Unlocking Low-Carbon Hydrogen Potential In Developing Countries

October 26, 2022

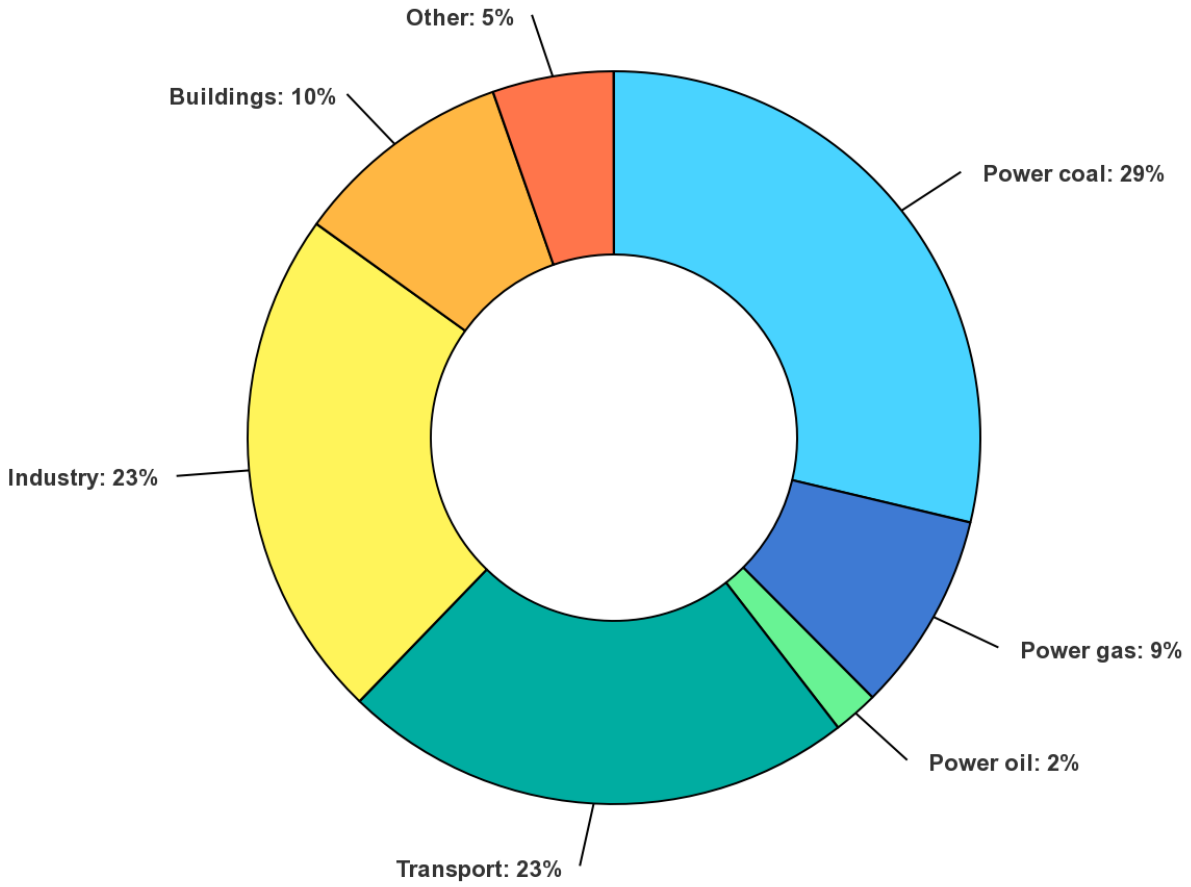
WORLD BANK GROUP
THE WORLD BANK IBRD • IDA
IFC International Finance Corporation

ESMAP
Energy Sector Management Assistance Program

LOW-CARBON HYDROGEN DEPLOYMENT PROVIDES A HISTORIC OPPORTUNITY TO TRANSFORM MACRO-ENERGY SYSTEMS

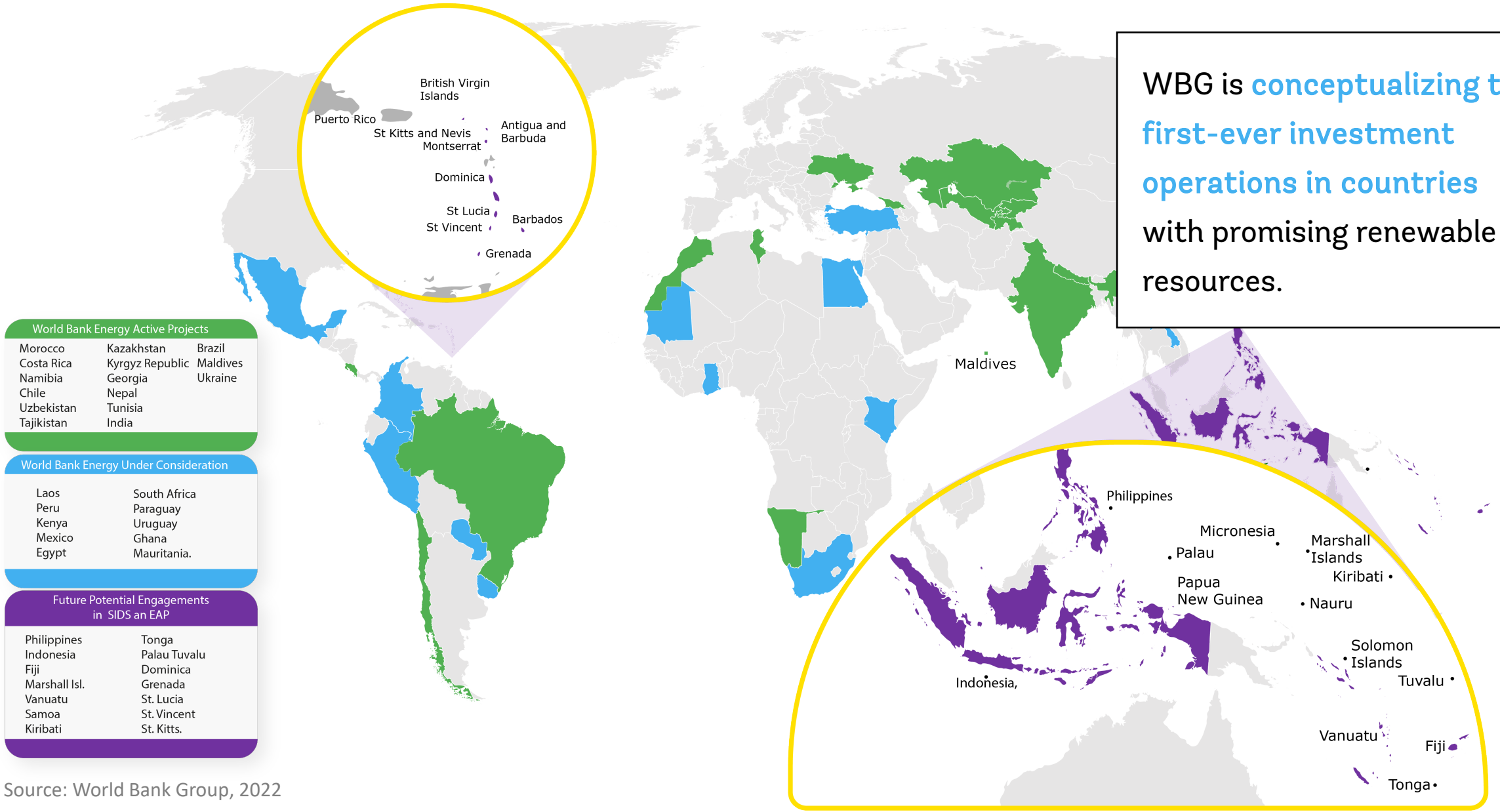
- Hydrogen has a crucial role in assisting developing countries in reaching net-zero emissions globally
- Key drivers include:
  - Global energy mix likely to shift towards electricity (3x projected electricity demand by 2050[1]) and hydrogen (94 MT in 2021; 4-6x projected hydrogen demand growth by 2050[2])
  - Rapid decline in the cost of renewables allows for improved competitiveness with traditional fossil-based generation
  - Unprecedented interest from developing countries to advance low-carbon hydrogen deployment
- Growth in end-use sectoral applications for H2 (mainly power and transport sectors)[3]
- Opportunity to decarbonize hard-to-abate sectors (heavy industry and long-distance transportation) while reducing reliance on imported fossil fuels
- Hydrogen allows for mitigating the intermittency of renewable energy sources and offers a long-term energy storage solution in island locations

Industry, power, and transport account for ~86% of the global energy-related CO2 emissions by sector[4].



Sources: 1. and 2. McKinsey 2022; 3. WBG Report 2020; 4. IEA, 2021

WBG Supporting 20 Developing countries to understand the role of low-Carbon hydrogen in end-use sectors



WBG is **conceptualizing the first-ever investment operations in countries** with promising renewable resources.

World Bank Energy Active Projects

Morocco	Kazakhstan	Brazil
Costa Rica	Kyrgyz Republic	Maldives
Namibia	Georgia	Ukraine
Chile	Nepal	
Uzbekistan	Tunisia	
Tajikistan	India	

World Bank Energy Under Consideration

Laos	South Africa
Peru	Paraguay
Kenya	Uruguay
Mexico	Ghana
Egypt	Mauritania.

Future Potential Engagements in SIDS an EAP

Philippines	Tonga
Indonesia	Palau Tuvalu
Fiji	Dominica
Marshall Isl.	Grenada
Vanuatu	St. Lucia
Samoa	St. Vincent
Kiribati	St. Kitts.

Source: World Bank Group, 2022

WBG HAS BEEN PIONEERING OVER THE YEARS TO ACCELERATE LOW-CARBON HYDROGEN DEPLOYMENT IN DEVELOPING COUNTRIES

Global Knowledge

- Green Hydrogen reports with viable opportunities.
  - Report on Green Hydrogen in Developing Countries
- Development of guarantees of origin.
  - Support Chile, India, and Colombia to comply with international standards
- Access to international and regional platforms.
  - Mission Innovation and H2LAC

Technical Assistance

- Development of Strategies and Roadmaps nationally and regionally.
  - India, Morocco, Oman, Qatar, Saudi Arabia, UAE.
- Policies, regulations, and standards to boost offer and demand.
  - Mauritania, Tunisia, Brazil, Uzbekistan, Morocco.
- Capacity building to develop hydrogen projects.
  - Chile, Colombia, Costa Rica, India, and Namibia

Financing

- Concessional financing for large scale projects, through IFC.
  - South Africa, Barbados, Mexico
- Concessional finance for governments.
  - Chile , India, Namibia
- Mobilize climate funds and other concessional resources.
  - CIF, GEF, SDG Partnership, SFLAC, GCF

SUPPORTING LOW-CARBON HYDROGEN AROUND THE GLOBE

Chile

Design a Green Hydrogen Facility of 1 billion USD ($300 M by WB) to leverage the low cost of renewable electricity ($1.2 cents) and position Chile as one of the global cheapest producer of hydrogen.

Namibia

Support the role of the government as strategic equity partner ($4 million USD by ESMAP), targeting a 24% equity shareholding in Hyphen's project, which is a $9.4 billion project to produce green ammonia.

Morocco

Develop feasibility analysis to export green hydrogen to Europe/India and implement a cross-border roadmap, taking advantage of the low cost of RE.

India

Inputs to the Roadmap for Green Hydrogen Adoption in India, **five key sectors have been identified** (Fertilizer, Refineries, Steel, Methanol and Transport).

Mapping of Demand and Supply Centers.

Bridging the Cost Gap between Grey and Green Hydrogen.

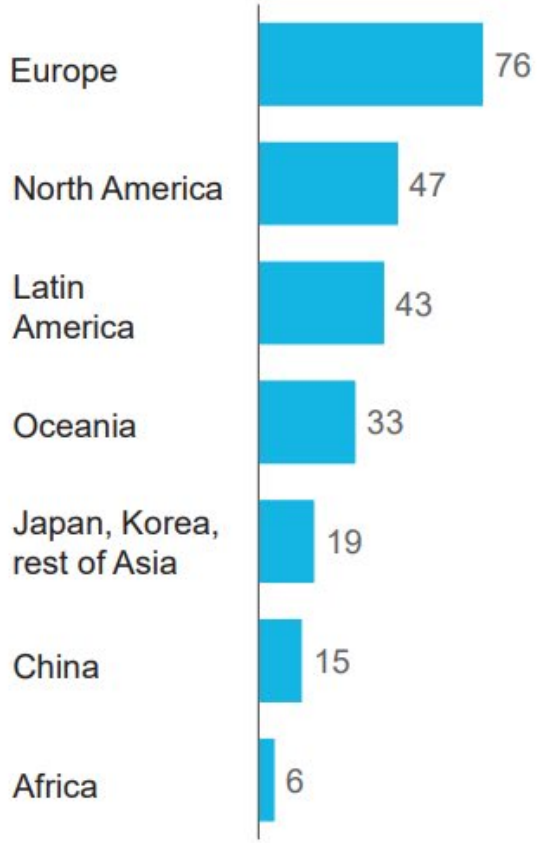
Brasil

Regulatory work with the State of Ceara to advance the policy and regulatory framework (**certification, use of water, value chain mapping**) as well as financing schemes to position as a bunker fueling hub.

