IRENA INNOVATION WEEK 2023

Walking the Last Mile of the Energy Transition with Green Hydrogen

Organised in Partnership With

CEFIM
CLEAN ENERGY FINANCE & INVESTMENT MOBILISATION
OECD

26 September 2023 | 09:30 am - 11:00 am CEST

#IIW2023

IRENA INNOVATION WEEK 2023

Setting the Scene:
Accelerating Green Hydrogen Deployment through Innovation

Francisco Boshell

Head of Innovation and End-use Sector Applications,

IRENA Innovation and Technology Centre

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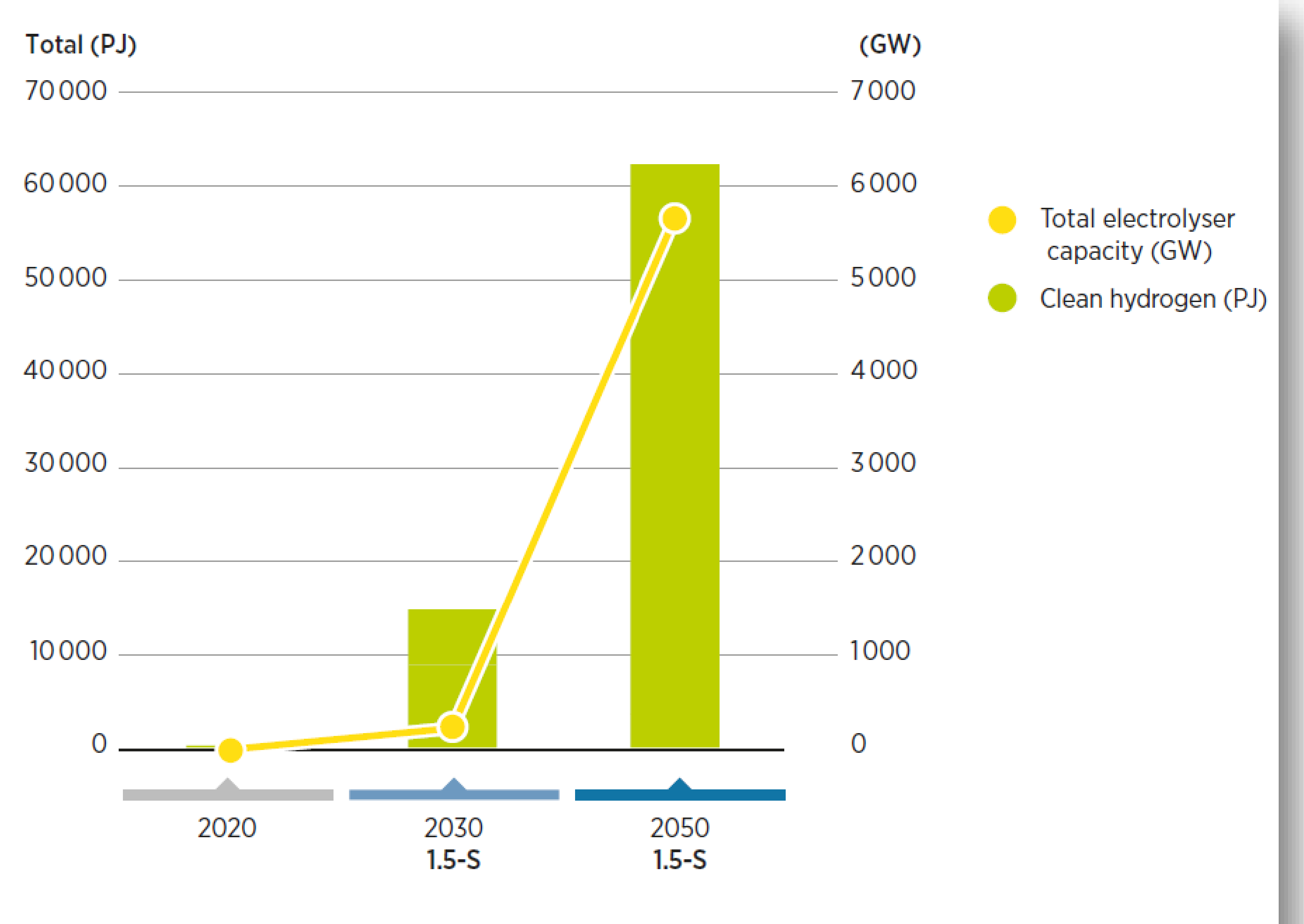
Global hydrogen supply needs to grow six-fold

Global clean hydrogen supply in 2020, 2030 and 2050 in the 1.5°C Scenario:

