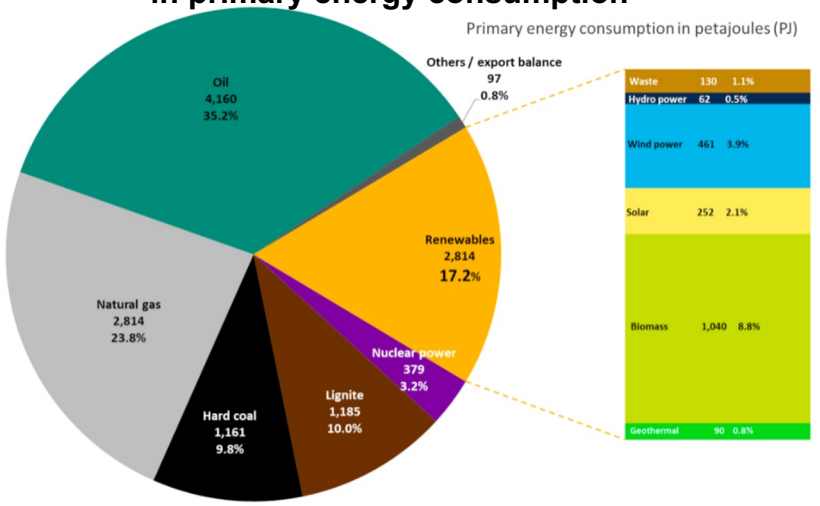
- Regarding the energy mix, the proportion of electricity generated from renewable sources rose to 45%, compared to 42.7% in 2021 (Clean Energy Wire, 2022).
- Despite the ongoing growth in renewable energy, several challenges persist: (1) Oil still dominates as the primary source of energy consumption, (2) Coal generation increased by 17% compared to 2021(Destatis 2022), and (3) Germany is still far from meeting its climate targets-80% RES by 2030- (Climate Action Tracker, 2022). Low-carbon hydrogen is seen as a crucial element in accelerating the energy transition.

Source: AGEB, 2023

Share of energy sources in gross German power production (2022)



German Energy Mix 2022: Energy's source share in primary energy consumption



National Hydrogen Strategy (2020)

- **Germany's aim:** to become the leading exporter of hydrogen technology across the entire green hydrogen supply chain.
- **Response:** Germany actively promotes collaboration within the EU and partner countries, establishes essential market catalysts, and takes the lead in critical technology advancements.

+10bn

Public funding for Kick-start GH2 market

- Package for the future (€7bn)
- National Innovation Programme on Hydrogen and Fuel Cell Technology (NIP), (€1.4bn€300m)
- Energy Research Programme (€300m).
- Regulatory Sandboxes for the Energy Transition (€600m)
- Decarbonization Program €1bn

10GW

Hydrogen production between 2030-2040

- Most of the hydrogen needed will have to be imported- +30 Energy Partnerships for that purpose.
- on top of that REPowerEU Plan aims for the EU to produce 10 million tonnes and import 10 million tonnes of renewable hydrogen by 2030.
- Renewable Hydrogen Acts- increase the need for more technology.

2GW

Electrolyser capacity 2030

- Expanded to 5GW by 2030.
- 20MW
- M3: Climate Action Innovation Pact, supporting providing funding for investments in electrolysers.
- M5: Create clear incentives for investments in electrolysers.
- Net Zero Industry Act: 40% of critical technology manufactured in house.

+60

Projects in the pipeline

- Flagship project: "H2Giga"dedicated to making the serial production of electrolysers competitive and minimising production errors.
- H2Global Initiative: market-based mechanism using CCfD approach.
- Includes the Enapter Campus in Saerbeck, North Rhine-Westphalia.

G2B-B2G Dynamics

Following the theory of Spencer, J. et al. (2005) and Vasudeva, G et al. (2013), the logic for creating new industries in Germany is associated with a highly centralized state apparatus that establishes regulations and instruments guiding company behavior towards collaborative models such as consortia, partnerships, and alliances. In essence, it aims to promote collaboration over competition.

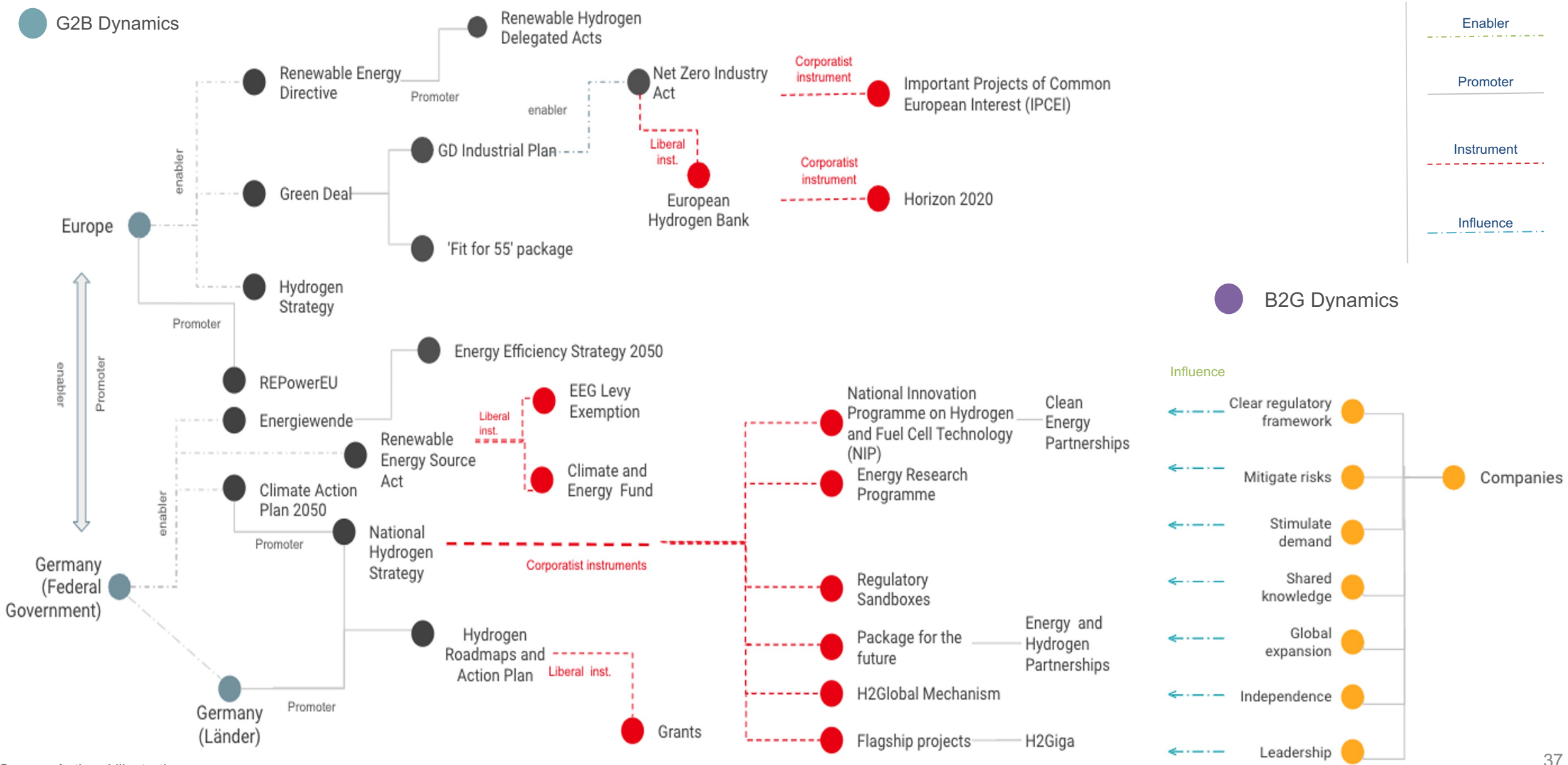
G2B Dynamics

The government plays a pivotal role by establishing a regulatory framework and implementing programs to attract companies that share similar values and goals, such as NIP, Regulatory Sandboxes, and H2giga. Firms with a similar background, like Enapter, inherently embrace collaboration as a positive-sum game. Additionally, the government fosters the development of new associations, such as Clean Energy Partnerships and H2Global, that promote cooperative norms and collective innovation. This harmonious combination of collaborative logic is particularly relevant in promoting innovation as it facilitates greater knowledge flows. For the hydrogen industry in particular, Germany also adopted a hybrid model that combines the centralization of certain decisions with some degree of states, (e.g. roadmaps and grants). This approach aims to prevent the formation of dependency relationships while fostering the organic growth of companies. Moreover, Germany's dynamic strategy acknowledges the potential to serve as a pivotal player in accessing international markets, facilitated through energy partnerships, thereby overcoming potential constraints associated with working in isolation. Additionally, it is worth noting that Germany does not differentiate between domestic firms and international talents, promoting a level playing field for all.