PROJECT IMPLEMENTATION IS LAGGING AND MORE SIGNIFICANTLY IN DEVELOPING COUNTRIES…

USD 240bn

investments required for announced projects until 2030



# of projects

- **51** Giga-scale production
- **262** Large-scale industrial use
- **128** Transport
- **53** Integrated H_2 economy
- **40** Infrastructure projects

Source: Hydrogen Insights Report, 2022, Hydrogen Council, McKinsey

MOREOVER, ONLY ~10% OF COMMITMENTS HAVE ACHIEVED FINAL INVESTMENT DECISION

USD 22bn

investments until 2030, related to committed projects

Europe	6
North America	8
Latin America	<1
Oceania	<1
Japan, Korea, rest of Asia	6
China	2
Africa	<1

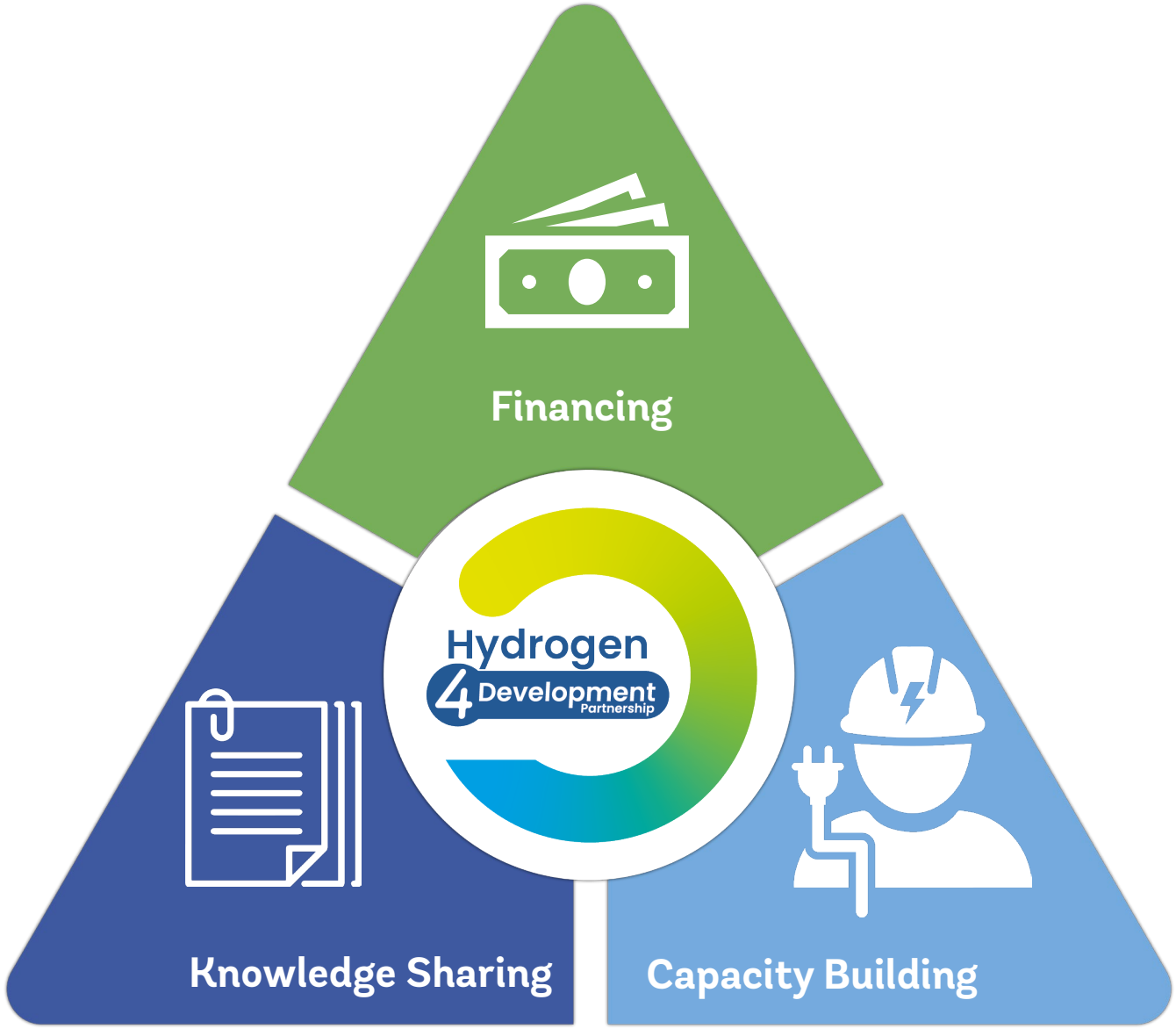
# of projects

- **3** Giga-scale production
- **77** Large-scale industrial use
- **61** Transport
- **29** Integrated H_2 economy
- **19** Infrastructure projects

Source: Hydrogen Insights Report, 2022, Hydrogen Council, McKinsey

THE HYDROGEN FOR DEVELOPMENT (H4D) PARTNERSHIP

- A platform to accelerate investments in low-carbon hydrogen deployment projects
- Realizing the full potential of hydrogen requires a direct investment of ~$700B by 2030[1]
- Projects and government support worth $160B have been announced already, leaving a gap of nearly $540B[2]
- The WBG identifies its necessary to provide:
  - Innovative and concessional financing schemes (blended finance and climate funds)
  - Financial mechanisms to mitigate risks perceived by developers and financiers
  - Access to grants will be essential for non-ODA frontrunning countries, which will serve as models for middle and low-income countries (i.e., Chile)



Sources: 1,2 - McKinsey, 2021

ROLE OF CONCESSIONAL CLIMATE FINANCE

- Given the nascent market conditions, technology costs and risks, concessional climate finance will play a key role in stimulating the green hydrogen market in developing countries.

- CIF has been a leader in providing such support in many areas including concentrating solar power, geothermal, energy storage etc. so is well suited to provide this catalytic support to public and private investments in green hydrogen.

- A dedicated program for green hydrogen development could be considered under the CIF to support countries similar to the CIF Global Energy Storage Program (GESP) that has a goal of US$ 1 billion in concessional climate financing .


Any
Question

Thank You!

Demetrios Papathanasiou

Global Director

Energy and Extractives Global Practice

WORLD BANK GROUP

THE WORLD BANK IBRD • IDA | IFC International Finance Corporation

ESMAP

Energy Sector Management Assistance Program

Green H2 and industrial decarbonisation - EBRD view/experience

Gianpiero Nacci
EBRD - Climate Strategy and Delivery

European Bank
for Reconstruction and Development

Supporting low carbon fuels is one of the EBRD's priority areas of focus

European Bank
for Reconstruction and Development

A GROWING MARKET FOR GREEN HYDROGEN

Growing interest on hydrogen as a **green feedstock** and a clean, storable, transportable **energy vector**

Clean hydrogen is a critical component for various **hard-to-decarbonise sectors**

Technology is **reaching maturity quickly** and investment announcements have significantly accelerated

MAIN BARRIERS

- From the producer side - **uncertainty in offtake** agreements
- From the offtaker side - need for **24/7 reliability**
- On both sides - still significant **green premium**

EBRD SUPPORT

Work with private sector developers and Governments in identifying **hotspots** for cost-competitive production, end-user uptake and transportation

Support policymakers creating fair, transparent and rewarding **regulatory and market frameworks**

Work with TSOs on repurposing of existing gas infrastructure

Provide TA for projects origination and early development (technical, environmental, commercial, legal studies)

Consultation on planning/permitting

Connect FDI organisations with local partners/players

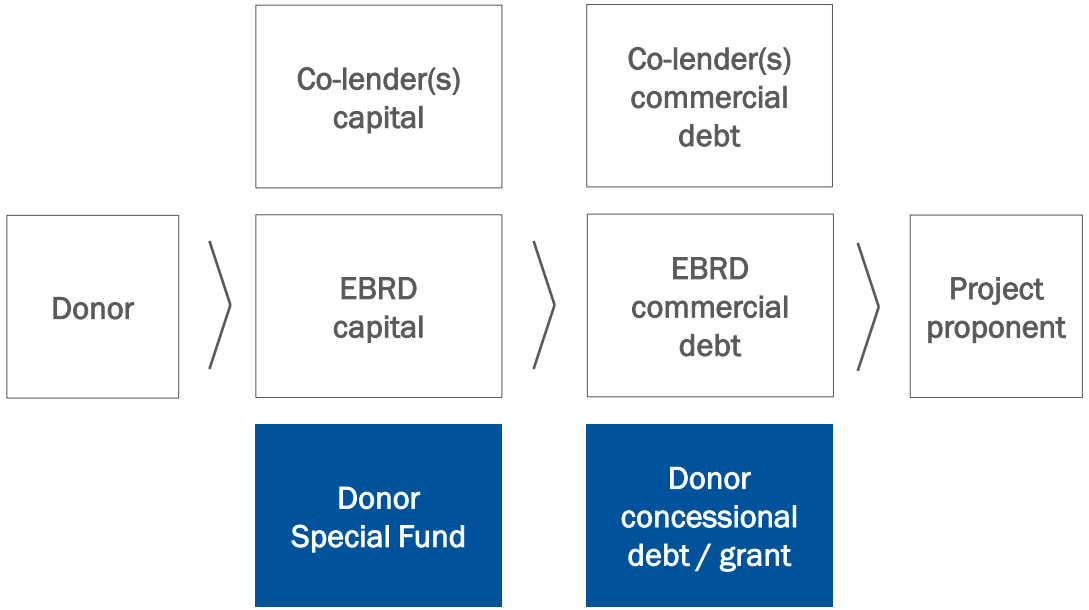
Direct financing of projects

EBRD financial instruments for LC-H2 projects

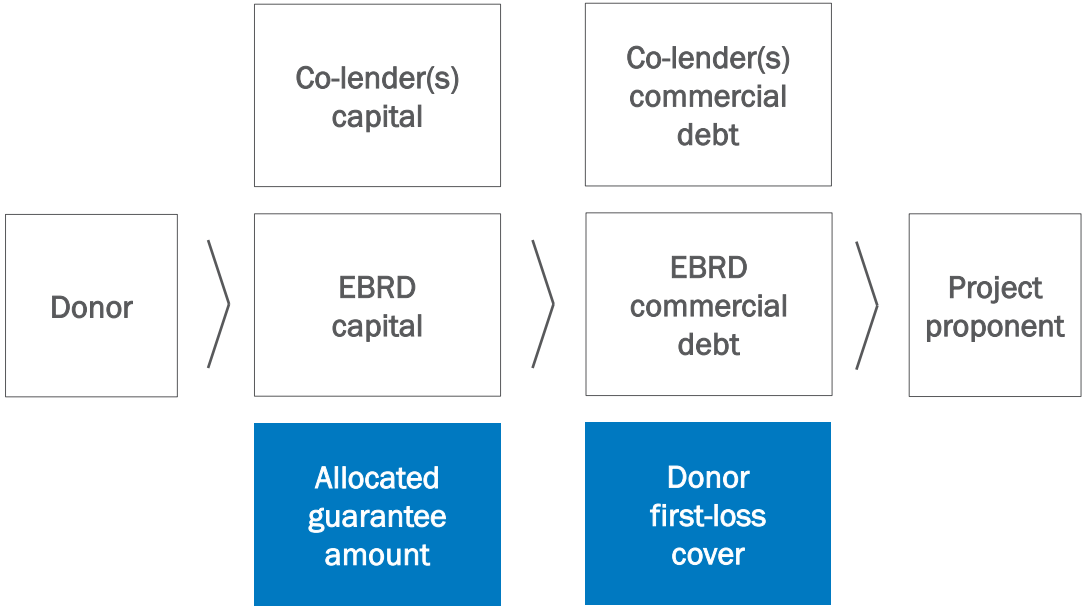
European Bank
for Reconstruction and Development

Besides project finance we need to offer the following financial instruments:

BLENDED FINANCE



GUARANTEE + PROJECT FINANCE

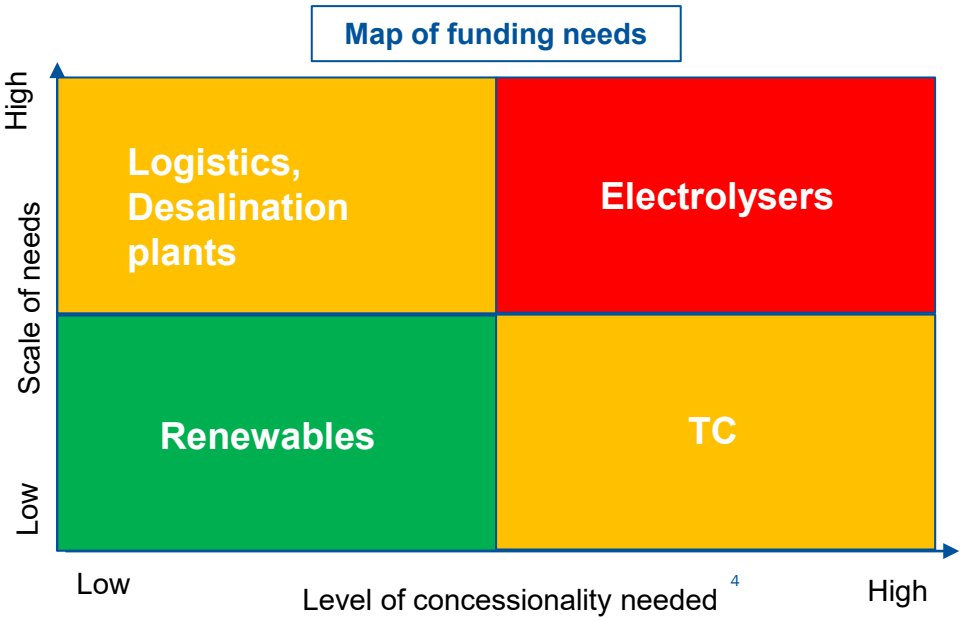


Funding needs for low carbon fuels

European Bank
for Reconstruction and Development

Why do we need concessionality?

- **Green premium:** Low carbon fuels, including green hydrogen, represent a substantial green premium compared to fossil fuel-based options, thereby reducing the viability of investment opportunities for offering a competitive green alternative.
- **Early stage of development:** Lack of supply chains, no implementation track-record, absent or uncertain off-take arrangements, underdeveloped policy environments, water availability, lack of logistics and network infrastructures introduce further barriers to the market's development.



What is the current situation?

- **Projects:** EBRD's first project expected to reach FC by Q1 2023 - huge Hydrogen Hub project in development in Egypt.
- **Market studies:** The EBRD has also been involved in scoping exercises, assessing potential of its CoOs to become significant players in this emerging market. Analyses confirmed that there is a significant potential in some geographies.
- **Funding:** While Green H2 and low carbon gases is a priority area for donors, and support is currently provided through select facilities (e.g. CTF High Impact) or proposals in negotiation (EFSD+), gaps emerge due to the very large capital outlays these projects entail

What is the outlook?