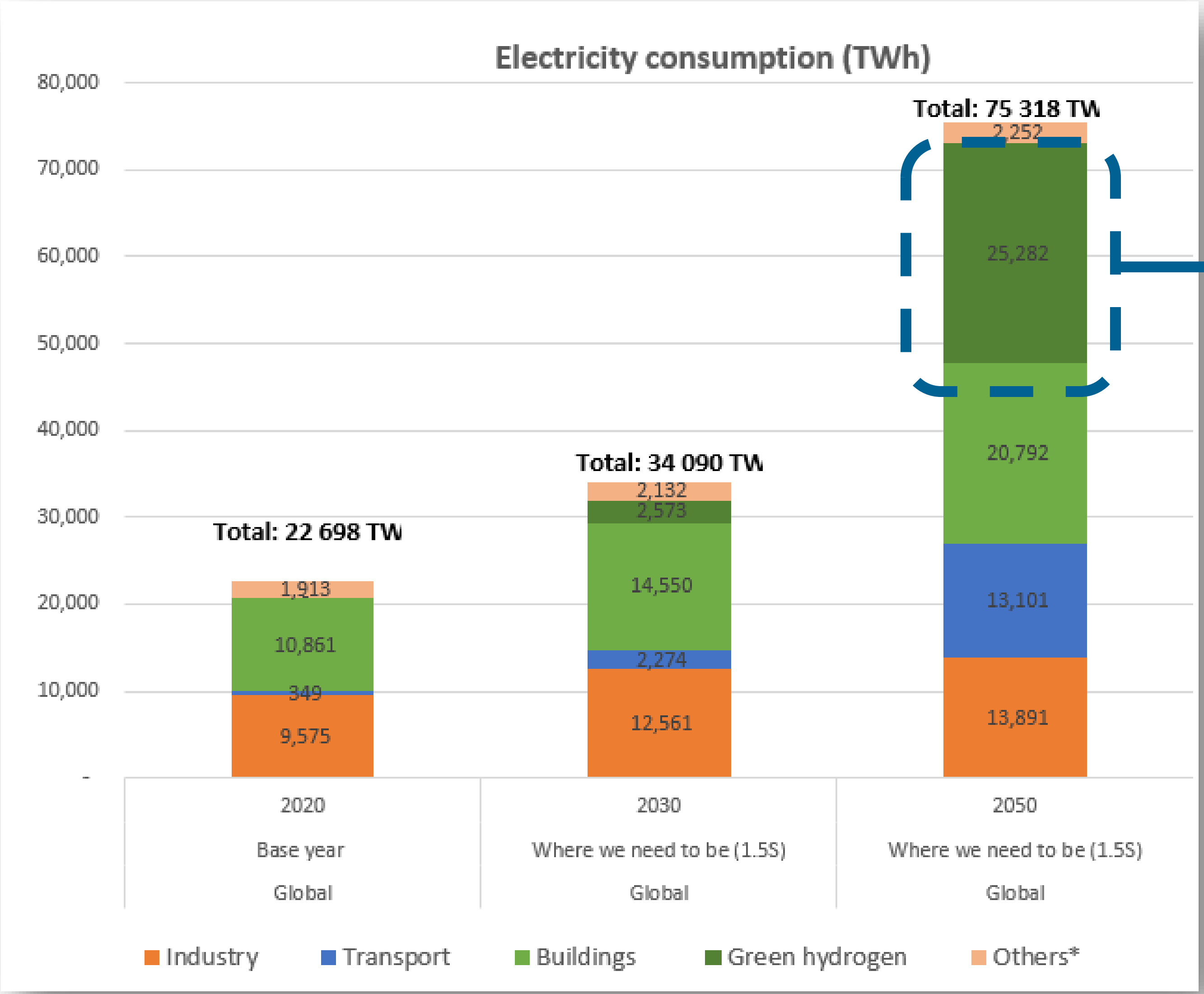


Notes: 1.5-S = 1.5°C Scenario; GW = gigawatt; PJ = petajoule.

- In 2050, **renewable electricity** is the **main energy carrier**.
- **51%** of the final energy consumption would be **direct** use of electricity. **14%** would be **indirect** use as hydrogen and derivates
- 6x grow in H2 supply from 90 Mt/y today to ~ **530 Mt/y in 2050** – electrolyzer capacity **~ 5 700 GW**
- 2050: **94% green** and 6% blue hydrogen
  - *Project pipeline dominated by green (410 green h2 projects vs 23 blue h2 projects)*

Source: IRENA (2023), World Energy Transitions Outlook 2023: 1.5°C Pathway, Volume 1 and https://www.fitchsolutions.com/power/global-low-carbon-hydrogen-project-pipeline-low-risk-markets-experience-more-development-success-amid-globally-growing-pipeline-28-02-2023

Innovation drivers for green hydrogen supply



Massive green hydrogen deployment needs massive renewable electricity deployment

Key considerations triggering innovation

- By 2050 more than 25,000 TWh of electricity demand for green hydrogen production –> **Increase efficiency and reduce cost of electrolysers**
- From < 1 GW to ~ 5,500 GW electrolyser capacity by 2050 -> **Peak demand management**
- We need a smart approach to integrate electrolysers in power systems, synergies with renewable generation -> **Electrolysers as flexibility providers**