B2G Dynamics

Firms engage with governments to express their needs and influence regulatory responses, which encompass attractive programs addressing market failures (e.g., H2Global), a clear regulatory framework, and a stable environment for successful ventures. Predictability enables the private sector to stimulate hydrogen demand and invest confidently in the nascent industry. Businesses expect the government to utilize various instruments to mitigate initial risks, catalyze the industry, and attract additional investments. These packages should enable decentralized work while maintaining global connectivity. In emerging industries, generating and sharing new knowledge is crucial for firms seeking leadership positions(Avadikyan et al., 2003; Teece et al., 1997). Government support is often necessary to mitigate entrepreneurial risks. However, seeking government assistance may limit firms' autonomy in developing diverse innovation strategies or create dependency relationships.

Mapping the Regulatory Framework and Dynamics



Source: Authors' illustration

Enapter A.G.

Company's description

Enapter A.G. is an energy technology German company founded in 2017. It specializes in manufacturing high-efficiency Anion Exchange Membrane (AEM) electrolysers, renowned for their modular design.
Objective: to produce hydrogen at the lowest cost through scaled production, thereby establishing competitive pricing compared to fossil fuels.
Vision: They aspire to achieve a similar impact in hydrogen production as solar panels have had in electricity generation by enabling users to generate hydrogen on-site, eliminating the need for a lengthy supply chain.
Goal:By 2050, Enapter's aims for their products to contribute to 10% of the global hydrogen production capacity.

Motivating Factors

Business culture: Enapter A.G. is a subsidiary of BluGreen Company Limited (German Co.), Therefore, they have the same founder who is of German nationality.
Risks mitigation: Germany's strong and stable economy, offers an ideal environment for Enapter to mitigate geopolitical and financial risks.
Foster's innovation: Germany's position as a global leader in innovation and its emphasis on leveraging scientific advancements for economic benefit aligned perfectly with Enapter's vision, gaining access to a thriving ecosystem of world-class talent, suppliers, and research institutions, continually enhancing its AEM Electrolyser technology and fostering the creation of valuable intellectual property.
Pivotal market: The country's large consumer base and strong emphasis on clean energy created a substantial demand for Enapter's innovative solutions and acts a pivot for markets abroad.

Enapter Annual Report 2022

€14.7	-10	€13.5	€443
million 2022 sales	million euros 2022 EBITDA	millions in order backlog	millions customer pipeline

Enapter A.G.

Enapter Campus in Saerbeck

Technological success factors

Unique technology: Patented Anion Exchange Membrane (AEM) electrolyser. Enables the cost-effective mass production of plug-and-play electrolyzers, since reduce over 75% of cost production, compared to conventional methods.
Pure H2: Produce high-purity hydrogen at approximately 99.9%.
Comparative advantages: combine the advantages of Proton Exchange Membrane (PEM) and Alkaline (TA) electrolysis.
Empowering users: Enapter focuses on providing standardized, scalable, and flexible solutions, enabling users to efficiently produce hydrogen on-site at a cost-effective rate.
Partnership-driven approach: Enapter collaborates with customers and certified partners for plug-and-play integration across diverse applications, including electricity storage, power-to-heat, power-to-gas, industry, and mobility.
Streamlined system integration: Technology easily managed with software, the Energy Management System Toolkit (EMS toolkit) connects any device to a unified energy network, allowing analyze correlation, plan and control energy generation, storage and transmission for any energy system.

Enapter large-scale projects

Enapter is currently undertaking seven large-scale projects, with the Enapter Campus as a standout endeavor.
Enapter Campus and Production Scale-Up: Enapter's campus, covering 82,000 square meters, will produce over 100,000 AEM electrolyser modules annually. On-site production started in 2022, gradually scaling to exceed 10,000 electrolysers per month. The modular design allows flexibility, robustness, and compliance with EU regulations, making it ideal for intermittent renewable energy.
Government Support and Financing: Enapter has received €5.6 million in funding from the German Government and €9.3 million from the North Rhine-Westphalia Ministry. The campus will be developed in partnership with Münster University.
Advancing in green technology: The Enapter campus operates on renewable energy aiming for minimal environmental impact throughout the product life cycle. This commitment reflects Enapter's dedication to sustainability and reducing carbon emissions.

Case Study III: Morocco and CWP Global

CWP GLOBAL

IAHE Green Hydrogen Division

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Morocco: Energy Profile

- In recent years, **the Kingdom of Morocco has taken steps to position itself as a global leader in the clean energy transition**: it aims to have 52% of installed electric power capacity using renewable resources by 2030. Electricity consumption continues to rise.
- Despite ambitious renewable targets, Morocco is a net energy importer with **fossil fuels continuing to dominate its energy mix (90%)** and placing a heavy burden on its foreign trade balance.

Key Figures:
- GDP $333.2 bn at PPP
- Population 37 million
- +7.93% GDP growth/year
- 11th largest CO2 emitter in Africa (1.97mt per capita)
- Corruption Index: 38

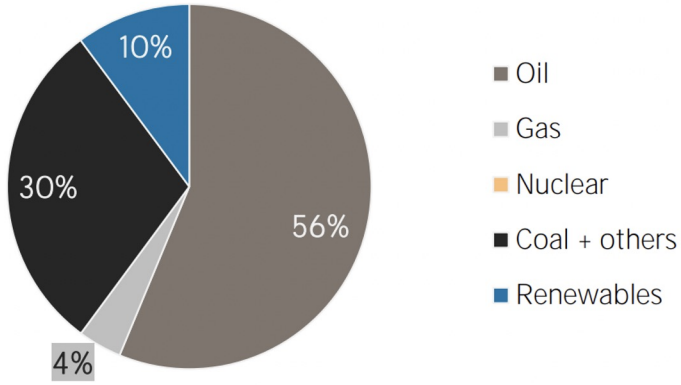
Other Key Sectors:
- Agriculture, tourism, phosphates, textiles

Main Trade Partners:
- France, Spain, China, US, Italy, Germany, Saudi Arabia, Russia

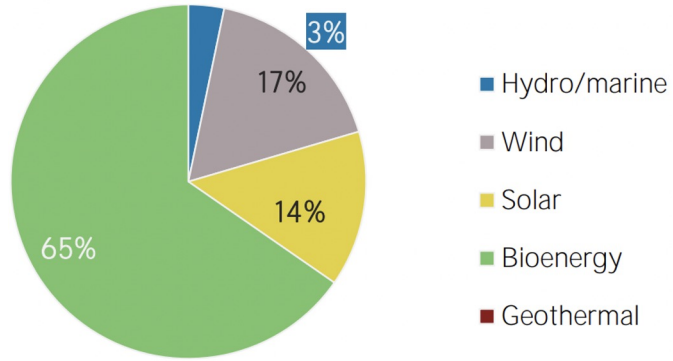
Morocco Primary Energy Data, 2021 in quadrillion btu | **Total Production: 0.076** | **Total Consumption: 0.949**

Coal	Dry natural gas	Petroleum & other liquids	Nuclear, renewables, & other
Production 0	Production 0.004	Production (s)	Production 0.072
Consumption 0.253	Consumption 0.031	Consumption 0.59	Consumption 0.075