- **Projects in the pipeline:** There is a large pipeline of projects on the horizon, primarily in the **SE Med region**. They need an element of donor support to bring to the market the first projects of their kind and address first mover externalities – similar to those faced by renewable projects 20 years ago, but of a different scale of support.
- **Need for instruments:** The smallest green hydrogen project being developed in the EBRD region has total costs of €350m, thus 'usual' contributions translate to very low grant intensity in supported projects. The first projects need grant support to be viable, but as the market develops there will be more need for risk-sharing instruments (guarantees, CfD-like schemes).

Regional focus – North Africa

European Bank
for Reconstruction and Development

Opportunity

- North Africa has **world class wind and solar resources at a vast scale.** Most of the renewable energy potential is untapped and cost-competitive vs. fossil fuels generated power.
- Ideal geographical location to **reach the EU market for green products.**
- **Unlock the value of natural resources:**
  - Create domestic production of green products (e.g. green steel, fertilisers) and energy carriers (e.g. hydrogen, eFuels, ammonia)
  - Make available natural gas for targeted high-value use or exports
- Mitigate the impact of the imminent **Carbon Border Adjustment Mechanism** (CBAM), which could put steep extra costs on exporters of energy intensive products

Enablers

- **Market structure** that support long term investments (e.g. long term off-take agreements, domestic and international).
- **Large investment tickets** to cover infrastructure needs (integration, storage, transmission), new industrial capacity (e.g. green hydrogen / ammonia), and inefficient and carbon intensive assets to be replaced by clean power and fuels.
- **Regulatory and policy framework** to provide confidence to investors, including enhanced decarbonisation commitments

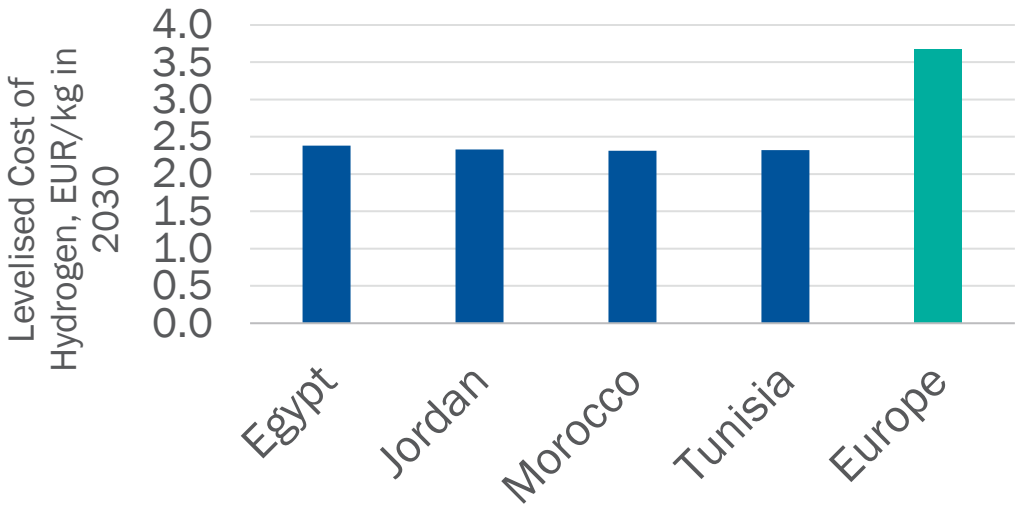
Pathway

Increase supply from renewables to decarbonise the economy and produce green fuels and industrial feedstock, while freeing up natural gas for high added-value uses.

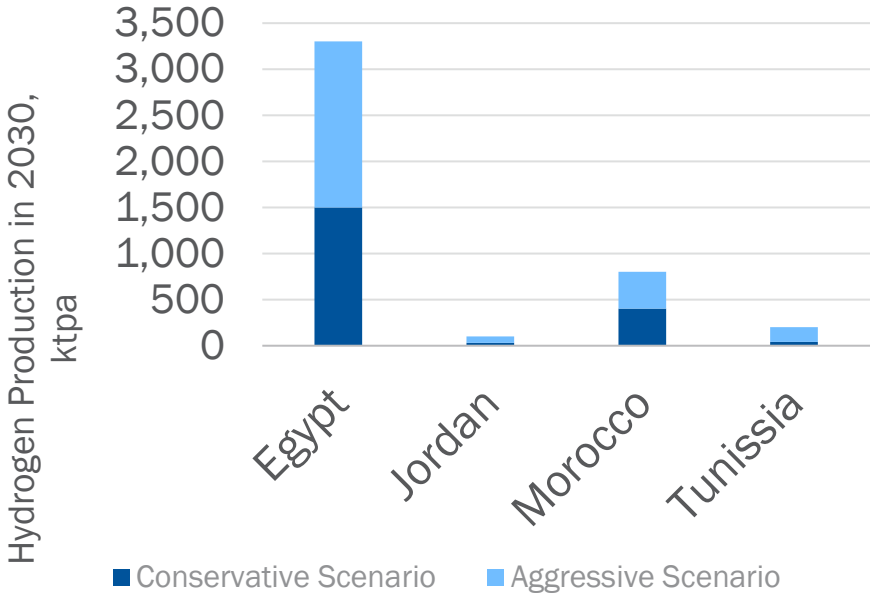
North Africa - low hydrogen production cost and high potential in 2030

European Bank
for Reconstruction and Development

Hydrogen production cost would be > 50% cheaper than in EU

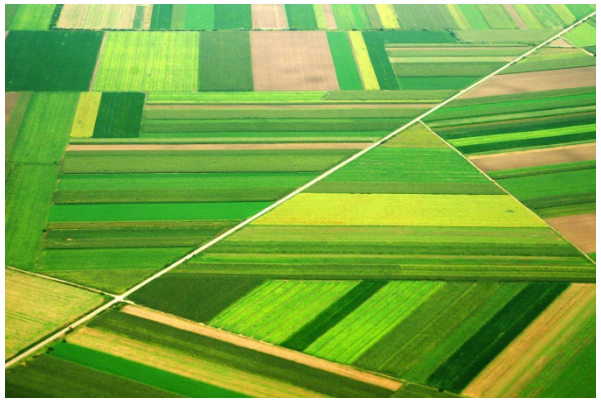


Projected electrolyser capacity in Egypt and Morocco is estimated at 16-34 GW and will require some €12-27 billion investment



Examples of supported project archetypes – green H2 and derivatives

European Bank
for Reconstruction and Development



Grey-to-Green ammonia production

Project:

- Substitution of conventional hydrogen production with renewable hydrogen in an existing ammonia plant
- Electrolyser capacity: 100 MW
- Power: 260 MW of dedicated wind and solar capacity connected via HV grid.
- Total project value: ca. $390 million

EBRD support:

- Technical assistance for project preparation
- Support for grant application
- Equity bridge loan and senior loan

Suez Canal EZ hydrogen hub

Project:

- Development of a green hydrogen/green ammonia production hub in the SCZONE.
- The implementation will follow a phased approach: 2.5 GW electrolyser capacity by 2026; 13.5 GW by 2030

EBRD support:

- Technical assistance focused on land development, shared facilities, commercial arrangements
- Cooperate with SCZONE and consortia towards implementation.
- Financing (tbd)

Repurposing of existing gas infrastructure

Project:

- Support national TSOs to develop future-proofing plans for the repurposing of existing infrastructure and the development of hydrogen-ready projects

EBRD support:

- Technical assistance to assess the readiness of the national gas transmission system to transfer hydrogen and to identify the required investments
- Senior loan for hydrogen-ready pipelines

Green methanol for shipping

Project:

- Green methanol production using biogenic CO_2 and renewable electricity
- Location: North Africa

EBRD support:

- Technical assistance for scoping/basic design
- Continuous support for progressing towards investment decision
- Financing (tbd)

Sustainable materials and products

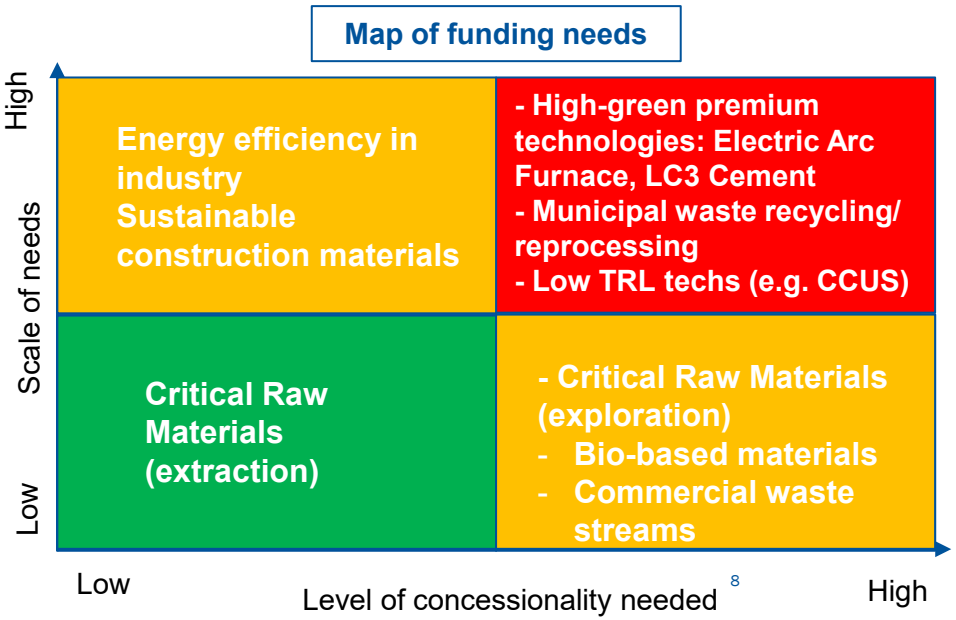
European Bank
for Reconstruction and Development

Why do we need concessionality?

- **Green premium:** use of low-carbon gases is not the only way of minimising environmental impact of industry; while other methods for transiting towards sustainable materials and products exist, they are also not cost competitive yet. Reduction of GHG emissions may also be achieved e.g. through deployment of electric arc furnaces (EAF). Other solutions relate to circular economy (from design to sourcing), bio-based products or alternative materials
- **Catalysing effect:** costs of different low-carbon technologies tend to decrease with their growing deployment, but first movers usually need to be incentivised – once the technology enters the local market, others might become more eager to follow

What is the current situation?

- **Projects:** to date most projects have taken place in **EU CoOs,** e.g. decarbonisation of steelmaking process in Slovenia through investment in EAF (syndicated € 230 m LT debt facility); construction of recycling facilities for li-ion EV batteries in Poland (TPC: € 182 m)
- **Funding:** High Impact facilities co-funded by GCF and CTF together with HIPCA can be tapped into for projects in most CoOs **outside EU**. Nevertheless, so far it has been difficult to find appropriate projects.



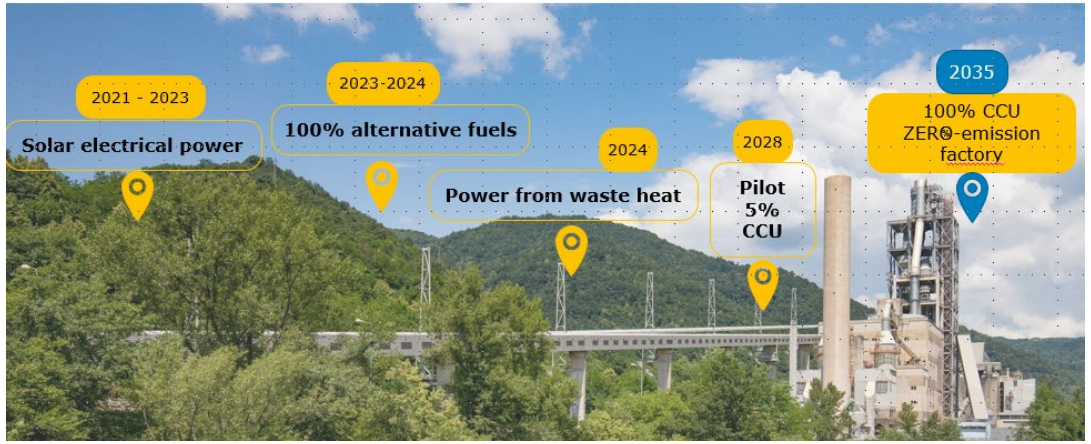
What is the outlook?

- **Projects in the pipeline:** projects aiming at deep decarbonisation of industrial operations may require support with high grant intensity to cover extra expenses related to still immature technology: deployment of **CCS** at the cement production plant in **Bulgaria** (TPC: €200 m); transformational EE investments by steelmaker in **Kazakhstan** (TPC: $200 m)

- **Need for instruments:** Large grant needs for high capex items such as CCUS, green steel, green cement. Within the EU these may partly rely on the ETS and CBAM mechanisms to be feasible, in addition to the support from the Modernisation and Innovation Funds. In countries where such market mechanisms are not yet in place, dedicated support is necessary to ensure that such priority pilot projects are not rendered infeasible. Performance linked loans, guarantees and targeted grants can provide the necessary incentives.

Examples of supported project archetypes – Sustainable Materials

European Bank
for Reconstruction and Development



Green cement production

Project: a number of investments as part of the client's long-term decarbonisation strategy, which would allow cement production with (near) zero GHG emissions, both in terms of energy and process emissions:

- Phase 1: 100% alternative fuels & solar power, as well as testing of alternative cementitious materials;
- Phase 2: waste heat recovery and pilot plant for CCUS (5% of emissions);
- Phase 3: zero emission plant with 100% CCUS.

Location: EU

Project size: €250 million (all phases)

EBRD support: Technical assistance for project preparation, debt finance

Raw materials recovery for energy storage

Project:

- Recovery of raw materials for battery production from historic tailings of an old mining operation.
- The project contributes to the diversification of the battery raw materials supply in a sustainable and circular way.
- Stringent ESG standards when compared to other producers.