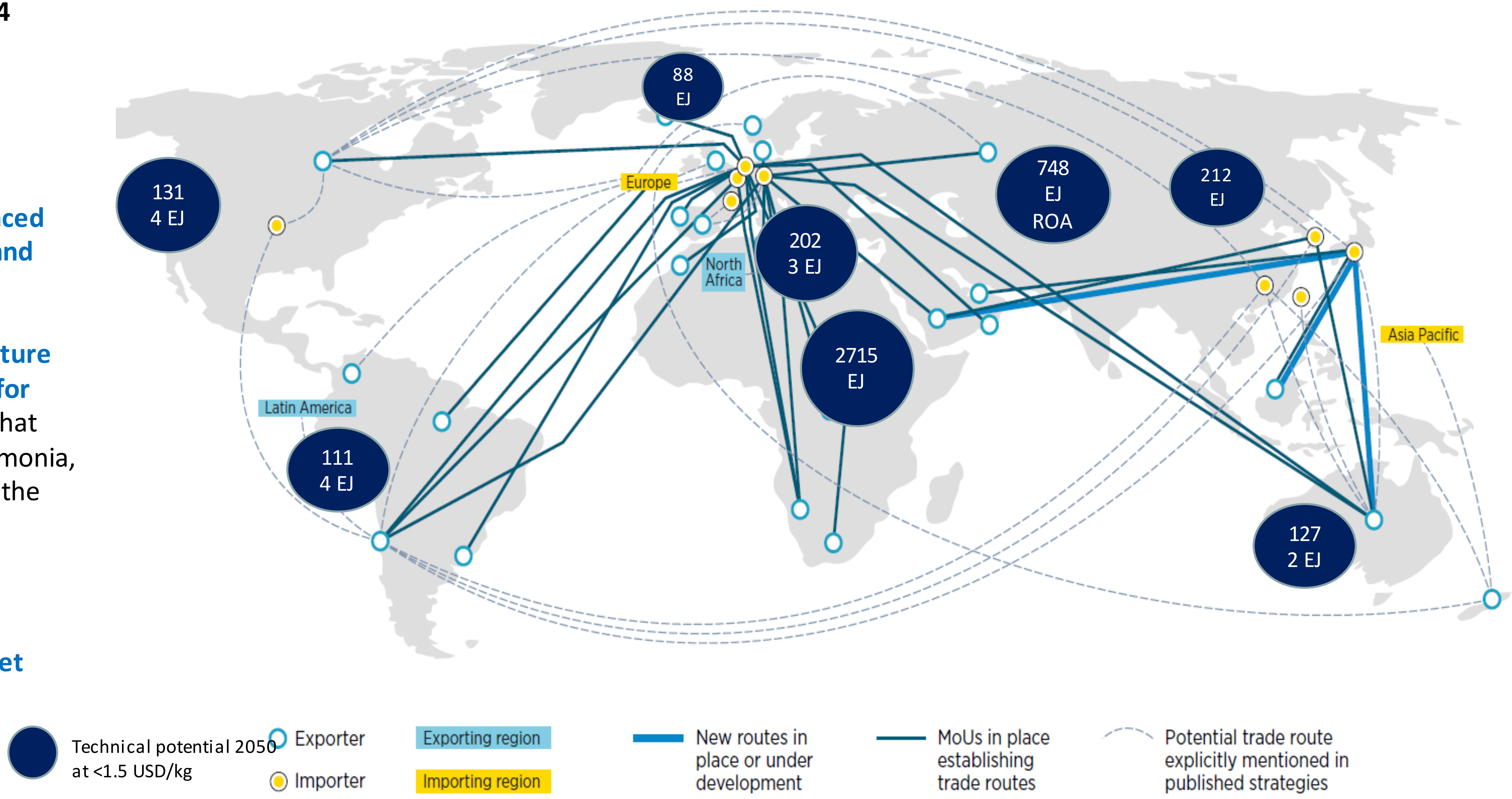
Source: IRENA (2023), World Energy Transitions Outlook 2023: 1.5°C Pathway, Volume 1

Innovation drivers for green hydrogen trade

Future hydrogen trade 2050: 1/4 internationally traded H2

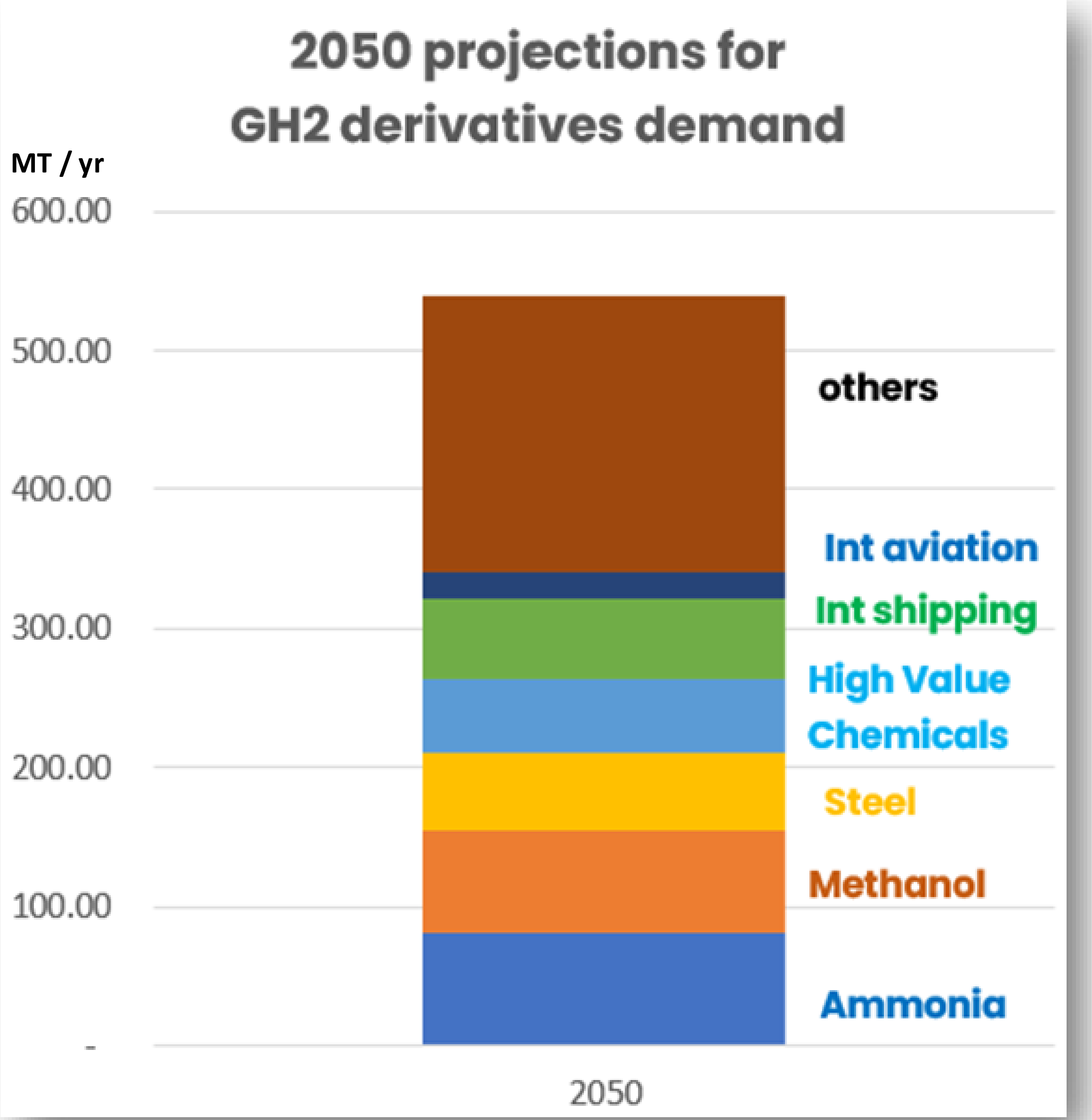
Key considerations triggering innovation