Total Energy Supply, 2019



Renewable Supply, 2019



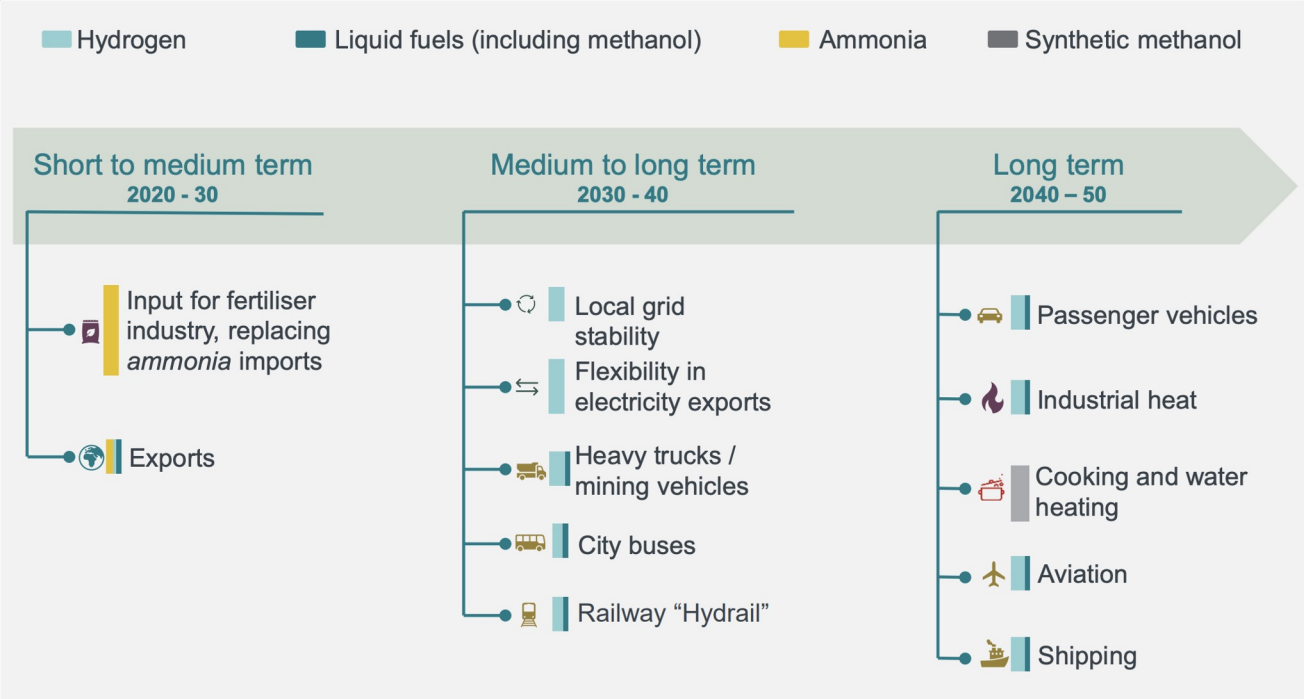
Sources: International Renewable Energy Agency (IRENA), https://h2council.com.au/government-hydrogen-policies/
US Energy Information Administration (EIA), 2022
World Bank World Development Indicators Database, 2021

Morocco: Green Hydrogen Roadmap and Strategy

- Explicit policy support: Morocco's National Hydrogen Roadmap (2021)

Country Objectives:

- Leverage extensive renewables potential to become a key exporter of GH2 to Europe, exports via pipeline expected from 2035 onwards.
  - Europe's Green H2 demand could reach almost 530 Mt by 2050
- Increase energy security/reducing import dependence:
  - Morocco is a major fertilizer producer and imports 1mn t/yr of ammonia which could be replaced by domestic GH2. The main actor OCP is mostly state-owned.
- Morocco aims to work on GOs for electricity to have the framework ready for grid integrated hydrogen production
- Water desalination for GH2 production



2020-2050	2050	2050
140 billion dirhams (€13 billion) up to 1,000 billion dirhams (€95 billion) in investment	Annual emissions reduction potential of 10.6-20.6 mt of Co2/eq	26,000-130,000 direct/indirect jobs created

Hydrogen Exports in National Strategy (TWh/Yr)

2030	2040	2050
10.3 to 21.7 TWh	45.9 to 91.8 TWh	114.7 to 229.5 TWh

Sources: Kingdom of Morocco Green Hydrogen Morocco Roadmap, https://www.mem.gov.ma/Lists/Lst_rapports/Attachments/36/Feuille%20de%20route%20de%20hydrog%C3%A8ne%20vert.pdf

Bilateral Trade Agreements/MOUs

- Morocco has several bilateral trade agreements

- **Morocco and Portugal sign MOU on green hydrogen development 2021**

The two countries signed an agreement in Feb 2021 to boost bilateral cooperation on green hydrogen development and to align their decarbonization strategies priorities. They also announced the establishment of a joint working group to examine the opportunities and the actions needed. A direct outcome was the HEVO green ammonia project.

- **Morocco and Germany alliance to advance green hydrogen 2020**
  - The Moroccan Government within the German Moroccan Energy Partnership (PARMA) signed an active partnership to advance green hydrogen and is developing a roadmap to 2050 to develop the green industry in Morocco. In June 2020, the Germany-Morocco Hydrogen Agreement was signed in Berlin for the joint development of the production of green hydrogen for its use in Morocco and Germany. An investment of €300 million has already been pledged, allowing Germany to source green hydrogen from Morocco in the future.

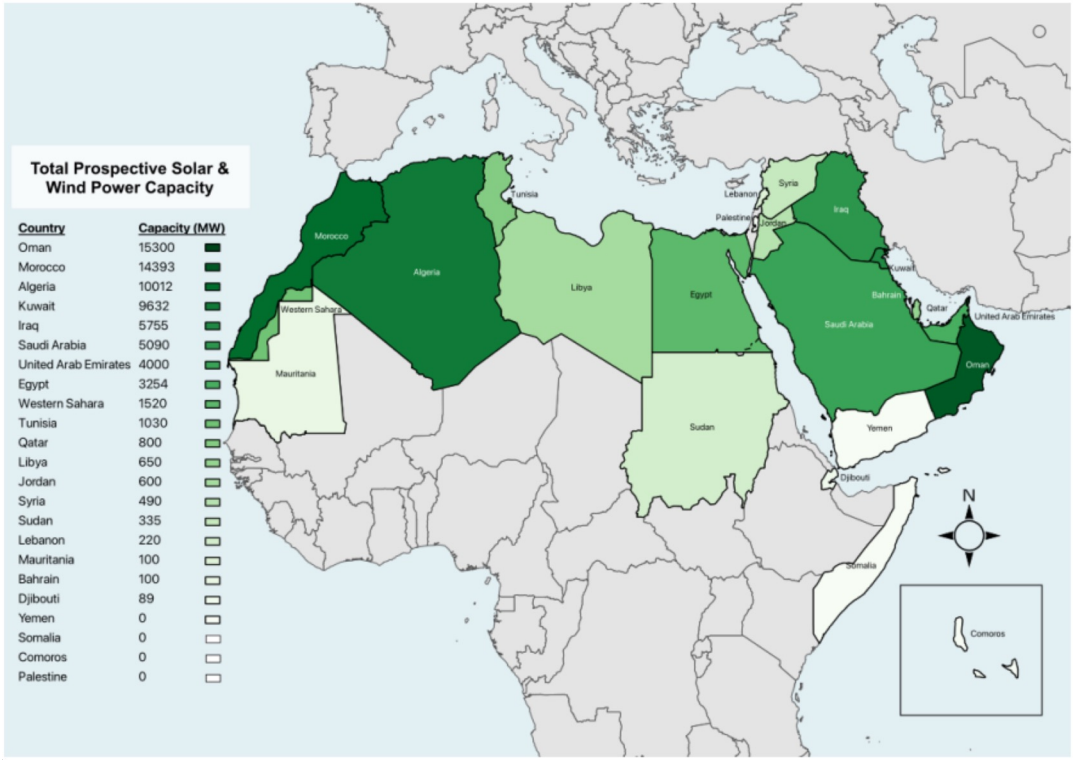
- **Morocco and EU free trade agreement 2000**
  - The EU and Morocco established a Free Trade Area as part of the EU-Moroccan Trade Association Agreement, signed in 1996, which entered into force on 1 March 2000. Trade and investment relations between the EU and Morocco are strong: Trade in industrial products is entirely liberalized, while market opening for agricultural products is also substantial. Negotiations for a Deep and Comprehensive Free Trade Area (DCFTA) with the EU started in 2013.

- **There are also free trade agreements with USA, Egypt, Jordan, Tunisia, Turkey, and the United Arab Emirates (UAE).**

Sources: Oeko Hydrogen Factsheet, North African Countries, https://www.oeko.de/fileadmin/oekodoc/GIZ-SPIPA-hydrogen-factsheet-North-African-Countries.pdf
GIZ, Green Hydrogen in Morocco, https://www.oeko.de/fileadmin/oekodoc/GIZ-SPIPA-hydrogen-factsheet-North-African-Countries.pdf

Morocco: Cost-Competitive Green Hydrogen Production

- Morocco has a large **competitive advantage in green hydrogen production** owing to its privileged geographic location, which hold enormous solar and wind potential that can drive down the cost of GH2 produced from renewable electricity.
- The country also has access to existing port and pipeline connections to Europe that make it well suited to attract private and foreign direct investment in green hydrogen and hydrogen derivatives.