Location: EU

EBRD support: Equity investment

Contact Details

European Bank
for Reconstruction and Development

Gianpiero Nacci

Director, Sustainable Business and Infrastructure
EBRD - Climate Strategy and Delivery
Email: NacciG@ebrd.com

EBRD, Five Bank Street
London, E14 4BG
United Kingdom
www.ebrd.com

EBRD's low carbon pathways and green hydrogen strategies

European Bank
for Reconstruction and Development

Project	Country	Sector
Azerbaijan LCP for Power Sector	Azerbaijan	Power/Electricity
Egypt LCP for electricity sector	Egypt	Power/Electricity
Jordan LCP for Energy Sector	Jordan	Energy
Kazakhstan LCP for the Power Sector	Kazakhstan	Power/Electricity
Serbia LCP (in the context of NECP) for Power Sector	Serbia	Power/Electricity
Uzbekistan LCP for the Power Sector	Uzbekistan	Power/Electricity
Development of Long Term Renovation Strategies for buildings in Bulgaria	Bulgaria	Buildings
Development of Buildings and Construction Decarbonisation Roadmap in Czech Republic	Czech Republic	Buildings
Egypt LCP for the fertiliser sector	Egypt	Fertiliser
Egypt Oil and Gas Low Carbon Roadmap	Egypt	Energy
IEA-EBRD Global Ammonia Low Carbon Roadmap	Global	Fertiliser
Sectoral Low Carbon Roadmap for Fertiliser Sector	Jordan	Fertiliser
Morocco Low Carbon Roadmap for the Cement Sector	Morocco	Cement
Net zero buildings roadmap	Poland	Buildings

EBRD's low-carbon pathways and green hydrogen strategies

European Bank
for Reconstruction and Development

Project	Country	Sector
Development of National Long-Term Renovation Strategy for Slovak Republic	Slovak Republic	Buildings
Tunisia Low Carbon Roadmap for Cement Sector	Tunisia	Cement
Turkiye Steel and Iron Sector Policy and Technology Roadmap	Turkiye	Steel and Iron
Turkiye Cement Investment Plan	Turkiye	Cement
Turkiye Aluminium Policy and Technology Roadmap	Turkiye	Aluminium
Turkiye Fertiliser Policy and Technology Roadmap	Turkiye	Fertiliser
Uzbekistan LCP for the Fertiliser Sector	Uzbekistan	Fertiliser
IEA Heat Pump Study - World Energy Outlook	All EBRD CoOS	City - District Heating
Egypt National Hydrogen Strategy	Egypt	Hydrogen
Regional Hydrogen Studies	SEMED, WB, Caspian, Uzbekistan, Kazakhstan (Ukraine and Belarus)	Hydrogen

Hydrogen Energy Activities in ADB

24 October 2022

Steve Peters
Senior Energy Specialist (Waste to Energy)
SDSC Energy Sector Group
Asian Development Bank

ADB support for Developing Member Countries (DMCs)

- **Knowledge sharing** (workshop, handbook and other knowledge products) - Policy makers and industry players awareness of trends and technologies, capacity building and safety.
- **Support government policy development** - Strategy, roadmap and regulatory framework for H2 energy development.
- **Enhance the hydrogen trading platform** - Promote international H2 supply chain with competitive market/trading hubs.
- **Engage with industry and associations** – Engage industry and associations on standards and knowledge sharing.
- **Support pilot and scaling up** - Pilot H2 technologies and business models for demonstration and scaling up (feasibility study with consultants). This include Transaction Support Technical Assistance.
- **Support finance** - Finance H2 energy projects, including production, transportation and distribution infrastructure, as well as market applications.

Hydrogen Activities

Knowledge sharing

- H2 energy workshop - Capacity building for DMC government officials, presentation by leading hydrogen engaged companies, and networking as “Friends of Hydrogen”.
- Hydrogen energy handbook - Prepared for project officers outlining role of hydrogen, technologies & products, business model, challenges and risks, policy recommendation. In preparation.

Research

- Study of hydrogen trading market - International H2 supply chain review with focus on potential physical/trading hub in Asia including lesson learnt from LNG market. Setting Long-Term targets/Incentives/Create demand for H2/Infrastructure investment/harmonizing standards. Mobilizing private capital.
- Prefeasibility study on deployment of renewable H2 energy in Pakistan - Identification of available resources/infrastructure, energy solution required including business models suggestion, financial analysis, identify barriers and challenges.

1st H2 energy workshop in Shanghai, 2019

2nd H2 energy workshop in Tokyo, 2020

Ongoing Hydrogen Related Activities

TA 6966-GEO: Preparing Energy Storage and Green Hydrogen Sector Development Program – creating the conditions for green H2 to be generated from abundant renewable energy resources through:

(i) policy and regulatory framework to allow sustainable battery energy storage system (BESS) deployment approved;

(ii) policy, strategy, and regulatory framework to encourage development of green hydrogen with private sector participation developed; and

(iii) sustainable battery energy storage system (BESS) to be installed.

TA 6619-REG: Marine Aquaculture, Reefs, Renewable Energy, & Ecotourism for Ecosystem Services - facilitating future investment in sustainable ocean economy development through two main activities:

(i) assessment of marine resource commercialization prospects (including energy, seafood, and tourism) and identification of investment projects in selected developing member countries (DMCs); and

(ii) review and recommendations on policy and regulatory frameworks to facilitate large-scale investment and on mechanisms to accelerate financing of selected projects

Marine Renewable Energy to H2^{++} (TA6619)

Going beyond renewable wind, solar and hydropower to H_2… Looking to marine renewables and integrating a range of regenerative industries s users of hydrogen.

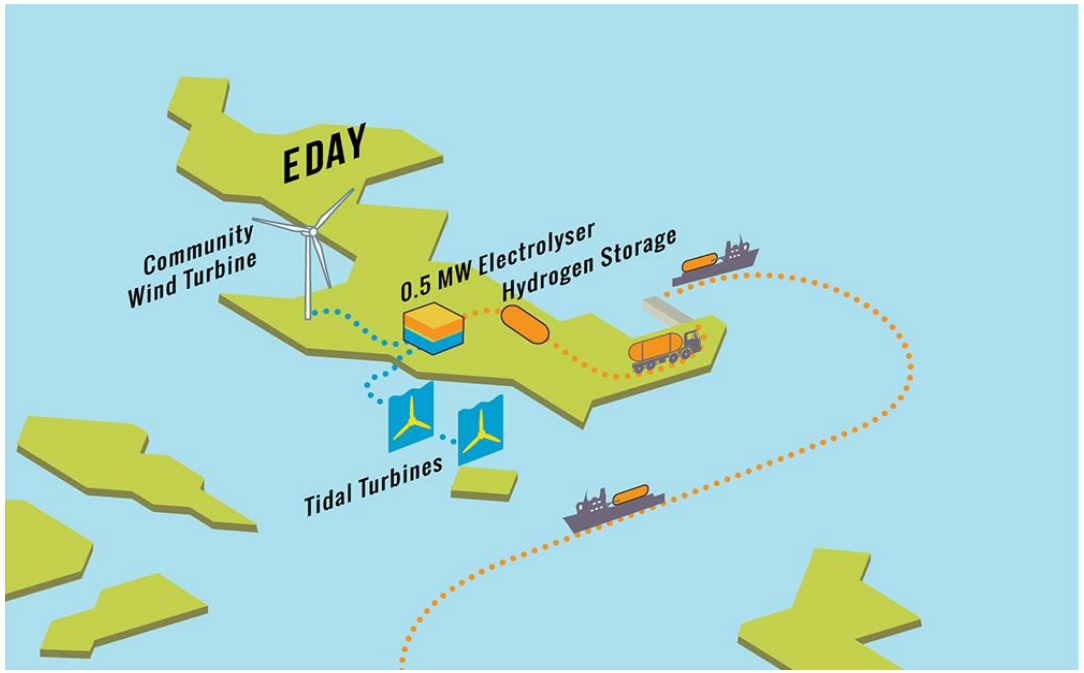
- Using marine energy to make hydrogen and alternative fuels (ammonia, methanol, ethanol – “Fuel to X”)
- Creating export market for the hydrogen, accelerating global green hydrogen development
- Using the fuels locally for transport and industry
- Using the energy locally to accelerate nature-based defenses and marine aquaculture for domestic and export markets while regenerating the ocean surrounding the infrastructure whilst
- Attracting high value tourism to see ocean regeneration in action.

Similar Approaches for Energy Only

The use of marine energy to make hydrogen has been demonstrated successfully in the Orkney islands, Scotland. Orsted, Total and Siemens are expanding capacity in marine power to hydrogen.

https://www.surfnturf.org.uk/
Orkney Islands – Surf ‘n turf hydrogen project

https://www.climatechangenews.com/2020/08/24/orsted-backs-danish-offshore-wind-powered-hydrogen-project/nshore
Orsted’s offshore wind to onshore hydrogen project



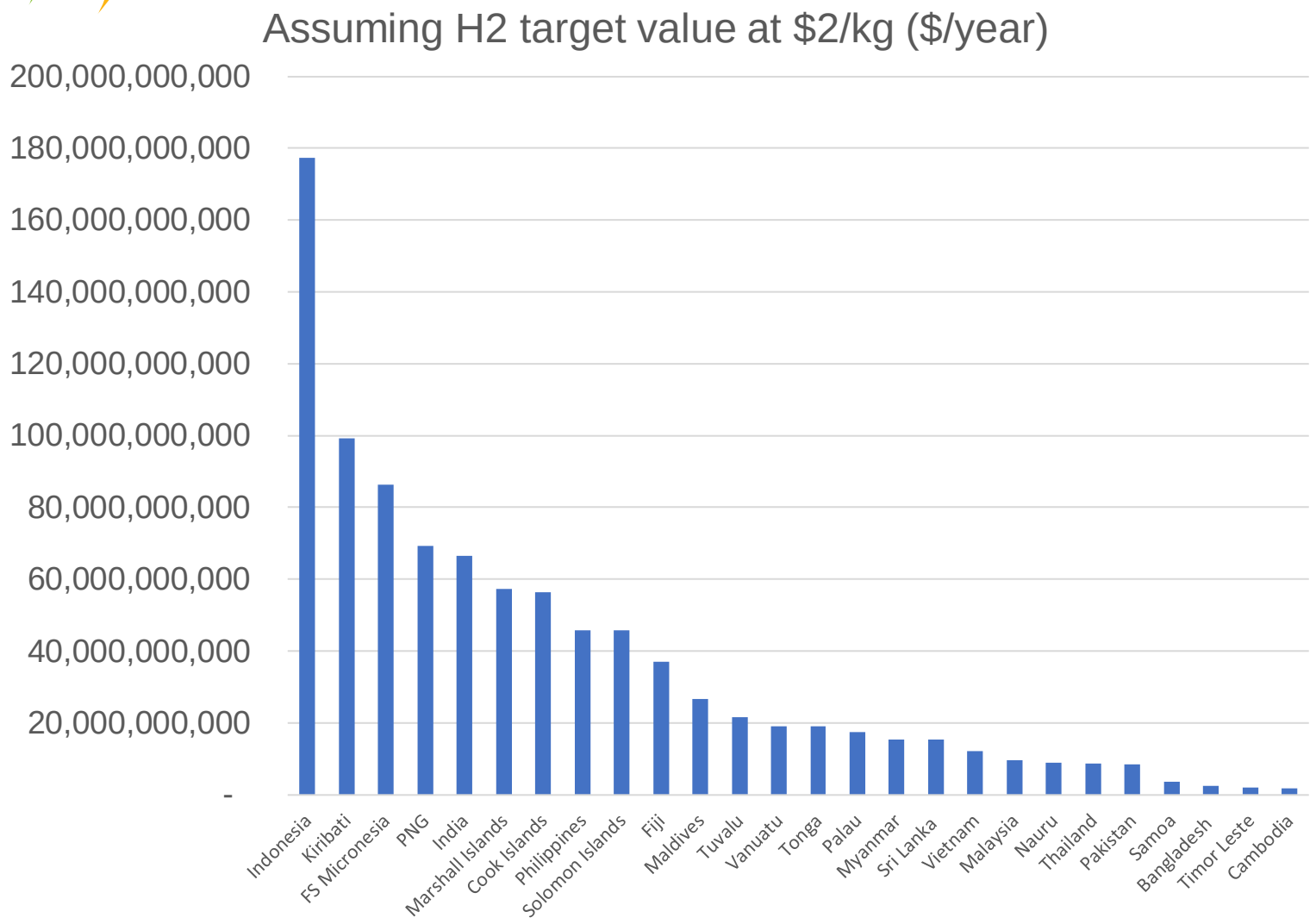
Energy

Fuel for Marine
Transport & Export

Food

Regeneration

Offshore Renewable Energy to H_2 Potential in ADB DMCs



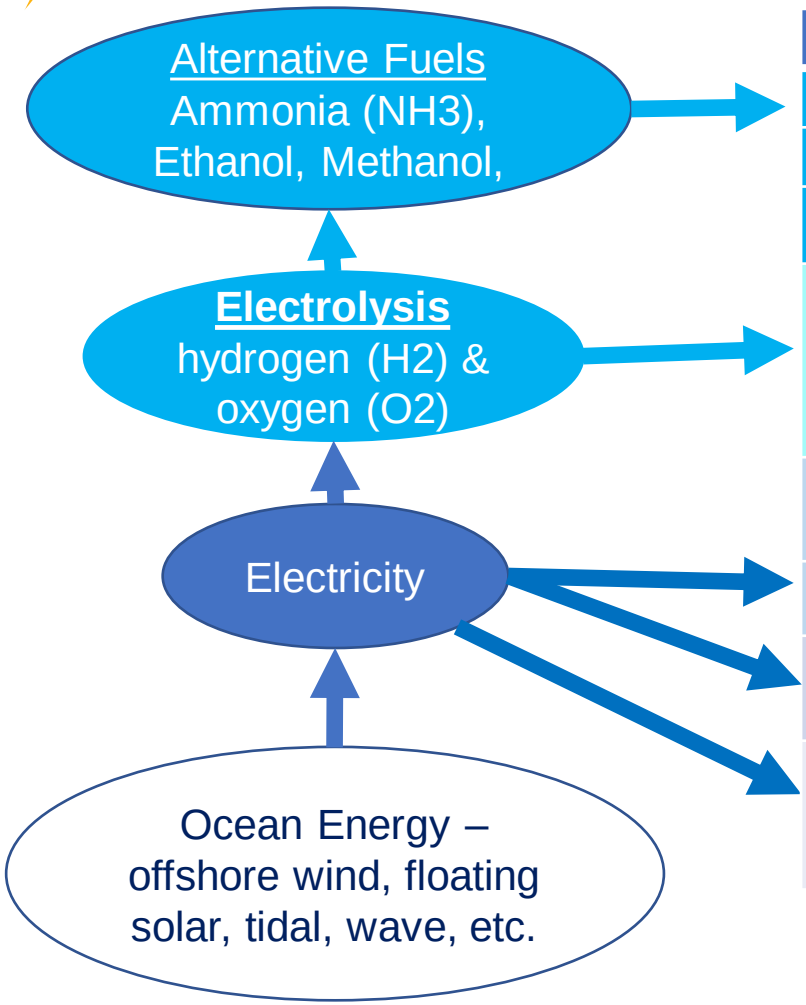
Assumptions:

- 1% of DMCs' EEZ area
- RE @ 50 MW/km2 @ 16% capacity utilization factor
- Conversion @ 50 MWh/ton H2

RESULTS:

- 23,000 TWh/y = current global electricity output!
- displace ~ 40% of global natural gas production (2019)
- avoid ~ 5 Billion tons CO2e/year.
- *New industry with revenues of **$1 Trillion/year.***

Including Regenerative Aspects to H_2 Supply Chain



USE CASE	TA6619 SCOPE	SCALE UP
Marine Transport (Shipping)	Learning from existing business models.	H2 AMC supported for target production price
Aviation Transport		
Local Marine Transport		
Bulk Transport to existing markets for fuels to be sold at commodity prices, albeit with regenerative fuel premium.	Hydrogen Fuel Advanced Market Commitment Fund – (H2 AMC) $Bn to catalyze supply chain and create market for Hydrogen @ US$2/kg	
Nature Based Defenses (coastal zone reefs)	Learning from existing business models.	New Insurance Product Line
Cultivated Reefs (including rigs to reefs)		
Regenerative Marine Aquaculture	Learning from existing business models.	PSOD Industry Support
Wrecks to Reefs	Pacific Blue Shipping Program (US$ 500m) Carbon offset Fund – in development	

DMCs - RMI, MAL, PAL, (THA/INO)

Emphasis on scaling up existing investment/lending outcomes from current and TA derived knowledge base.
Innovation in blended finance to reduce H2 production cost.
Integrating nature-based defenses into mitigation of marine energy infrastructure

Thank you for your kind attention.

Steve Peters, speters@adb.org

For more information on ADB's work on regeneration driven by hydrogen, please visit TA6619's dataroom:

https://events.development.asia/learning-events/adb-data-room-marine-aquaculture-reefs-renewable-energy-and-ecotourism-ecosystem

POTENTIAL FOR GREEN H2 IN AFRICA

Results of case studies and AfDB's role

Gareth Phillips, Manager Climate and Environment Finance

Part 1: Brief overview of CIF funded study: Just Transition in a renewable energy rich environment; potential role of GH2

Introduction

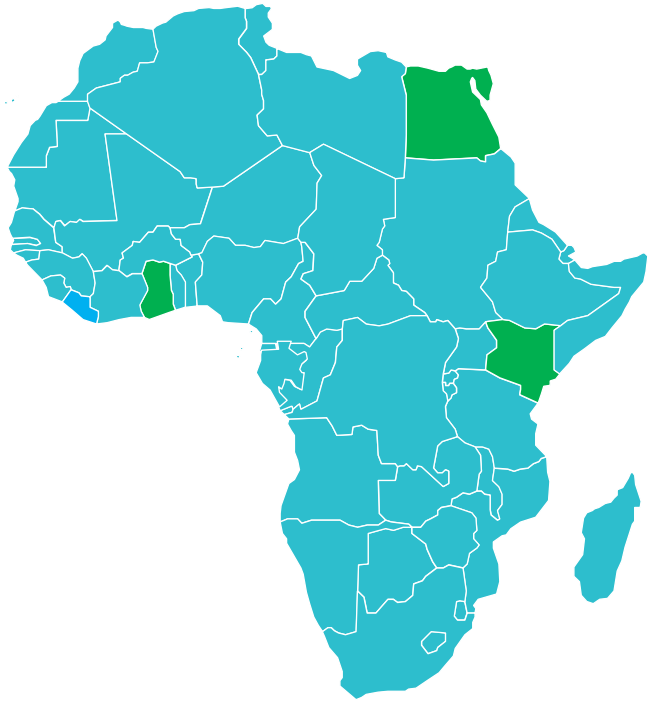
- Global Hydrogen status
- Hydrogen applications in various sectors
- Potential of green hydroen
- Barriers and opportunities for H2 production
- Embedding the Just Transition process

Supply chain analysis

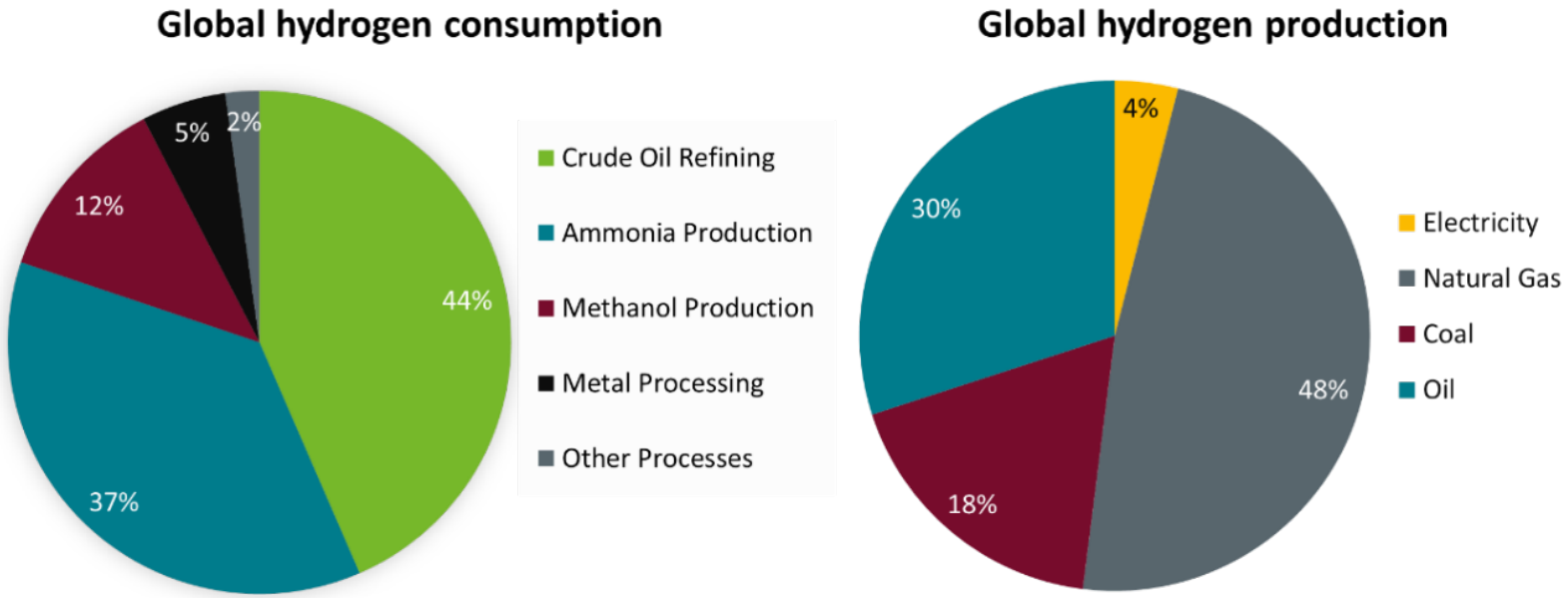
- Water treatement – desalination
- Renewable energy
- Hydrogen production technology – water electrolysis
- Hydrogen logistics
- Conditioning
- Storage
- Transport

Three case studies

- Egypt as a hydrogen exporter
- Kenya as an ammonia exporter
- Ghana as a PtL [Power to Liquid] exporter



Introduction / Background

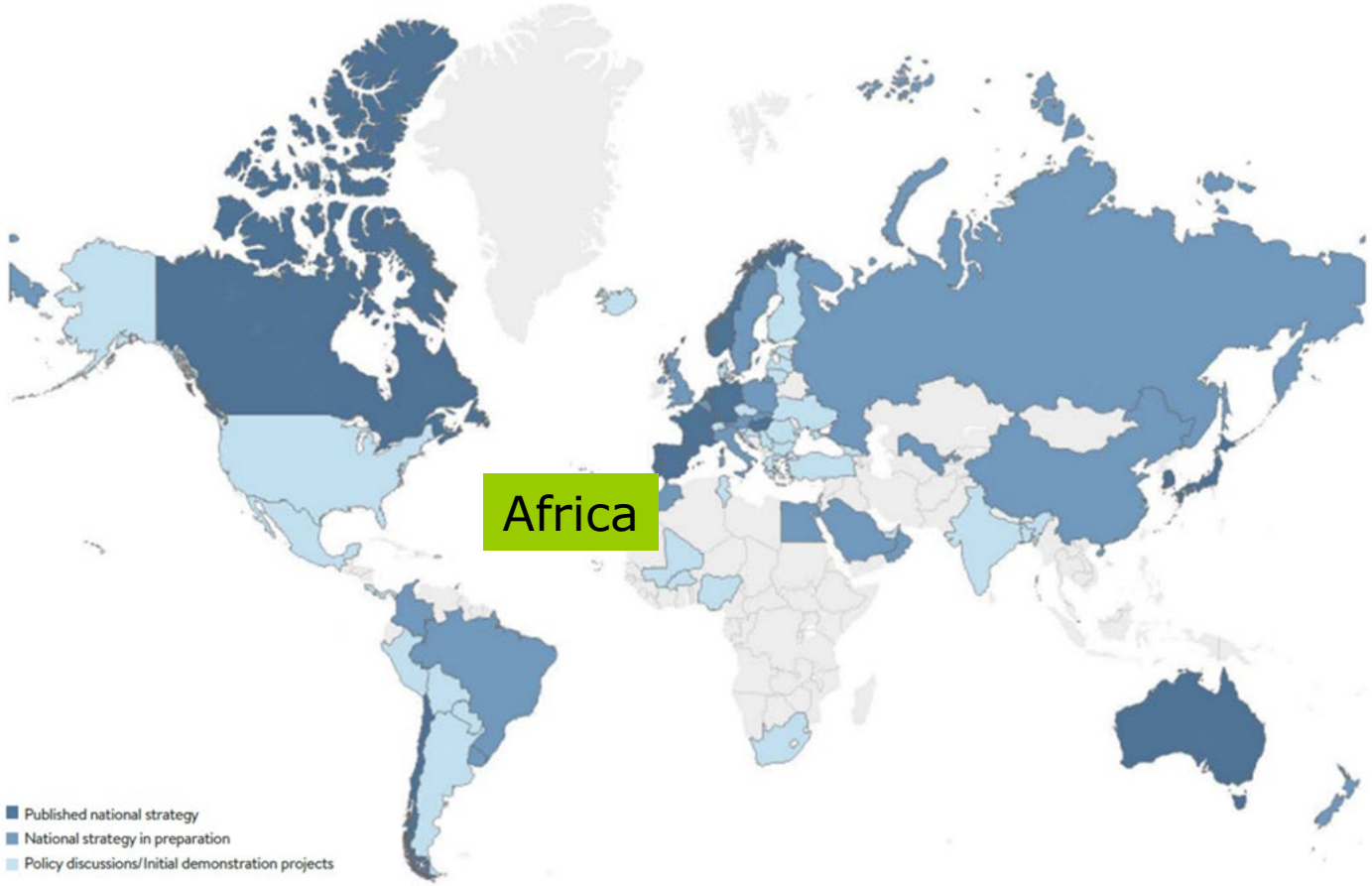


Looked at global demand for hydrogen consumption for different end uses and current sources

Introduction / Background * mining industry

		Application of hydrogen
Mobility sector	Aviation	• Production of PtL-fuels as aviation fuel • H_2 as aviation fuel
	Shipping	• Ammonia as fuel • H_2 as fuel
	Rail transport	• PtL fuel • H_2-powered FC train
	Road transport	• H_2-powered FC electric vehicles - cars • H_2-powered FC electric vehicles – Trucks • H_2-powered FC electric vehicles - busses
		Application of hydrogen
Industry sector*	Steel Making	• Direct reduced iron (DRI) process for steel production
	Refinery	• Removing impurities (desulphurisation process) • Conversion of long-chain hydro-carbons (heavy oils) into short-chain hydrocar-bons (light oils) (hydrocracking process)
	Chemical industry	• Ammonia production (e.g. for fertilisers) • Methanol production (e.g. for glue or resins)
		Application of hydrogen
Electricity and Heat	Generation of process heat	• Green H2 to provide process heat, especially at a high-temperature level
	Energy storage	• H2 gas turbines and FC power plants can be used for the large-scale reconversion of H2 into electricity
	Heat supply for buildings	• The application of green H_2 is an option to replace fossil natural gas and to reduce greenhouse gas emissions in the building sector

Overview of activities worldwide towards national hydrogen strategies, status 06/2021 – Africa lacking strategies



		Egypt as a Hydrogen Exporter	Kenya as an Ammonia Exporter	Ghana as a PtL Fuels Producer
Carbon Neutrality and the Environment				
1.1	Will the carbon-intensive industries be phased out on time?	●	●	●
12.	Do the plans and projects synchronize with national-level decarbonization strategies (and NDCs)?	●●●	●●●	●●●
1.3	Have comprehensive decarbonization plans been prepared?	●●●	●●●	●●●
1.4	Are the environmental impacts of the proposed just transition Green Hydrogen projects adequately assessed?	●●●	●●●	●●●
1.5	Has an assessment been prepared of the environmental impacts of the industries being phased out?	●	●	●
Socio-Economic impacts				
2.1	Will new skills, training or re-training be undertaken for those impacted, the poor, the youth, women, and jobseekers to seize opportunities offered by the new technologies of Green Hydrogen)?	●●●	●●●	●●●
2.2	Will employment opportunities be secured for people losing their jobs?	●	●	●
2.3	Are the issues of various vulnerable groups being addressed?	●●●	●●●	●●●
2.4	Do the Green Hydrogen projects significantly address the issues faced by women?	●●●	●●●	●●●
2.5	Do the Green Hydrogen projects address the needs of the young?	●●●	●●●	●●●
2.6	Has economic redevelopment actually been ensured?	●●	●●	●●
Public Participation				
3.1	Has an inclusive participatory process been ensured (so no one is left behind)?	●●●	●●●	●●●
3.2	Have relevant stakeholders with a quieter voice been included in the process?	●●●	●●●	●●●
3.3	Has local capacity been developed to ensure a more inclusive process?	●●●	●●●	●●●
3.4	Has a good Green Hydrogen project selection process been ensured?	●●●	●●●	●●●
3.5	Has good governance over the operating phase been ensured?	●●●	●●●	●●●