- 70 MT via pipelines -> **Enhanced standards to ensure safety and performance**
- 60 MT via ships -> **Infrastructure planning and development for maritime transportation.** What would be the H2 carrier (ammonia, methanol, LOHC) to develop the infrastructure
- A few importing markets -> Harmonisation of **carbon certification balancing market growth and environmental integrity**



Source: IRENA (2022), Global hydrogen trade to meet the 1.5°C climate goal: Part II – Technology review of hydrogen carriers

Innovation drivers for green hydrogen demand

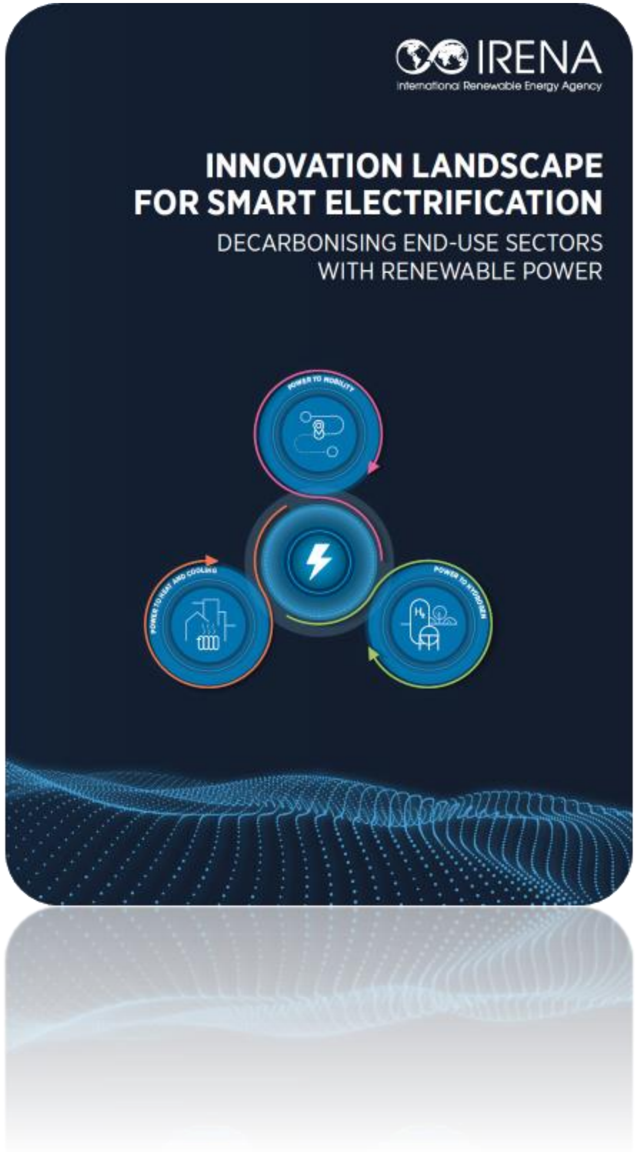


Green hydrogen to be used in sectors where direct electrification is challenging **– Chemicals, Iron & Steel, Shipping and Aviation-. Not a major role** in sectors that can be directly electrified including **road transport (BEV)** and **residential/commercial heating (HPs)**

Key considerations triggering innovation

- Pull demand for PtX -> **procurement instruments**
- Synthetic fuels -> **source of sustainable carbon**
- Variety of commodity to be traded **-> infrastructure implications**

Systemic innovation to grow sustainable GH_2 markets



TECHNOLOGY AND INFRASTRUCTURE

Electrolyser technology

- **1** Pressurised ALK electrolyser
- **2** PEM electrolyser
- **3** SOEC electrolyser
- **4** AEM electrolyser

Hydrogen infrastructure

- **5** Compressed hydrogen storage
- **6** Liquefied hydrogen storage
- **7** Hydrogen-ready equipment

Digital technologies

- **8** Digital backbone for green hydrogen production
- **9** Hydrogen leakage detection

MARKET DESIGN AND REGULATION

Power market

- **10** Additionality principle
- **11** Renewable PPAs for green hydrogen
- **12** Cost-reflective electricity tariffs
- **13** Electrolysers as grid service providers

Hydrogen market

- **14** Certificates
- **15** Hydrogen purchase agreements
- **16** Carbon contracts for difference

Standard and regulations

- **17** Regulatory framework for hydrogen network
- **18** Streamlining permitting for electrolyser projects
- **19** Quality infrastructure for green hydrogen
- **20** Regulatory sandboxes

SYSTEM PLANNING AND OPERATION

Strategic planning

- **21** Electricity TSOs, including grid-connected hydrogen facilities in their planning
- **22** Co-locating electrolysers with renewable generators (onshore and offshore)

Smart operation

- **23** Smart hydrogen storage operation and P2P routes
- **24** Long-term hydrogen storage
- **25** Co-operation between electricity and gas operators

BUSINESS MODELS

Primary revenue streams

- **26** Local hydrogen demand
- **27** Hydrogen trade
- **28** Hydrogen industrial hub

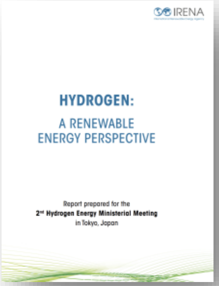
Stacking other revenue streams

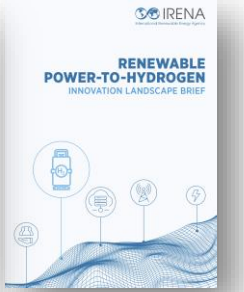
- **29** Revenues from providing services to the power system
- **30** Sale of electrolysis by-products (oxygen and heat)