If only 5% of potential is installed, it will correspond to 1,000 GW of solar power and 325 GW of wind power.

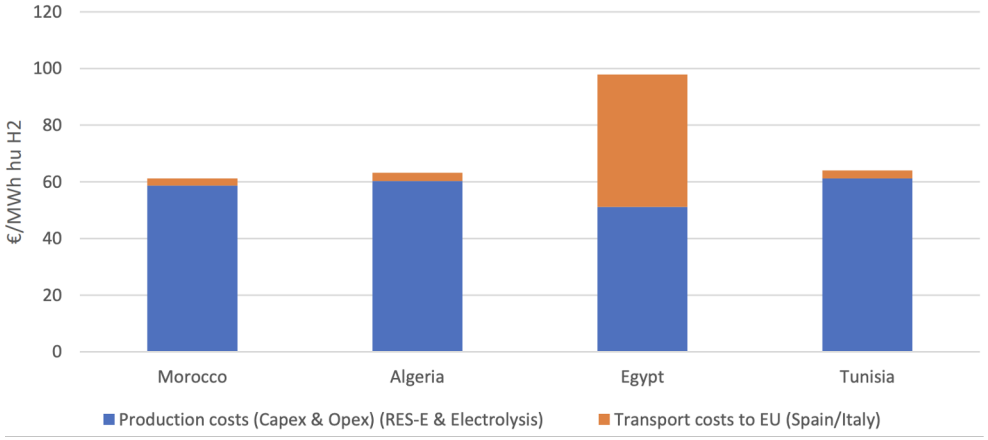
Solar

3k Hours Sunshine/Yr
5 Kwh/m2 Avg Irradiation
$0.19/kWh

Wind

Offshore/onshore wind
Over 10 m/s wind speed
$0.30/kWh

Total Supply Costs of H2 Including Transport to Spain/Italy by 2030



- Morocco ranks lowest in cost because of short transport distance to EU and existing pipelines.

Sources: International Energy Agency (IEA), 2022
International Renewable Energy Agency (IRENA), Morocco Energy Profile, 2022
IRESEN, 2020, Power to X in Morocco, Driver of Mediterranean Energy Market Integration

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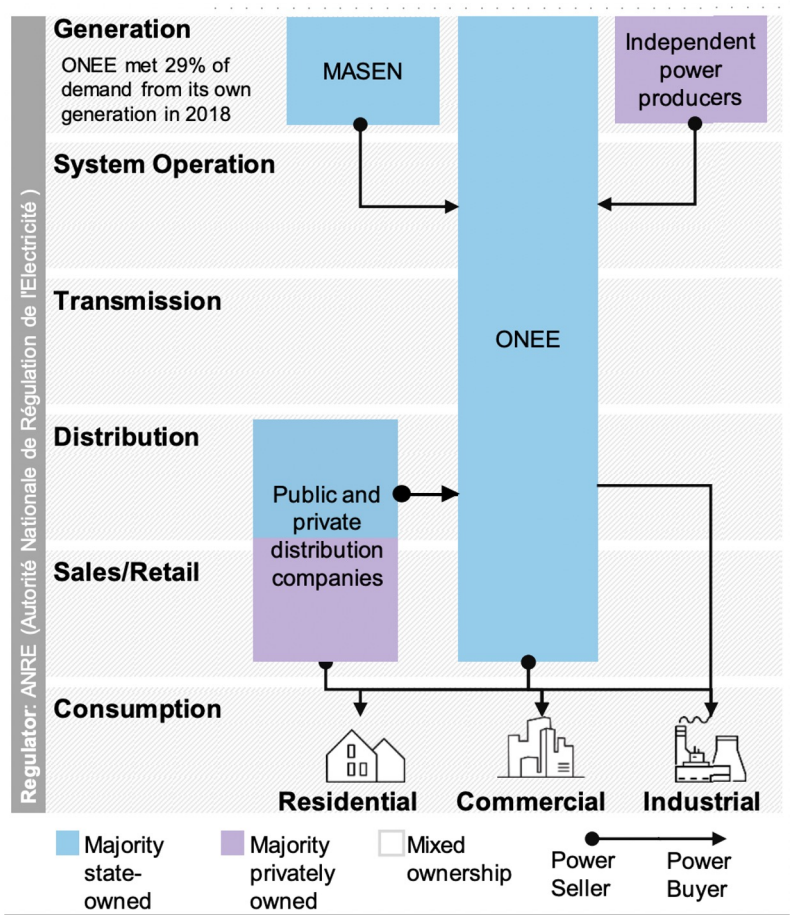
Moroccan Energy Institutions and Regulatory Environment

- Morocco's political and regulatory framework are critical to understanding both private investment and state policy decisions in green hydrogen. Private investment in GH2 depends on the expansion of renewable electricity, which is very much centralized and managed by the state, a constitutional monarchy presided over by King Mohammed VI.

Key Laws and Regulations
▪ Law No 2-94-503, allowing private electricity generation by authorising IPPs to install more than 10 MW of renewable energy.
▪ Law 13.09 is a pioneering law allowing Independent Power Producers (IPP) to sign a PPA directly with end customers (High Voltage only so far), use the national grid for power transmission, and sell excess generation to ONEE, at a regulated price.
▪ The implementation decree of Law 58-15 was published in January 2022, establishing a gradual opening of the medium voltage market with the publication of the RE injection volumes to be integrated into the MV network for the next 10 years.
▪ It could facilitate the development of integrated renewable energy/hydrogen production projects under the self-generation regime, and the development of Direct PPAs between IPPs and hydrogen producers.
Main State Actors
▪ National Hydrogen Commission
▪ Green H2 Maroc
▪ AMHYD (L'Association Marocaine pour l'Hydrogène et le Développement Durable)
▪ Institute Research Energy Solar And Energy Nouvelles (IRESEN)
▪ Moroccan Ministry of Energy, Mines and Sustainable Development (MEMDD).
▪ Moroccan Agency for Sustainable Energy (MASEN).
▪ National Office for Electricity and Water (ONEE): grid operator.
▪ Energy Investment Company (SIE).
▪ OCP Group: a state-owned phosphate rock miner, phosphoric acid manufacturer and phosphate fertilizer producer. Expected to be largest domestic consumer of hydrogen.

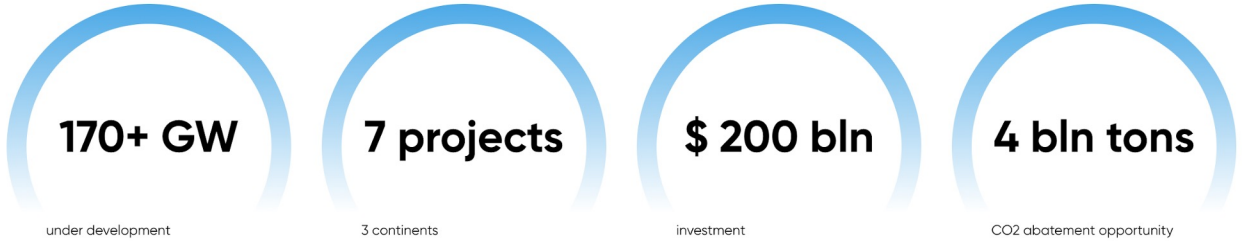
Moroccan Power Structure Still Heavily Regulated



Source: Bloomberg NEF

Company Overview: CWP Global

- CWP Global develops large-scale renewables and hydrogen energy projects around the world, and one of the global pioneers of ultra-large scale green hydrogen hubs with 170+GW under development.
- Its Australian business was sold by Swiss investor Partners Group to Andrew Forrest's Squadron Energy in December 2022 for a reported A$4bn



- **Industry**: Renewable Energy Developer
- **Privately held**
- **Founded 2006**
- **Size:** 51-200 employees
- **Headquarters**: Serbia