Part 2: SWOT analysis for GH2 in Africa

Strengths

- World class wind: Egypt; North Africa; Namibia
- World Class solar: North Africa, Sahel and Southern Africa
- Land areas available where electricity for GH2 can complement with agricultural use
- Extensive coastlines

Weaknesses

- Relative remoteness of some countries from key consumption centers of Green Hydrogen and derived products
- Significant investments in ports will be needed
- Water supply in some locations

Opportunities

- Potential to supply a range of GH2 products east and west and for domestic consumption
- EU Carbon Border Adjustment Mechanism
- Carbon zero minerals
- GH2 (ICE or FC) for transport due to large distances and for mining
- Dual use water infrastructure
- Reuse some existing infrastructure
- Couple growth in RE production with energy access

Threats

- Slow start
- Dumping of fossil technologies from global north

Part 2: Potential role for AfDB

As Africa's premium financing institution, the Bank has multiple roles

- Massive need to raise awareness and educate public and private sector (starting within the Bank)
- Develop national and regional strategies, linked to LTS and NDCs – GH2 has the potential to help Africa, more than any other continent, leapfrog a fossil fueled development pathway
- Support the development of commercial models, contracts and agreements (ALFS)
- Lead, convene, support industry associations – eg African Green Hydrogen Association
- Mobilize public sector finance from donors, international climate funds (CIF included), bilateral donors etc and private sector to invest: Directly for Green hydrogen projects; Indirectly for associated investments in supply chain; Wind, solar, hydro and geothermal energy generation projects; Dual-use potable water solutions; Industrial development; Trnsport; Ports
- Goal: To EEnsure Africa becomes a supplier of green hydrogen to the global north in a just and equitable manner

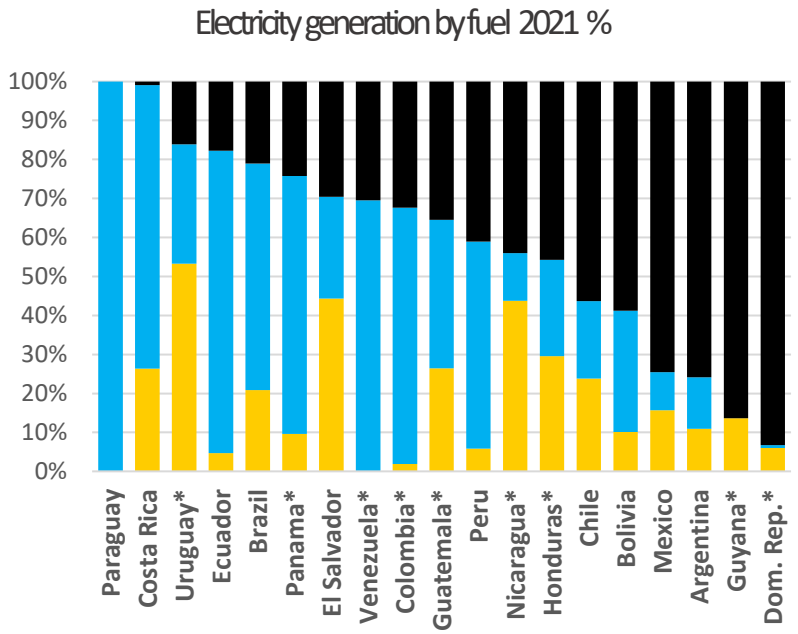
Progress to date

- CIF funded study
- Supporting African Green Hydrogen Alliance (Launched at CoP 27)
- Received and reviewed proposals including Namibia GH2; GH2 to ammonia to fertilizer in Zimbabwe
- Convened African Green Hydrogen Forum in Abj:
  - Global hydrogen demand is expected to increase sevenfold by 2050, requiring USD 450-900 billion in cumulative investment.
  - Global import market for hydrogen and its derivatives is expected to grow by 5-6 times between 2030 and 2050 to reach 100-180 million tonnes by 2050.
  - There is a need to localize green hydrogen value chains, thus creating jobs for African countries while addressing knowledge gaps.
  - Governments should adopt inclusive approaches to ensure communities benefit from green hydrogen investments.
- GH2 event coming up at CoP27

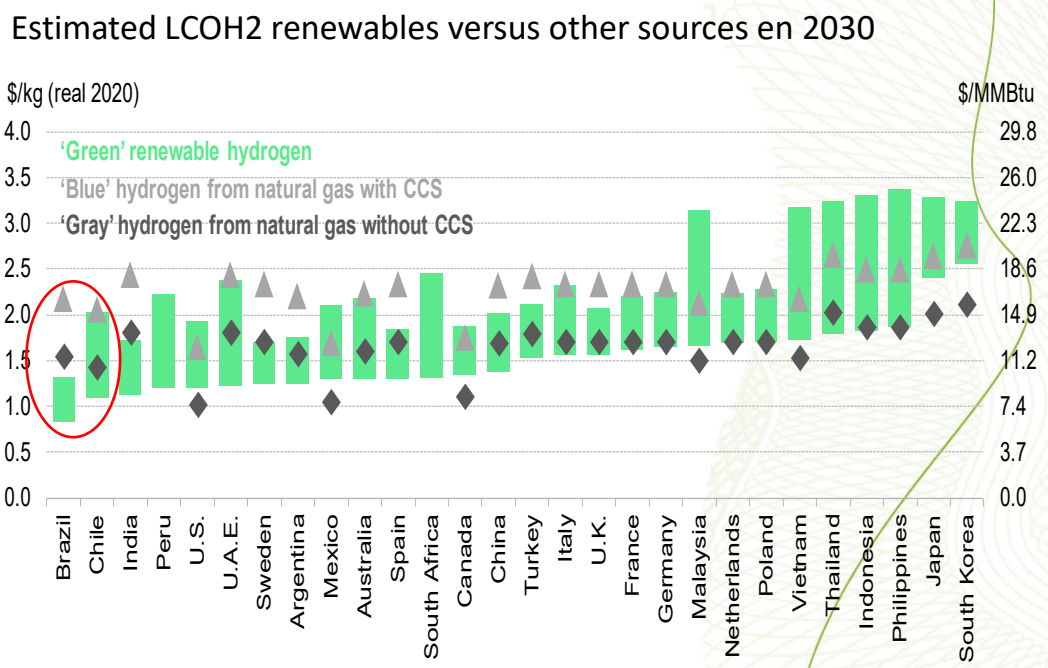
THANK YOU FOR YOUR ATTENTION

IDB GREEN HYDROGEN PLATAFORM

Why LAC



- Fósiles
- Grandes Hidroeléctricas
- Renovables No Convencionales



Source:BNEF

The role of the IDB

4 Fields for Action 15 countries in LAC

KICK-OFF

- Knowledge & Training
- Regional Dialogue

TECHNICAL SUPPORT

- National GH2 strategies
- Roadmaps, NDCs, regulations, certifications, social and environmental norms
- Pre-feasibility studies

PILOT PROJECTS

- Mostly grant funds
- Technological assessments
- Private sector participation
- Demonstration/Dissemination

INVESTMENTS

- Grants and reimbursable funds
- Enabling conditions
- Storage, Transport, Fertilizers< Mining & Heavy Industry
- Commercially viable

Some of the key ongoing activities

RoadMaps

- Colombia
- Uruguay
- Panamá
- Bolivia
- El Salvador
- Paraguay
- Ecuador
- Peru

Pre-feasibility studies

- Uruguay
- Panama
- Paraguay
- Peru
- Bolivia
- Trinidad and Tobago
- Chile

Value chain

- Bolivia
- Brazil
- Chile
- Uruguay

Regulation and safety conditions

- Chile
- Colombia
- Bolivia

Pilots

- Costa Rica
- Uruguay
- Paraguay

Next Steps

Technical assistance for enabling conditions (certification)

Grants to finance pilot projects

Concessional and blended funds to enable infrastructure, heavy industry, fertilizers, mining

Agreements to guarantee H2 off-taker agreement

Thank you very much!

Why Green-Hydrogen

IFC | International Finance Corporation
WORLD BANK GROUP

Tonci Bakovic
International Finance Corporation

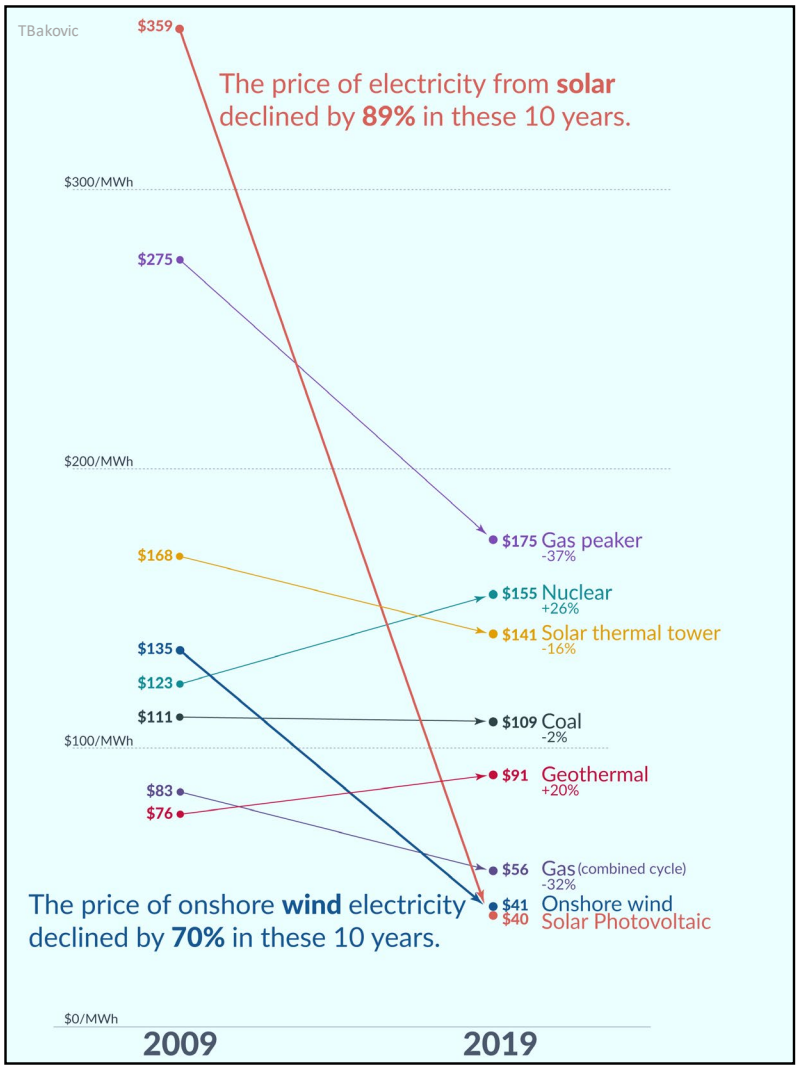
Washington – October 2022

Disclaimer

The findings, interpretations, and conclusions expressed in this presentation are entirely those of the author and should not be attributed in any manner to the International Finance Corporation or to the World Bank Group or to members of its Board of Executive Directors or the countries they represent.

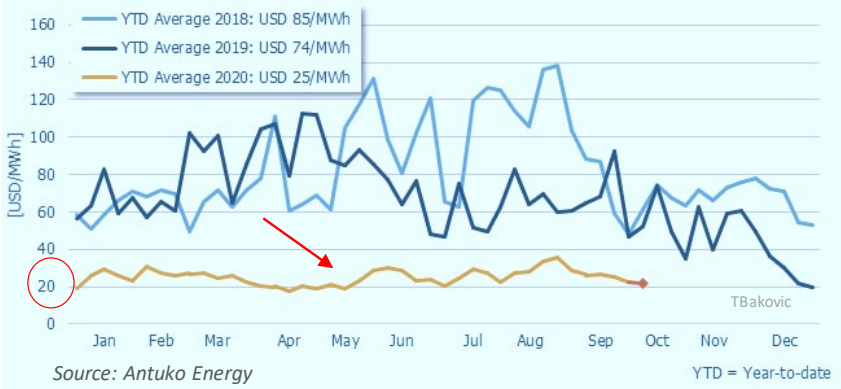
-This presentation cannot be quoted without permission-