Publications

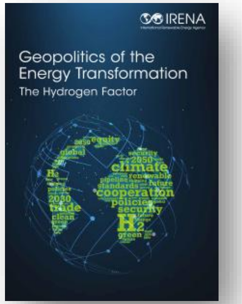
Supply

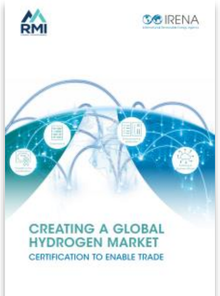
Sector coupling

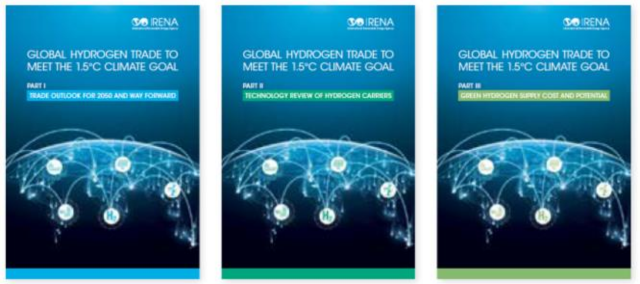




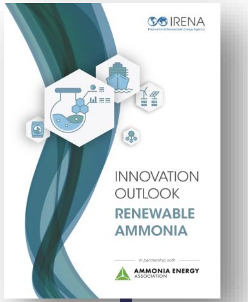
Trade

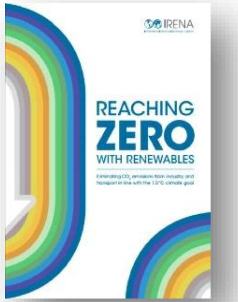


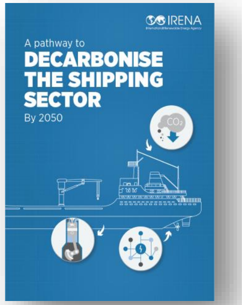


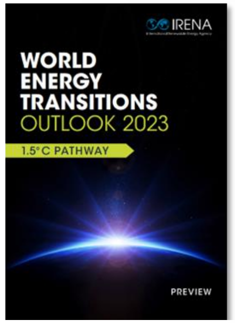


Demand

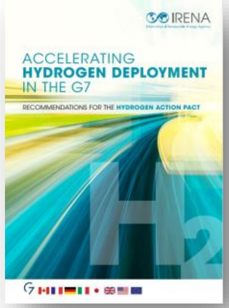


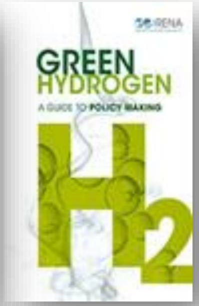


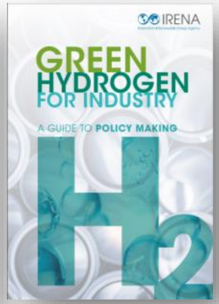




Policies & cross cutting







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Keynote:
Financing Solutions to Foster Green Hydrogen Development

Deger Saygin

Lead Industry Decarbonisation Programme,
Environment Directorate, OECD

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BETTER POLICIES FOR BETTER LIVES

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Financing hydrogen development in emerging and developing economies

Deger Saygin
Industry Programme Lead

Walking the Last Mile of the Energy Transition with Green Hydrogen: A Systemic Approach

26 September 2023, 09:30-11:00

Overview of Industry and Hydrogen within CEFIM's work

CEFIM
CLEAN ENERGY FINANCE & INVESTMENT MOBILISATION

- *Framework for industry's net-zero transition* released in September 2022

- 5-step approach to:
  - Improve enabling market conditions
  - Propose financing solutions
- Framework implementation:
  - Country-level
  - Focus Area: sector, or cross-cutting technology
  - Business cases and list of net-zero pathway projects
- Renewable hydrogen can help decarbonise industry
- Currently industry main consumer of hydrogen, with large potential to transform conventional processes

OECD
BETTER POLICIES FOR BETTER LIVES

CEFIM
CLEAN ENERGY FINANCE & INVESTMENT MOBILISATION

- Clean Energy Finance and Investment review / roadmap
- Implementation support activities
- Investor dialogues
- Regional peer learning

Framework for industry's net-zero transition

2022-2024 implementation in Indonesia, Egypt, South Africa and Thailand

- Country implementation for a sector or a low-carbon technology
- Pipeline of projects
- Enabling market conditions and financing solutions