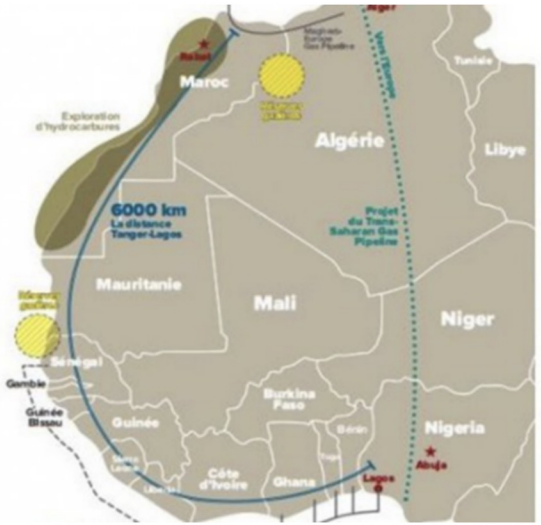
- When fully operational, CWP Global's hydrogen project pipeline will produce in excess of Europe's entire hydrogen target for 2030.
- Company takes into consideration wind and solar resource, land and water availability, proximity to markets, and political stability when choosing new H2 markets
- While several of its renewable projects are already operational, no hydrogen projects have yet to reach production stage

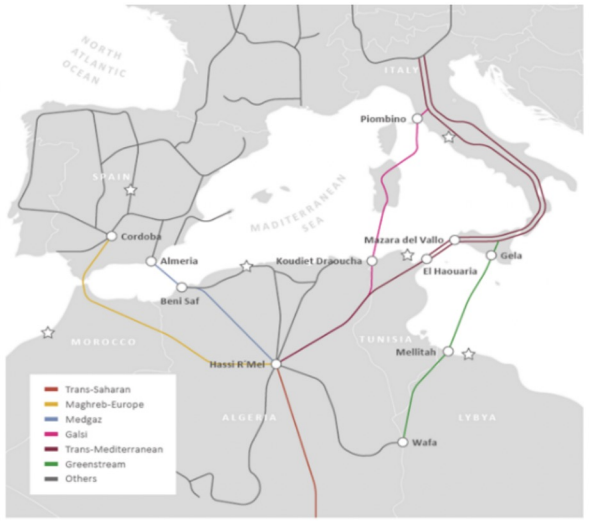
Source: CWP Global

Project Overview: AMUN

- The AMUN project in Tan Tan, Morocco is the country's first large-scale green hydrogen project initiated in December 2019, about 100 kilometers along the coast and 20 to 30 kilometers inland with installed **15 GW capacity wind and solar**. Designed in three phases, it is expected to provide Morocco with the first million tons of green hydrogen and ammonia by 2028.

Phase I: 2027 • Wind power generation • Solar power generation • Green ammonia production	**200,000 Ha** • 3.0 GW • 3.0 GW • 2.0-2.5 mn tons
Phase II: 2030 • Wind power generation • Solar power generation • Green ammonia production	**300,000 Ha** • 3.0 GW • 3.0 GW • 2.0-2.5 mn tons
Phase III: 2032 • Wind power generation • Solar power generation • Green ammonia production	**70,000-320,000 Ha** • 1.0-5.0 GW • 1.0-5.0 GW • 0.75-4.0 mn tons





Ideal Connectivity to W Africa and Europe:

- Favorable location if international H2 export market develops
- Natural gas pipeline runs from Algeria to Spain through Morocco, contracts expired 2021
- Port infrastructure available (Port of Tan Tan).
- While this project is focused on producing ammonia locally from green hydrogen, in the interest of flexibility, CWP has partnered with Hydrogenious LOHC Technologies to explore transporting 500t/day of green hydrogen directly to Europe as a feasibility study (4 May 2023).

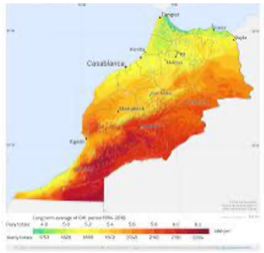
Source: CWP Global

Morocco creates an enabling policy environment for Green Hydrogen

- In this case study, G2B dynamics are most prevalent as the country mobilizes a top-down approach to attracting private investors such as CWP Global.

Factors Enabling CWP Global's Project

HIGH REN POTENTIAL



SUCCESSFUL REN DEPLOYMENT

STRONG POLITICAL BUY IN & PARTNERSHIPS

STRONG PROXIMITY + MARITIME&GAS CONNECTIVITY TO EU

GROWING R&D INFRASTRUCTURE

INVOLVEMENT OF INDUSTRY/PRIVATE SECTOR

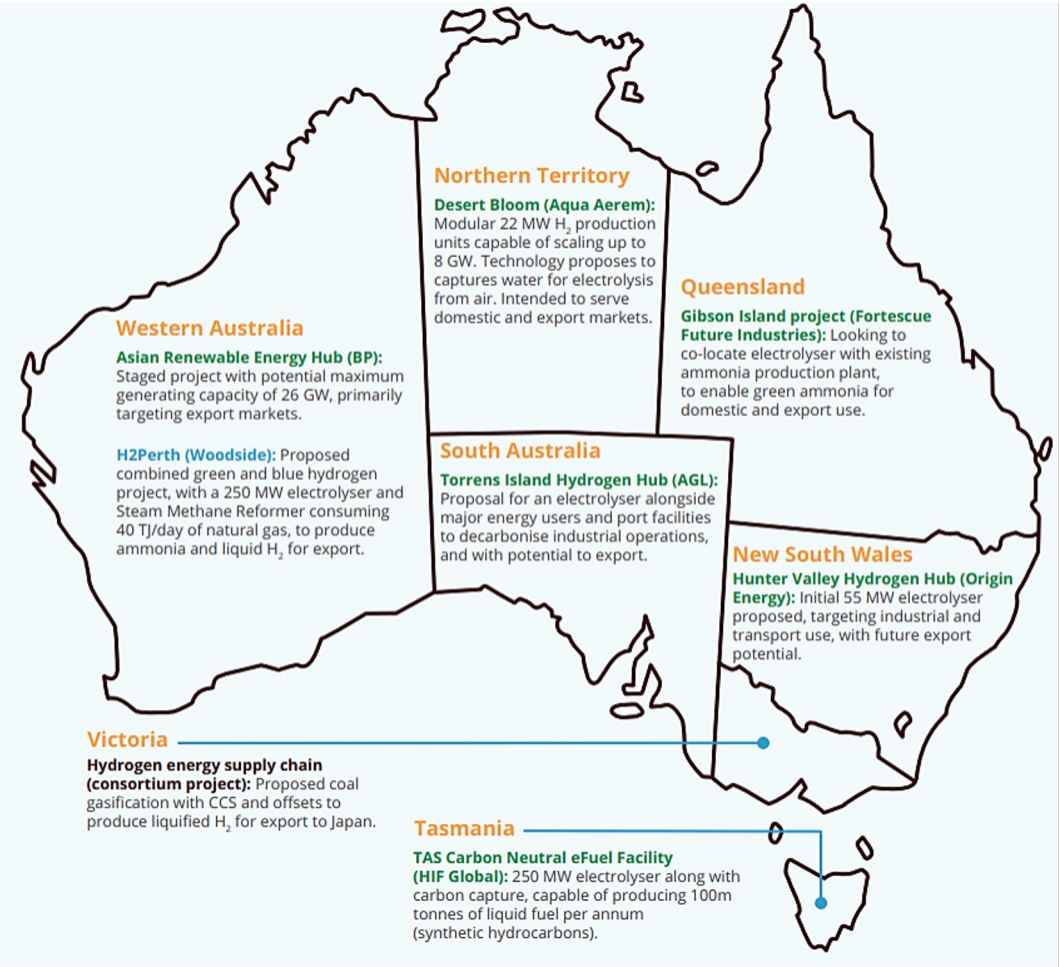
Vitol

OCP

Challenges
▪ Underutilization of renewable resources, a growing supply of renewable power is critical to GH2 expansion. ▪ New fossil fuel additions threaten to sideline renewable expansion necessary for GH2 production (signing of 30-year PPAs for coal, 1.3GW added in 2018). ▪ No quantifiable H2 targets in national roadmap for the entire value chain (electrolyzer capacity and costs, production, etc), can derail investment. ▪ Morocco shows high water stress especially in populated and economic areas. ▪ Centralized state structure makes it difficult to incorporate private commercial considerations into hydrogen policy.
Opportunities
▪ Strong political buy-in from government helps de-risk private GH2 investment. ▪ Experience in clean power deployment allows for greater renewables funding and investment by development banks. ▪ Relatively mature financial sector. ▪ Possibility to advance green certification in order to participate in international hydrogen trade.