Technological Disruption -*and zero marginal-cost electricity*



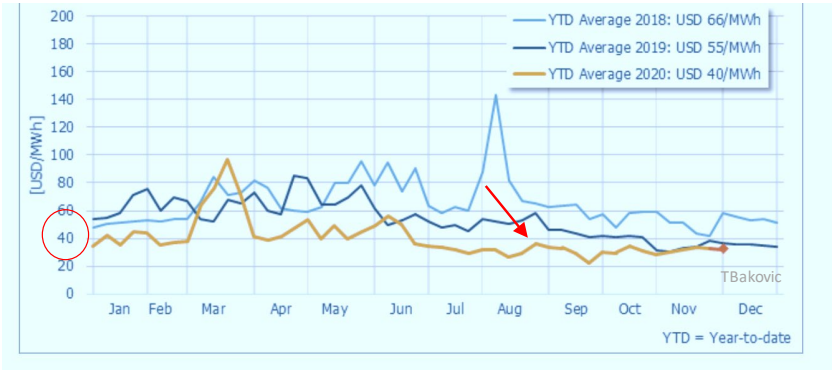
Source: Our World in Data

Electricity Spot Prices Mexico USD/MWh



Source: Antuko Energy

Electricity Spot Prices Chile USD/MWh



Source: Antuko Energy

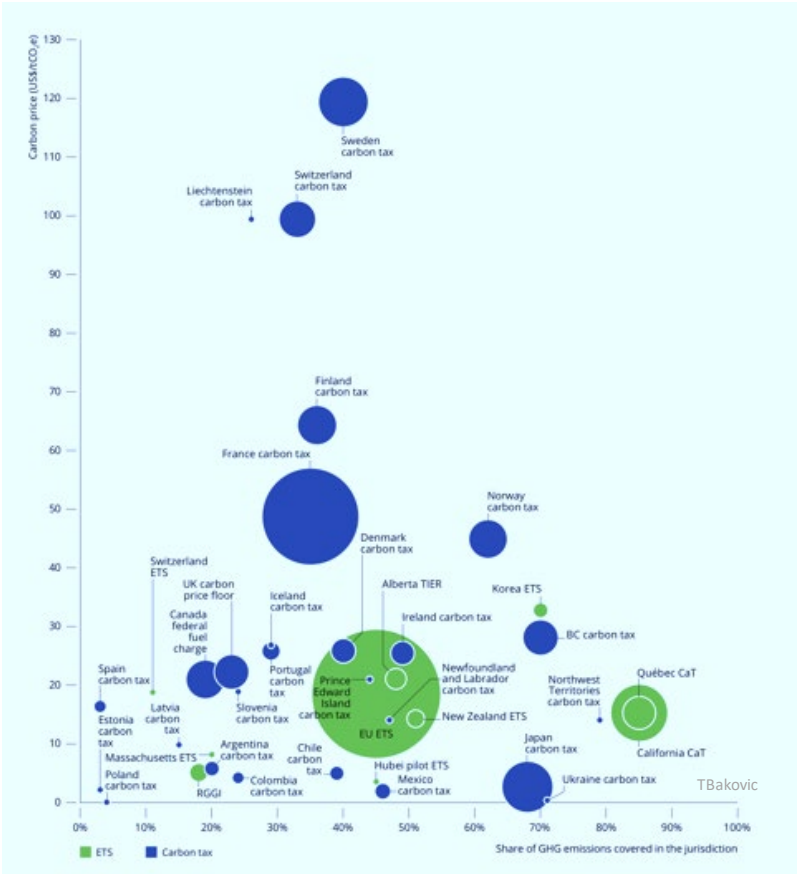
IFC International Finance Corporation WORLD BANK GROUP

Carbon Taxes -*are here to stay*

Carbon Pricing Initiatives

Source: World Bank

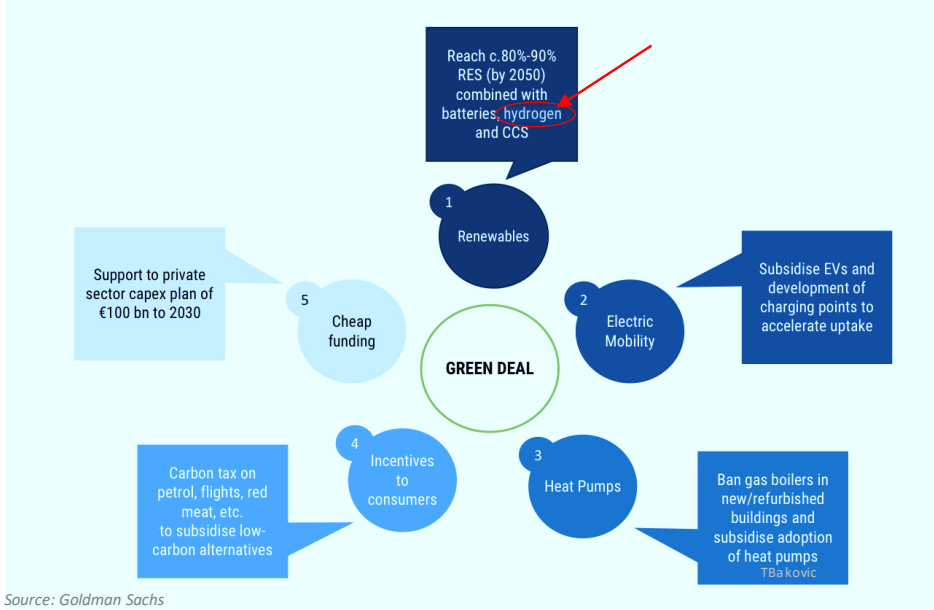
Carbon Price, Share of Emissions and Carbon Pricing Revenues



Source: World Bank

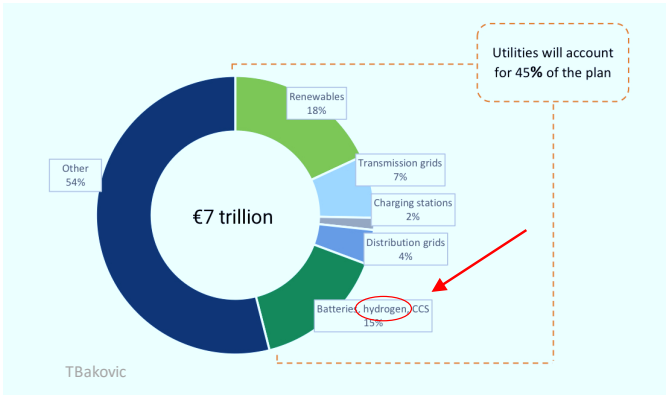
IFC International Finance Corporation WORLD BANK GROUP

Europe's Green Deal -*and the role of green-hydrogen*



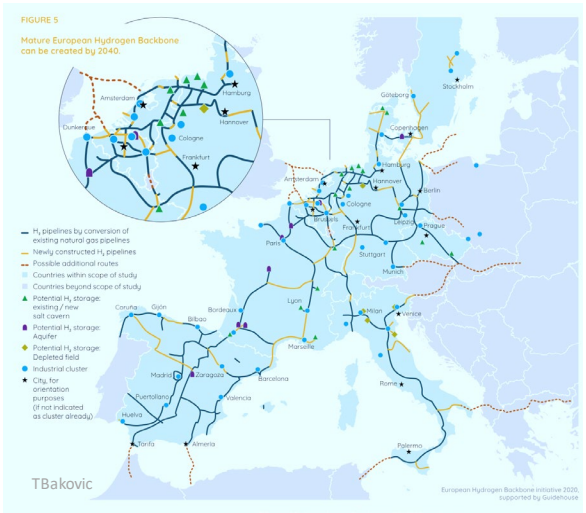
Source: Goldman Sachs

Europe's Green Deal: €7 Tn to 2050



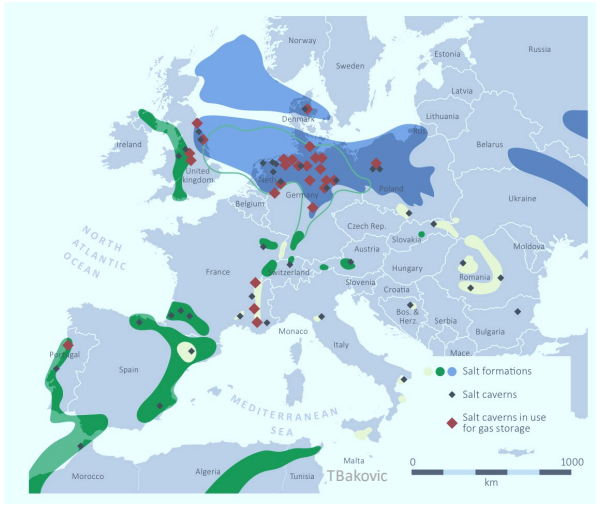
Source: Goldman Sachs

Europe's Hydrogen Backbone



Source: ENTSOG, GIE

Europe's Hydrogen Storage

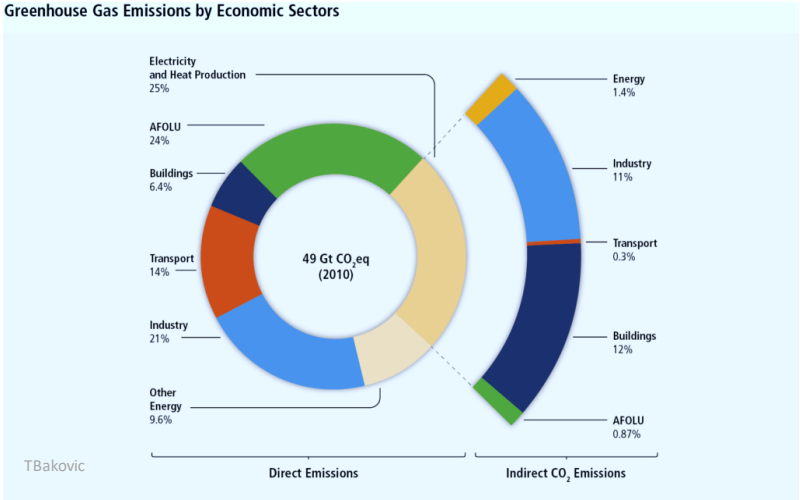


Source: Hydrogen Europe 2x40GW

IFC International Finance Corporation WORLD BANK GROUP

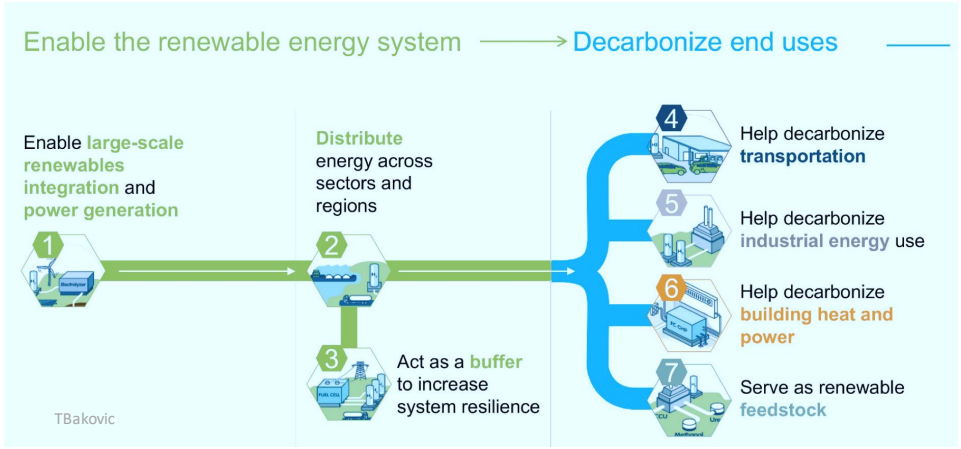
Green Hydrogen -*and the role of ammonia as energy carrier*

Electricity only 25% of the problem



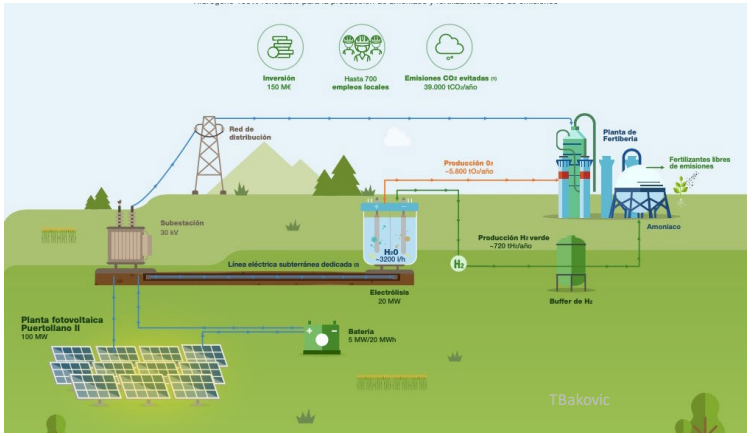
Source: IPCC 2014

Hydrogen as renewables enabler and energy carrier



Source: Hydrogen Council

Enter – Green Ammonia



Source: Iberdrola

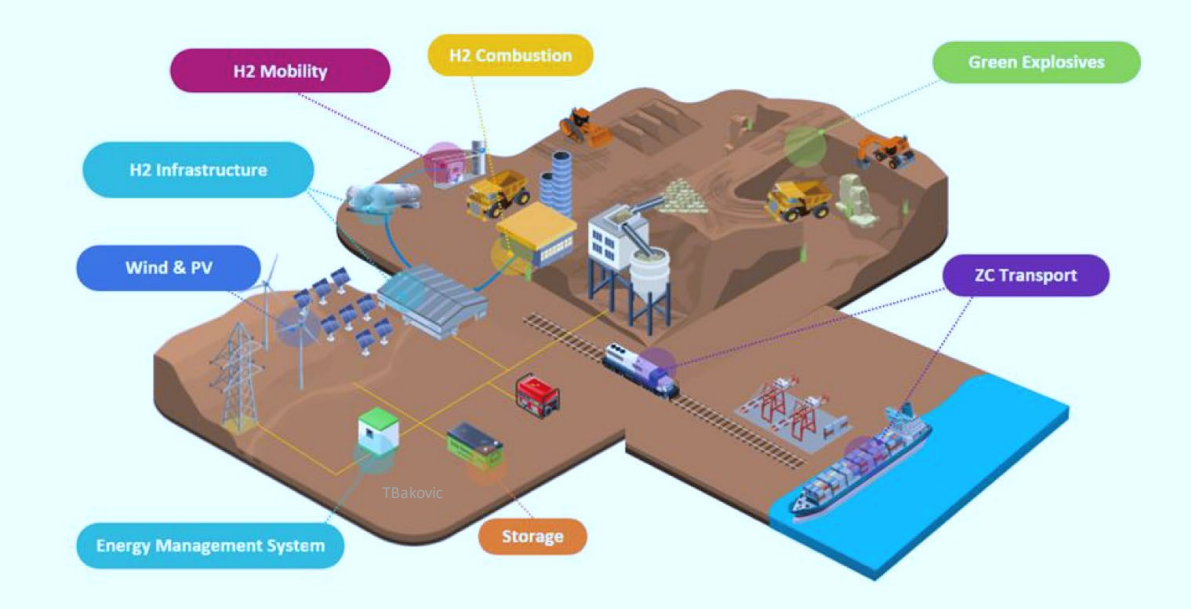
International Finance Corporation WORLD BANK GROUP