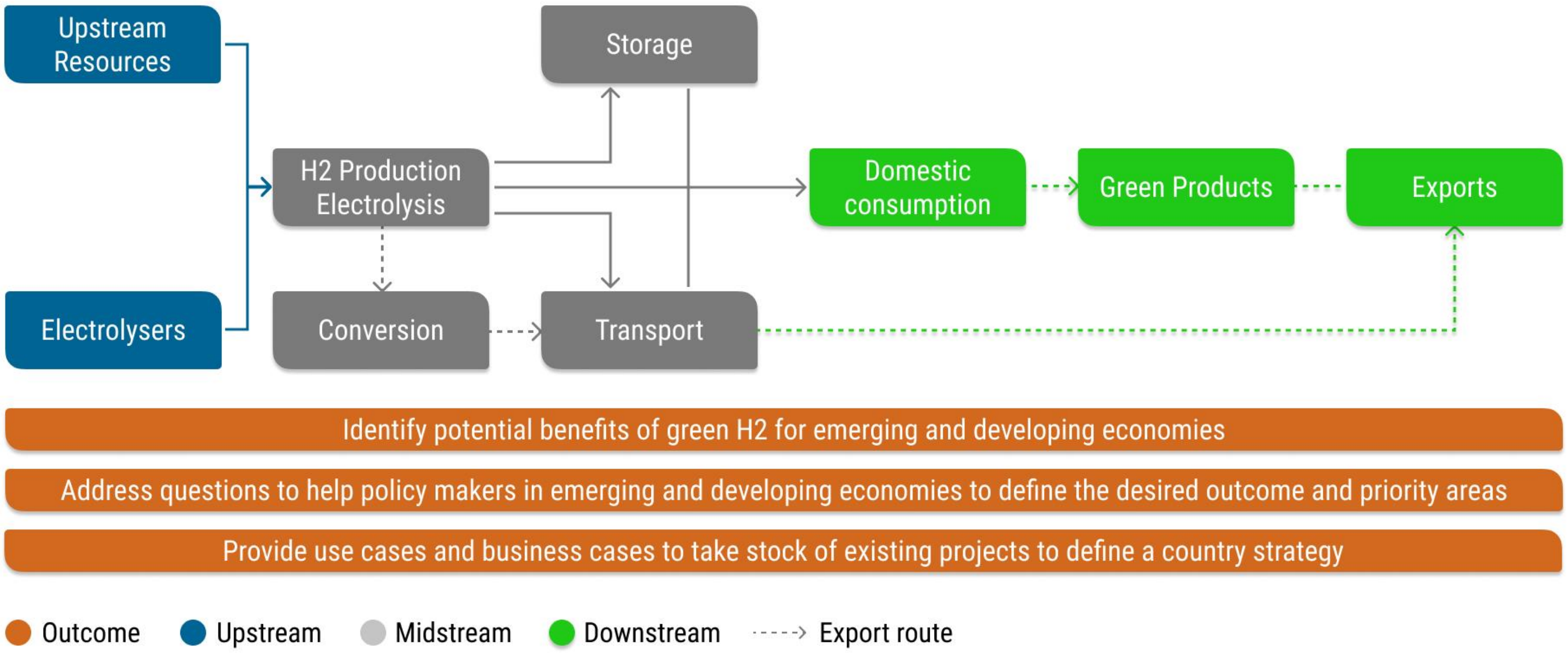
Renewable Hydrogen

- Value Chain approach
- Country national strategies
- Case studies

Green hydrogen for emerging and developing economies

CEFIM – Clean Energy Finance & Investment Mobilisation

CEFIM's approach to assist countries in reaping the benefits across the whole hydrogen value chain



Outputs

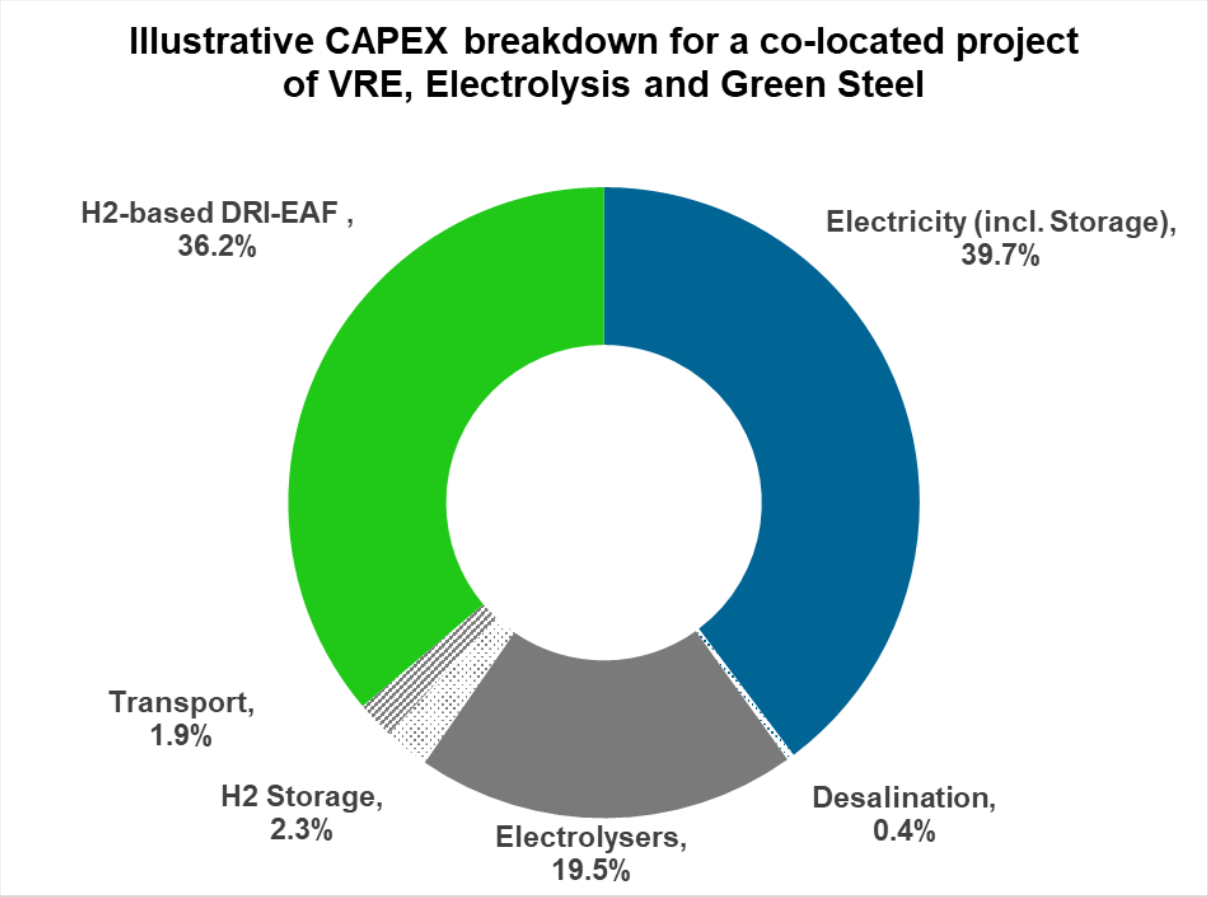
- 2022: Green hydrogen opportunities for emerging and developing economies
- 2023 Series of peer-learning webinars
- 2023 Project case studies
- 2023 (December) Working Paper Cost of capital

Illustrative green steel business case (CAPEX)

- Illustrative business case for a co-located project of a greenfield steel plant of 1 Mtpa capacity.