Source: Bloomberg NEF State of The Energy Transition

Case Study IV: Australia and InterContinental Energy



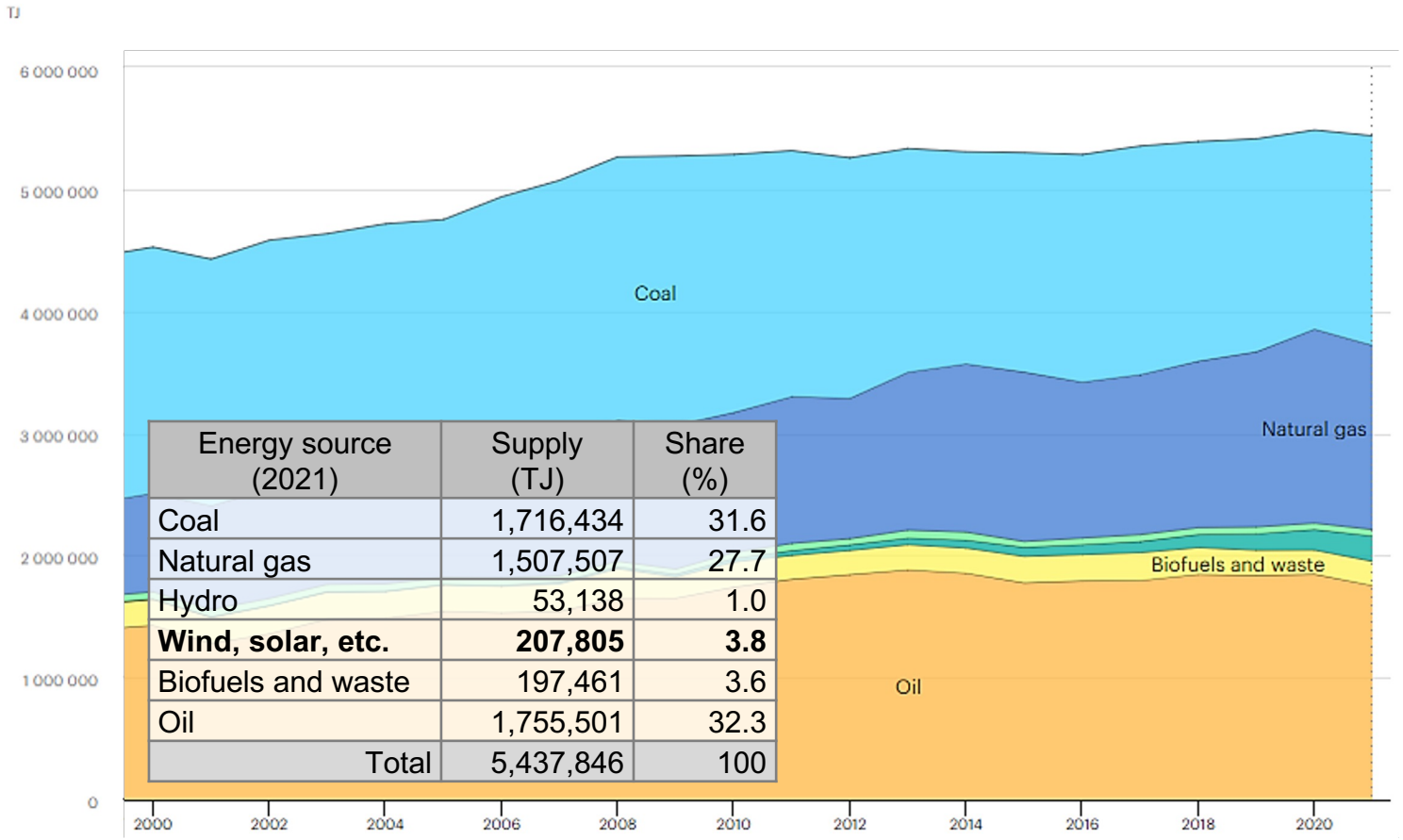
InterContinental Energy

IAHE Green Hydrogen Division

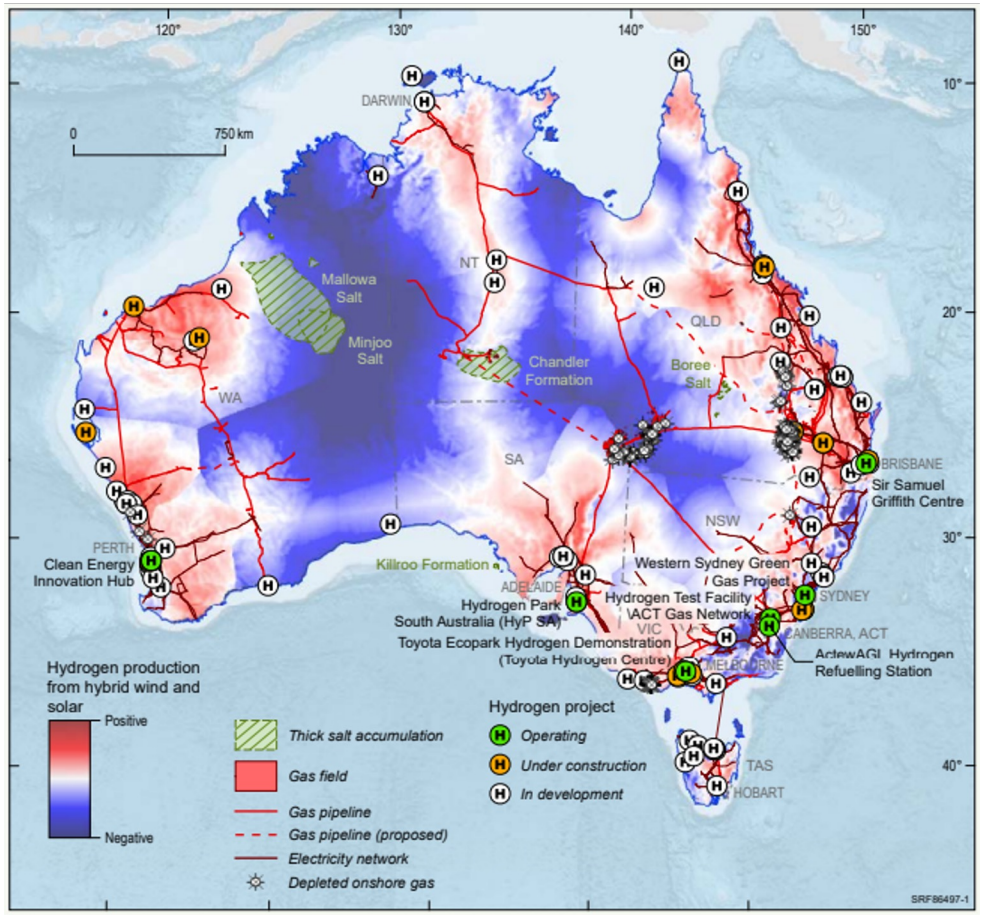
SciencesPo
Paris School of International Affairs

Australian Energy Landscape

- Australia has abundant energy resources and is a leading exporter of coal, uranium and LNG
- While its carbon intensity is in decline, it is still the highest level (91.6% in 2021)
- Australia estimates about 3% of land (262,000 km^2), which is mostly coastal area, could be highly suitable for green H2 production based on the quality of wind, solar, hydro resources, and infrastructure constraints



Energy source (2021)	Supply (TJ)	Share (%)
Coal	1,716,434	31.6
Natural gas	1,507,507	27.7
Hydro	53,138	1.0
Wind, solar, etc.	**207,805**	**3.8**
Biofuels and waste	197,461	3.6
Oil	1,755,501	32.3
Total	5,437,846	100



Sources: IEA, Australia, https://www.iea.org/countries/australia
COAG Energy Council Working Group, Australia's National Hydrogen Strategy, 2019
Australian Government, 2022, State of Hydrogen 2022

Australian Hydrogen Policies

- In Australia, the both the Commonwealth and States or Territories each have their own H2 strategies
- The National Hydrogen Strategy (2019) are to be updated after public consultation (decided in Feb. 2023)
- Supportive policy signals from the Australian Government including ca. €25 billion (AU$ 41.4 billion) of financial support
- Some regulatory challenges and barriers that need to be overcome, such as relatively slow environmental approval processes, requirement for electricity grid connection approvals, and safety compliance issues

Jurisdiction	Documents	Release Date
Australia – Commonwealth	Australia's National Hydrogen Strategy	November 2019
Australian Capital Territory	ACT's Transition to Zero Emissions Vehicles Action Plan 2018-21 / ACT Climate Change Strategy 2019-25	April 2018 / September 2019
New South Wales	NSW Hydrogen Strategy	October 2021
Northern Territory	Northern Territory Renewable Hydrogen Strategy	July 2020
Queensland	Queensland Hydrogen Industry Strategy 2019-2024	May 2019
South Australia	South Australia's Hydrogen Action Plan	September 2019
Tasmania	Tasmanian Renewable Hydrogen Action Plan	March 2020
Victoria	Victorian Renewable Hydrogen Industry Development Plan	March 2021
Western Australia	Western Australian Renewable Hydrogen Strategy	July 2019