Climate is not Local it is Global –*the role of mid-income countries scaling up H2*

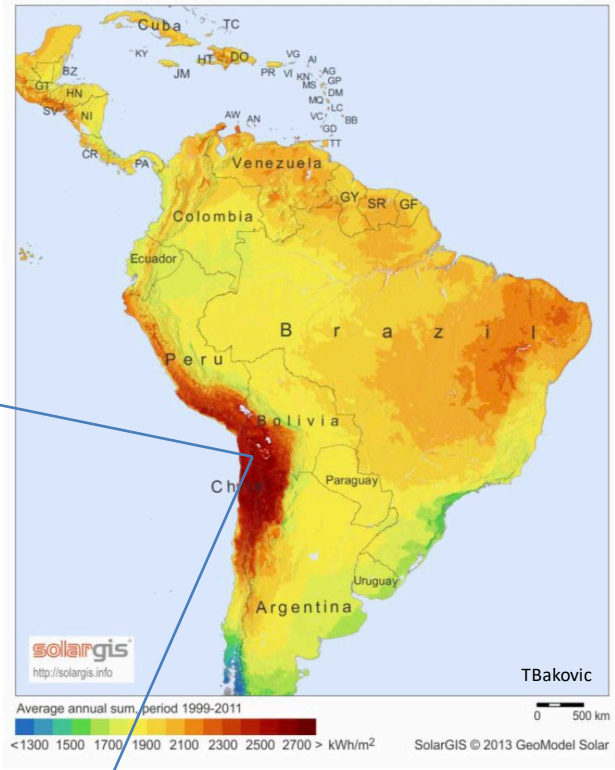
The Atacama Desert *(location, location, location)*:

"A Multi Demand Multi Delivery Node"

- *40% of the world's copper*
- *among the best solar resources in the world*
- *next to seaports*
- *country committed to green H2*



Source: ENGIE

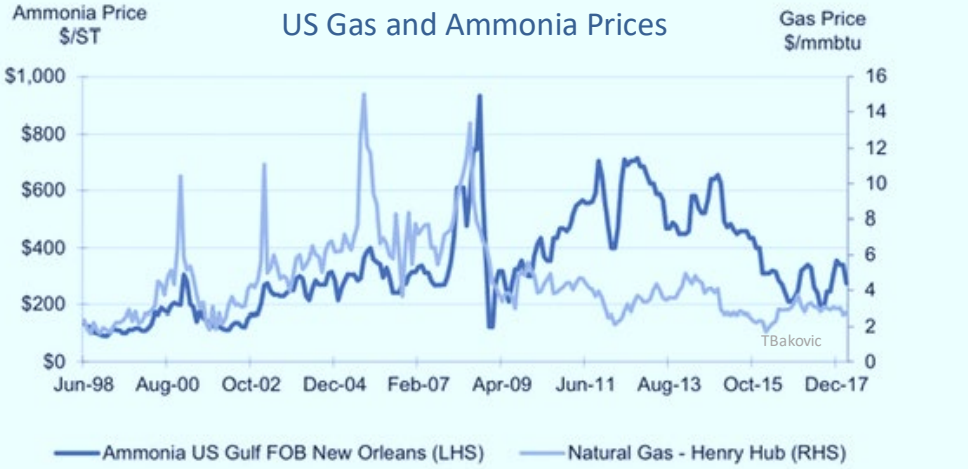


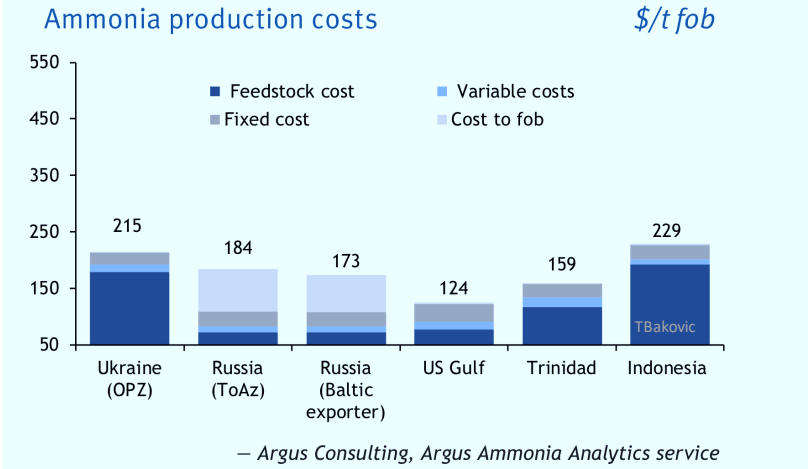
Source: ESMAP

IFC International Finance Corporation WORLD BANK GROUP

Challenge: *Gas Prices* *(and Ammonia Prices)*

Grey Hydrogen as feedstock to ammonia production – *predatory competition or transition tool….?*

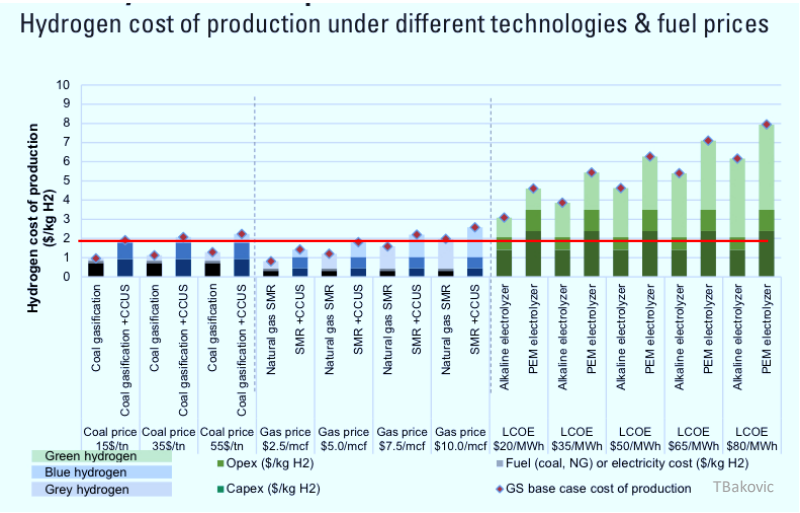




Source: Bloomberg, AIMS

Grey Hydrogen/Blue Hydrogen
vs
Green Hydrogen

as feedstock to ammonia production



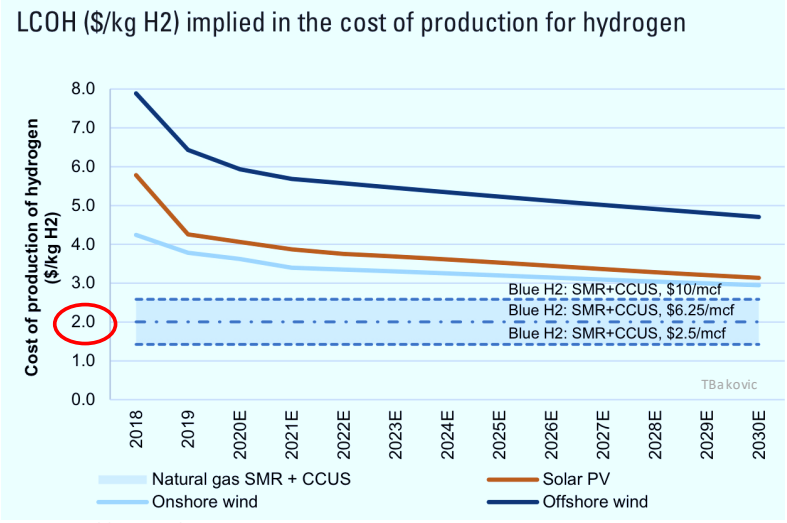
Source: "The 100% Solution"

Source: Goldman Sachs

IFC International Finance Corporation WORLD BANK GROUP

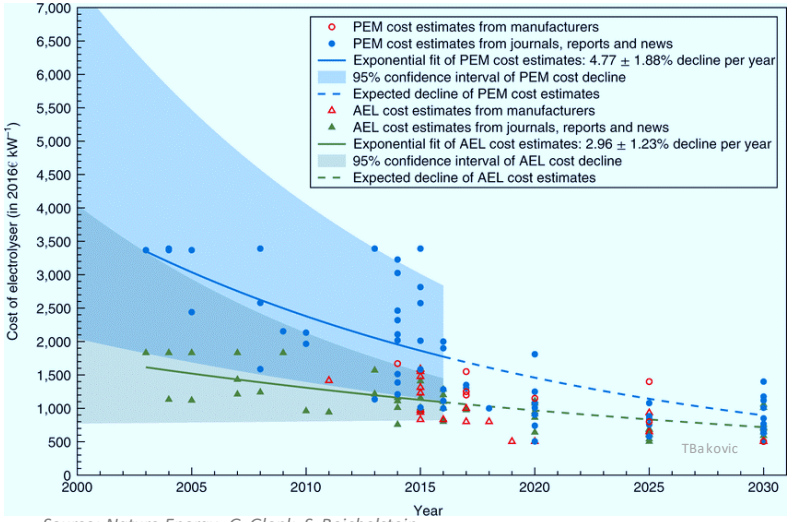
Green Hydrogen *–are we there yet…?*

Beyond Carbon Taxes - What does it take for green hydrogen to compete…



Source: Goldman Sachs

Electrolyzer Costs Europe/USA



Source: Nature Energy, G. Glenk, S. Reichelstein

USD/kg @ Electrolyzer Cost $800/kW

Utilization \ USD/MWh	20	25	30	35	40	45	50
90%	1.55	1.77	1.99	2.21	2.43	2.65	2.87
85%	1.59	1.81	2.03	2.25	2.47	2.69	2.91
80%	1.64	1.86	2.08	2.30	2.52	2.74	2.96
75%	1.69	1.91	2.13	2.35	2.57	2.79	3.01
70%	1.74	1.96	2.18	2.40	2.62	2.84	3.06
65%	1.81	2.03	2.25	2.47	2.69	2.91	3.13
60%	1.89	2.11	2.33	2.55	2.77	2.99	3.21

Source: Own elaboration (for illustration purposes only) Tbakovic

USD/kg @ Electrolyzer Cost $400/kW

Utilization \ USD/MWh	20	25	30	35	40	45	50
90%	1.22	1.44	1.66	1.88	2.10	2.32	2.54
85%	1.24	1.46	1.68	1.90	2.12	2.34	2.56
80%	1.26	1.48	1.70	1.92	2.14	2.36	2.58
75%	1.28	1.50	1.72	1.94	2.16	2.38	2.60
70%	1.31	1.53	1.75	1.97	2.19	2.41	2.63
65%	1.35	1.57	1.79	2.01	2.23	2.45	2.67
60%	1.38	1.60	1.82	2.04	2.26	2.48	2.70

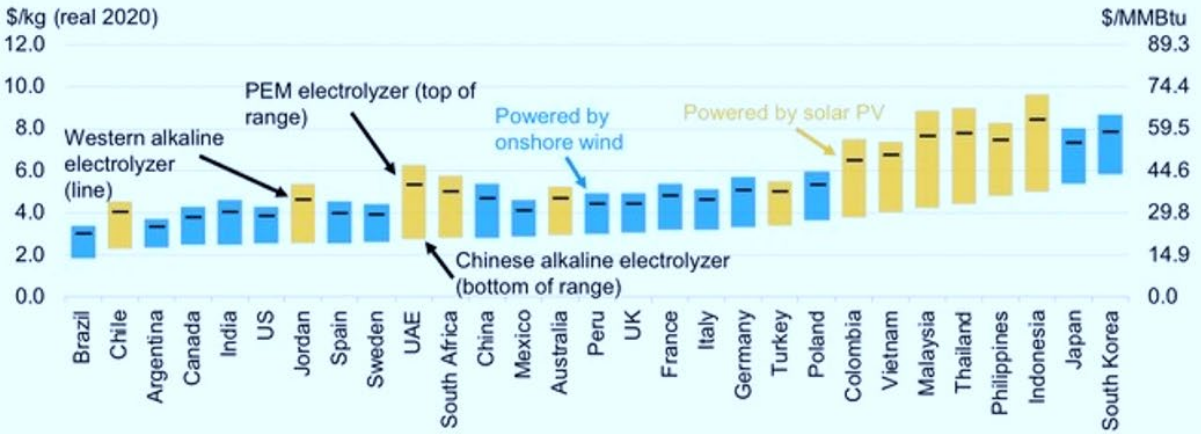
Source: Own elaboration (for illustration purposes only) Tbakovic

IFC International Finance Corporation WORLD BANK GROUP

ESTIMATED GREEN Hydrogen costs BY COUNTRY

Chile, Brazil, India South Africa amongst countries with high potential for lowest cost

Levelized cost of hydrogen production as of 1H 2022



Nations with exceptional natural resources have the potential to produce hydrogen with renewables at lowest cost.

Brazil operates onshore wind projects with some of the highest capacity factors in the world. Partly as a result, Brazil has the lowest potential levelized cost for zero-carbon hydrogen at $1.5-3.37/kg. Chile, thanks to its exceptionally sunny conditions in parts of the country, also has the potential to produce at relatively low cost ($2.24-$4.52/kg).

The cost of the equipment used to produce hydrogen – *electrolyzers* – is critical in the final levelized cost of producing the fuel.

Alkaline electrolyzers manufactured in China tend to be lowest cost while proton-exchange membrane (PEM) electrolyzers tend to be most expensive. Equipment costs are declining, however.

Source: BloombergNEF. Note: Countries colored by color (wind/blue, solar/yellow) based on which technology offers the lowest levelized cost in the country. Assumes a 1:1 capacity ratio of electrolyzer and power source. Assumes 2022 Chinese alkaline electrolyzer costs of $0.25/W, Western alkaline electrolyzer costs of $0.93/W and PEM electrolyzer costs of $1.11/W. By 2030, costs are assumed to converge to those listed in Hydrogen: The Economics of Production From Renewables (web | terminal). Electricity costs derived from BNEF's 2H 2021 LCOE Update (web | terminal), mid scenario.

IFC's Global Reach

100+ offices in 86 countries worldwide

GLOBAL KNOWLEDGE, LOCAL PRESENCE

IFC International Finance Corporation WORLD BANK GROUP