- The breakdown is sensitive to parameters such as:
  - *the access to renewable electricity sources*
  - *the electricity storage needs;*
  - *the availability of geological storage.*

- High investment costs along the value chain require to share risks between stakeholders, via policy instruments, enabling conditions, governance scheme and financing conditions.



Illustrative calculation based on 50% solar and 50% onshore wind in a favourable location (LCOE USD 30/MWh), USD 550/kW electrolyser costs, 50% capacity utilisation rate for the electrolyser, and availability of geological storage for H_2.

Impact of cost of capital on levelised cost of hydrogen (DRAFT)

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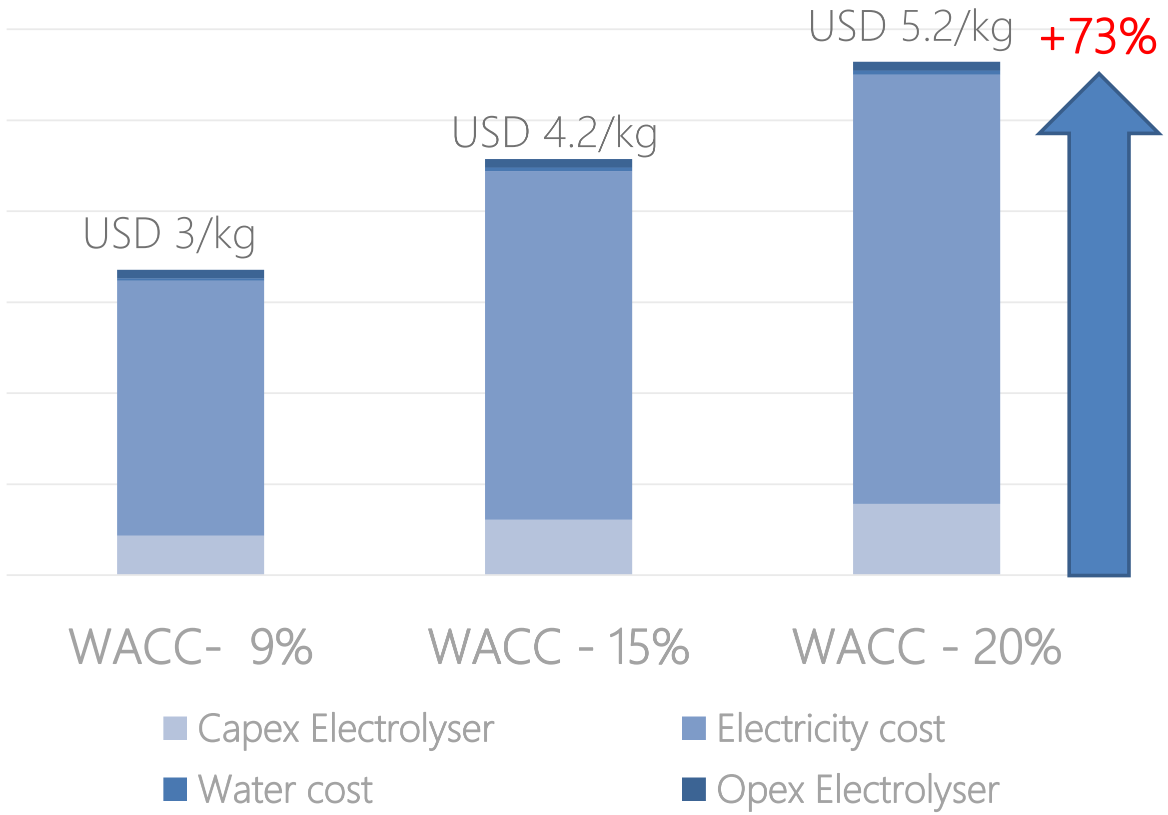
- Capital costs have a higher share in the green hydrogen project due to higher upfront cost with little OPEX share
- The high cost of capital is major factor that constrains the cost-competitiveness of green hydrogen
- Cost of capital is estimated to be around 7%-30% depending on location and project structure where offtake related risks found to be major contributor
- Cost of capital increase from 10% to 20% can lead to a substantial increase of up to +73% in LCOH
- Favourable policy is important as it plays a significant role to lower cost of capital, thus stabilising cash flow



Analysis is enhanced by a collection of case studies that provide real project information