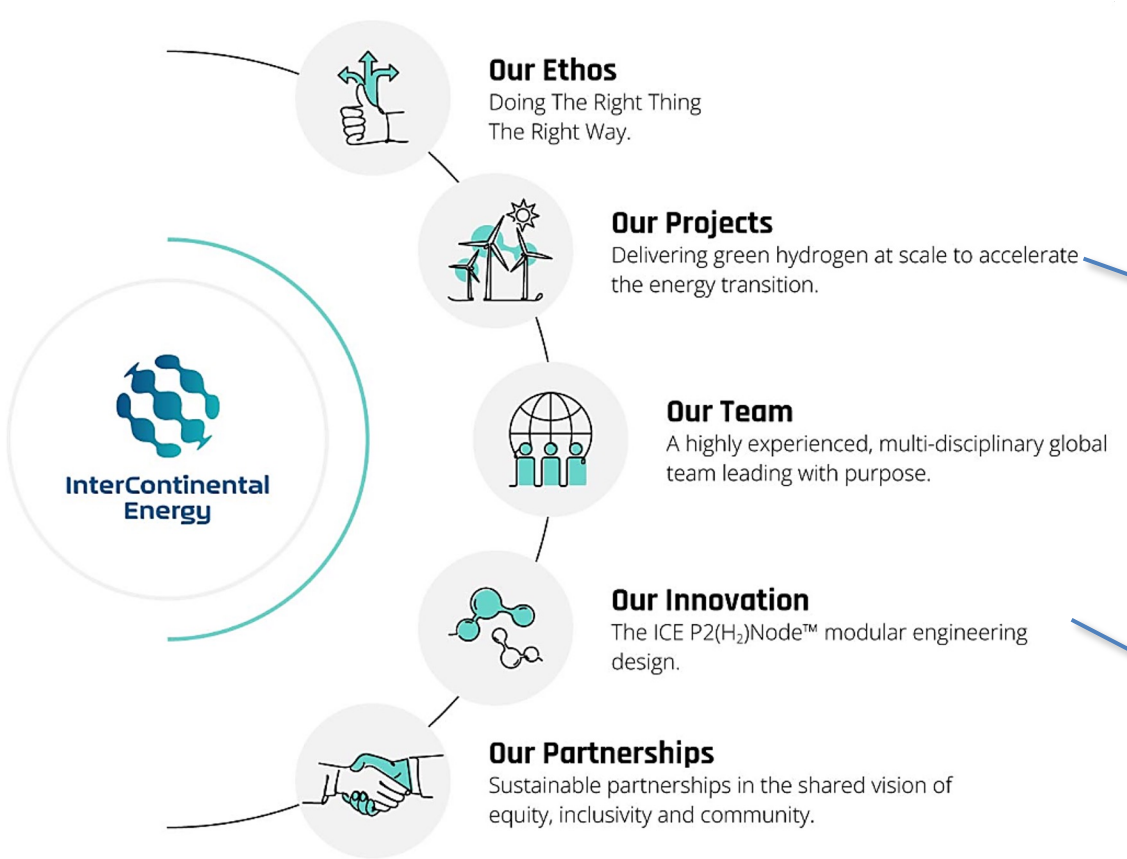
1. Annual Statement of Progress
2. Partnering internationally to supply hydrogen
   > **Partnerships** with Germany, India, Japan, The Republic of Korea, Singapore, UK, US, The Netherlands
3. Guarantee of Origin scheme
4. Building **regional hydrogen hubs**
   >7 Hydrogen Hubs (including **Pilbara, Western Australia**) and 9 Development & Design projects announced. An additional Hydrogen Hub still to be determined
5. Improving hydrogen regulation
6. Better informing the market and Australians
7. Progressing the hydrogen industry

Totals	Number of PJ	Hydrogen specific support	Hydrogen eligible support	as of Jan 2023
Commonwealth	36	$ 1,589,377,972	$ 27,057,000,000	
States &Territories	72	$ 4,661,293,665	$ 8,141,400,000	
Total	108	*$ 6,250,671,637*	*$ 35,198,400,000*	
		$ 6.3	$ 35.2	AU$billion
Combined hydrogen specific & eligible support:			**$ 41.4**	**AU$billion**

Sources: Australian Hydrogen Council, https://h2council.com.au/government-hydrogen-policies/
Investor Group on Climate Change, Unlocking investment in the Australian hydrogen industry, 2022
HyResource, Funding, 2023 https://research.csiro.au/hyresource/funding/

Company Overview

- InterContinental Energy, founded in Singapore in 2014, is a developer pioneering large-scale green fuel hubs. Its offices are in Perth (Australia), London (UK), Dubai (UAE), and Muscat (Oman)
- Its four projects are under development and none of them have started operations



Australian Renewable Energy Hub (AREH)
- -up to 26GW renewable energy and 1.6 Mt of greenH2 production is planned
- -Adjacent land was granted from the government in Jan 2023.

Western Green Energy Hub (WGEH)
- -up to 50GW renewable energy and 3.5 Mt of greenH2 production is planned
- -Indigenous Land Use Agreements is scheduled for 2023.

Green Energy Oman (GEO)
- -up to 25GW renewable energy and 1.8 Mt of greenH2 production is planned
- -Shell took 35% of share in Jan 2023

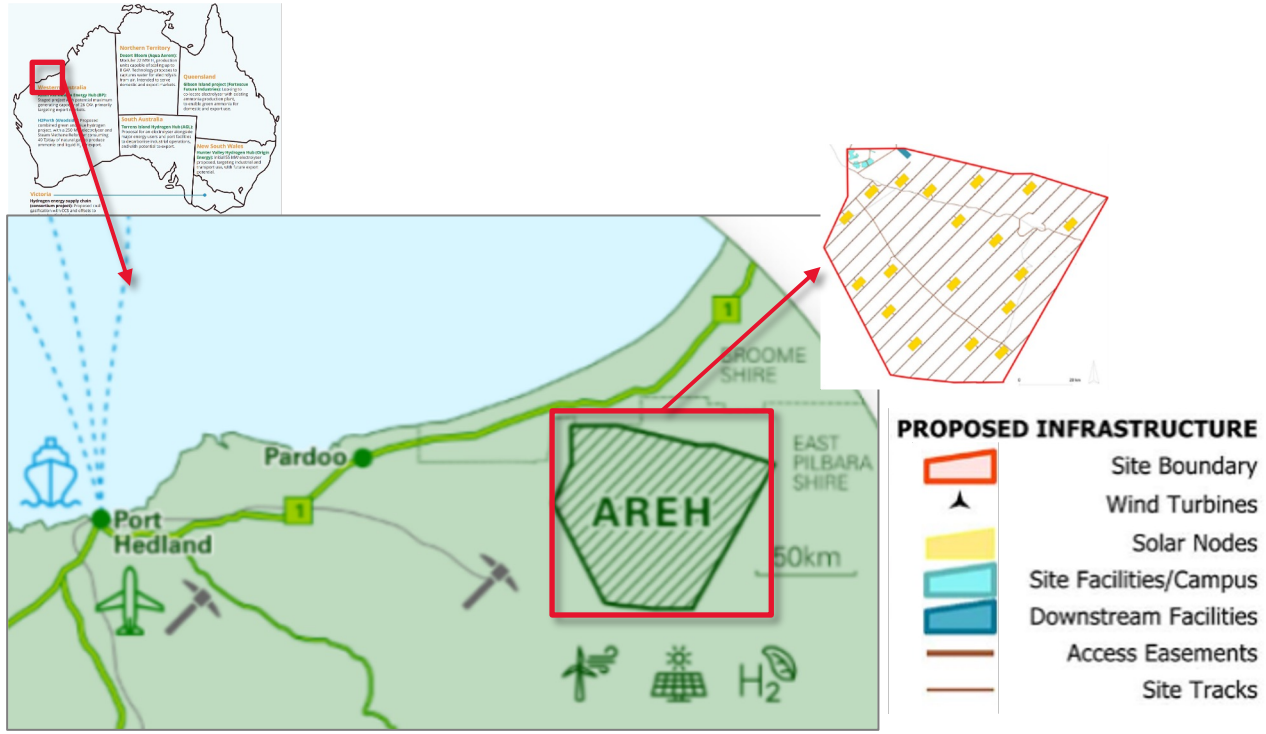
Saudi-Arabia Renewable Energy Hub (SAREH)
- -except the media release in 2021, no information on the site

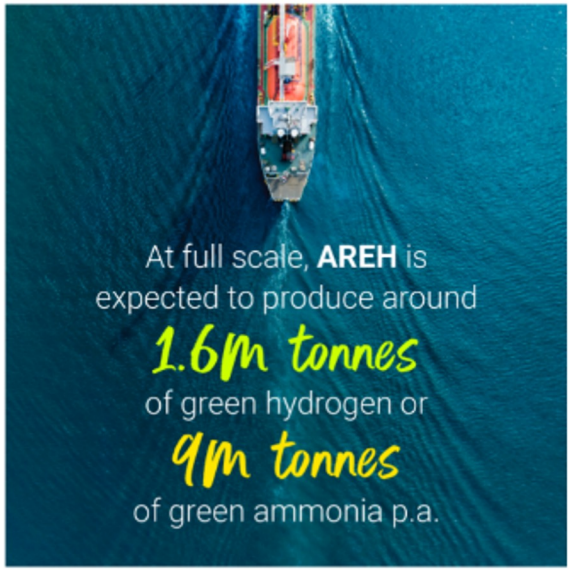
The ICE P2(H2) Node™ is an innovative modular engineering transmitting renewable energy from in molecular, rather than electrical form, which minimises electrical losses in the system

Source: https://intercontinentalenergy.com

Project Overview

- Australian Renewable Energy Hub (AREH) site encompasses 6,681 km^2 of land in the East Pilbara region of Western Australia, and sits alongside the Nyangumarta Highway approximately 200 km east of Port Hedland. It is on the traditional lands of the Nyangumarta People
- The AREH project proposes construct and operate a large-scale wind and solar hybrid renewable energy facility, developed in phases up to 26GW of renewable energy generating capacity (90TWh/year) and 1.6 million tonnes of hydrogen (9 million tonnes of ammonia) production, which is expected to abate around 17 million tonnes of carbon per annum in global markets
- The project proponent comprises bp (a 40.5% share, operator), InterContinental Energy (26.4%), CWP Global (17.8%) and Macquarie Capital and Macquarie's Green Investment Group (15.3%)

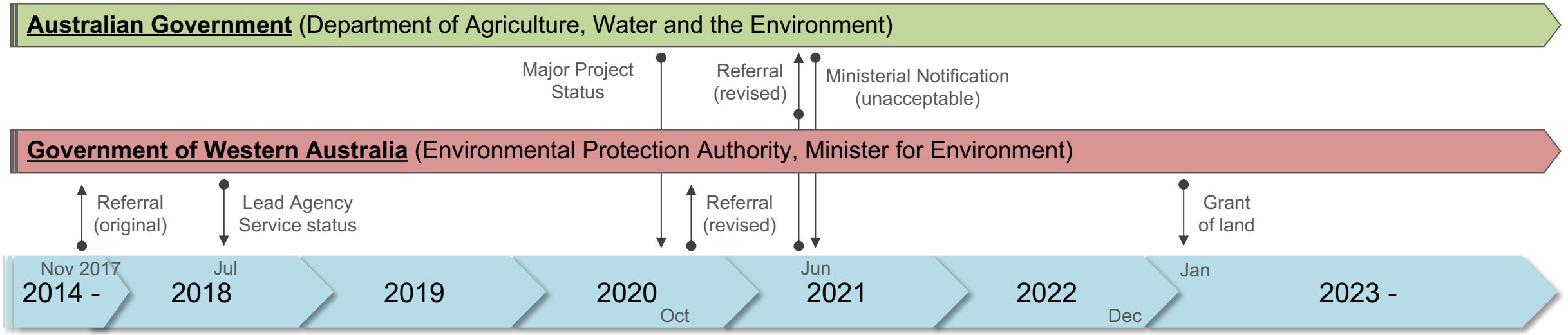




Sources: https://intercontinentalenergy.com/our-portfolio
https://www.bp.com/en_au/australia/home/who-we-are/reimagining-energy/decarbonizing-australias-energy-system/renewable-energy-hub-in-australia.htm

Trajectory of the Project

- The AREH project, starting in 2014, has experienced three phases in terms of the composition of proponents
- Upon the unacceptance of revised referral by the federal government in Jun 2021, a minister of WA expressed concern that this decision could be a false signaling to the Australian hydrogen strategy



Asian Renewable Energy Hub (original)

-CWP Energy Asia (45%),
-InterContinental Energy (45%),
-Vestas (10%)

Asian Renewable Energy Hub (revised)

-InterContinental Energy (46.4%),
-CWP Energy Asia (43.9%),
-Pathway Investments (7.3%),
-Vestas (2.4%)

In July 2021, InterContinental Energy, CWP Global, and Mirning Green Energy Limited announced the Western Green Energy Hub project, whose capacity reached 50 GW.

Australian Renewable Energy Hub

-bp (40.5%),
-InterContinental Energy (26.4%),
-CWP Global (17.8%),
-Macquarie Capital and Macquarie's Green Investment Group (15.3%)

Trajectory of the Project (detailed)

InterContinental Energy

- 2014 — Initiation of Asian Renewable Energy Hub project with 6GW renewable energy generation capacity and subsea electricity cables from Australia to Singapore and Indonesia
- Nov 2017 — Sent an original proposal to Environmental Protection Authority (EPA) of Western Australia (WA)
- Jul 2018 — Awarded Lead Agency Services status by the WA government
- Apr 2020 — Received an assessment report with recommendations for the project from EPA of WA
- Sep 2020 — Awarded Major Project Status by the Australian Government
- Oct 2020 — Acquired the approval of the project from the Minister for Environment of WA
- Oct 2020 — Sent a revised proposal to EPA of WA, which includes the expansion of generation capacity to 15GW (26GW in the future expansion); downstream plants, such as electrolysis plants, desalination plants, ammonia production, and hydrogen and ammonia storage; offshore infrastructure, including pipelines and export buoys; and the abolition of subsea cables to South East Asia. The concept of the High Voltage Direct Current to Asia had pivoted to hydrogen export in 2018.
- May 2021 — The revised proposal documentation was submitted to the Australian Government Department of Agriculture, Water and the Environment in line with the Environment Protection and Biodiversity Conservation Act
- Jun 2021 — Ministerial Notification noted that the revised project scope was unacceptable
- Jun 2022 — Announced that bp would take a 40.5% of share and operatorship
- Dec 2022 — Completed the acquisition by bp and Renamed to Australian Renewable Energy Hub
- Jan 2023 — Granted 2.72 km2 of land in the Boodarie Strategic Industrial Area for export facilities from the WA government

Details of the Project Revision in Oct 2020

- Due to the revision, the Australian Government Department of Agriculture, Water and the Environment concluded in Jun 2022 that the revised proposal would have an unacceptable impact on the ecological character of the Eighty-mile Beach Ramsar site (protected under sections 16 and 17B of the EPBC Act) and migratory species (protected under sections 20 and 20A of the EPBC Act)

Category	Original Approved proposal	Revised proposal	Change
Export	**Direct via undersea electricity cable**	**Downstream production of ammonia and hydrogen to be loaded on ships**	**+ Ammonia chemical processing plant, desalination plant, expanded 5-pipeline and offshore export infrastructure, up to 250 ship calls per year**
Workforce	Fly-in fly-out (FIFO) model	Establishment of a new town for up to 8000 workers within a 2,095 ha development envelope	+ Permanent new town
Development envelope	662,400 ha	666,038 ha	+ 3,638 ha
Permanent clearing	11,962 ha	20,810 ha	+ 8,843 ha (3,380 ha from the town and heavy industrial area)
Temporary clearing	592 ha	492 ha	- 100 ha
Partial clearing (management)	15.3 ha	345 ha	+ 329.7 ha
Eighty-mile Beach disturbance	0.2 ha	Undefined	
Wind turbines	1,743 turbines 800m apart	1,743 turbines 700m apart	- 100m in-line turbine spacing
Solar	Up to 2,000 MW solar PV in 37 x 55 MW modules	Up to 10,800 MW solar PV in 18 x 600 MW arrays	Fewer, larger arrays

Sources: https://www.epa.wa.gov.au/proposals/asian-renewable-energy-hub-revised-proposal
https://www.agriculture.gov.au/sites/default/files/documents/23611.pdf