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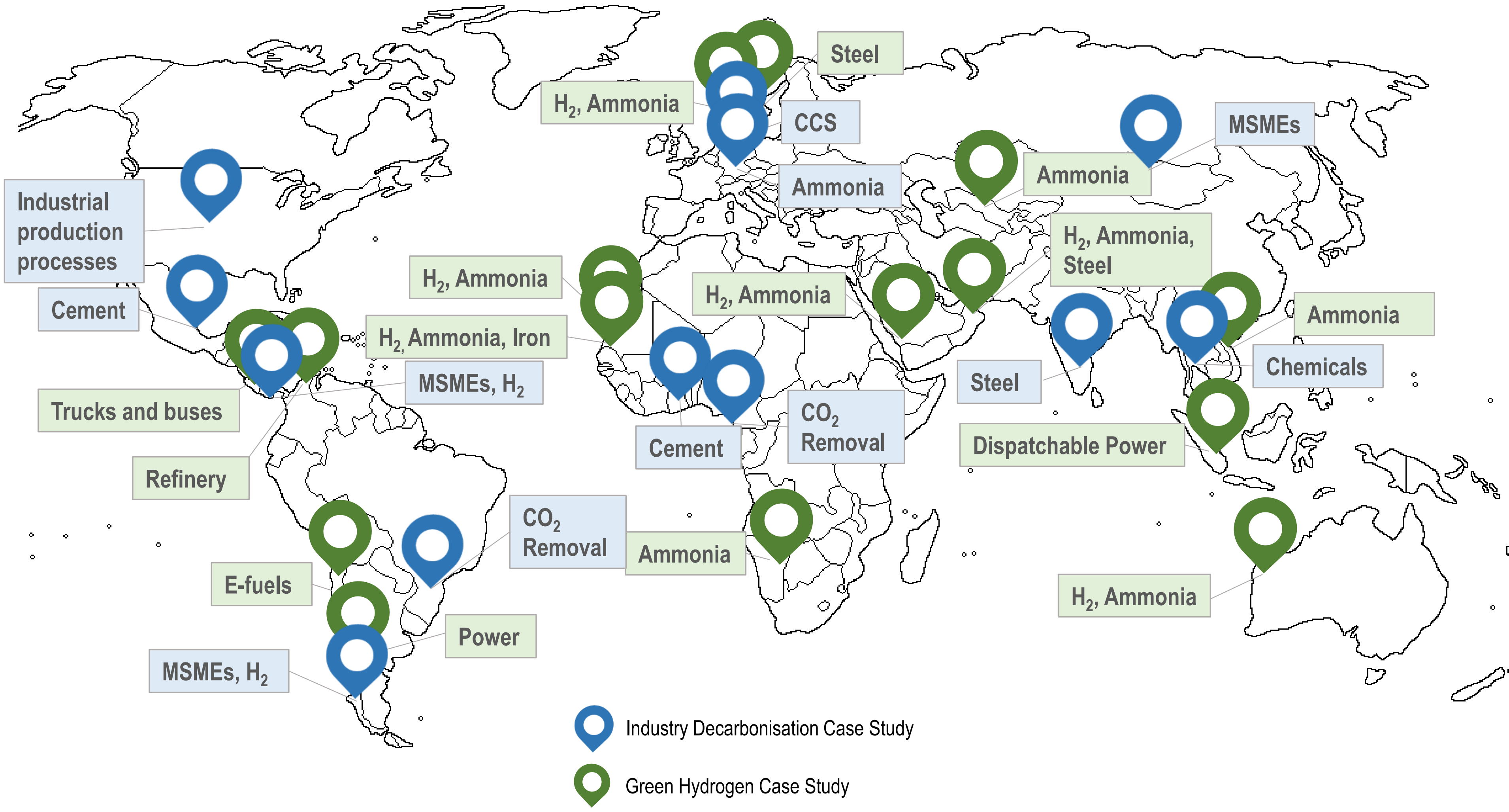

- 22 case studies on renewable hydrogen & industry decarbonisation across >20 countries
- Covering >30 GW electrolyser capacity & all hard-to-abate sectors

Project success factors and derisking mechanisms

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Offtake risk mitigation

- Business models based on hydrogen derivatives
- Long-term offtake agreements

Project structure

- Public-private partnerships

Relevant Infrastructure

- Access to electricity grids, water desalination, transportation systems, etc.

Access to capital

- Concessional funding and blended finance
- Aligning interests between equity holders and off-takers

Macroeconomic & Political risk mitigation

- Insurance and guarantees against political instability or currency risks in EMDEs

Credible stakeholders to mitigate technology and construction risks

- Strategic alliances and partnerships

There are a suite of measures available to facilitate hydrogen market creation and growth

	Market creation			Market growth		
	Strategy, Governance, Standards	Enabling market measures	De-risking instruments & Financing	Strategy, Governance, Standards	Enabling market measures	De-risking instruments & Financing
Public sector (incl. DFIs)	Integrated energy roadmap including hydrogen targets and priority sectors	Land allocation	Feed-In tariffs / premiums	Large-scale green hydrogen demonstration projects or hydrogen valleys	Guarantees of origin and tracking system	Regulated Asset Base model / Minimum Revenue Guarantee
	Infrastructures roadmap and investment planning (transport, storage, …)	Duty relief on Renewable Energy Assets / Electrolysers	Carbon Contract for Difference	Auctions	Consumption quotas / mandates	Credit enhancement mechanism
	Climate and renewable energy policies setting national targets	Fossil fuel subsidy reform	Grants/Viability Gap Fund		Tax relief for green products / Surcharge on end products	Subordinated debt
	Simple licensing process	Public Procurement	Simple licensing process			Blended Finance
			Subordinated debt			

Upstream Midstream Downstream Cross-cutting

Priority measures

Based on an OECD poll in June 2022

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BETTER POLICIES FOR BETTER LIVES

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Thank you

Deger Saygin

Industry Programme Lead

Deger.SAYGIN@oecd.org

IRENA INNOVATION WEEK 2023

Keynote:
Delivering Green Hydrogen and Ammonia Projects at Scale: Efficient, Innovative, and Sustainable

Alicia Eastman

Co-Founder and President, Intercontinental Energy

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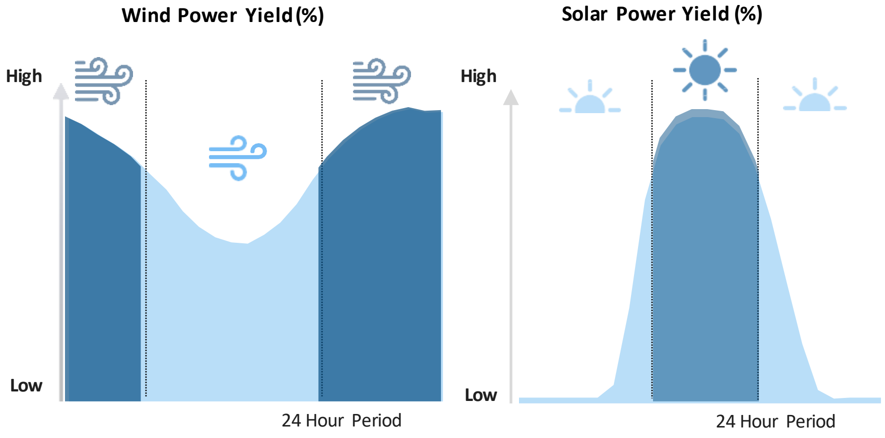
ICE Projects Feature Substantial Cost Advantages

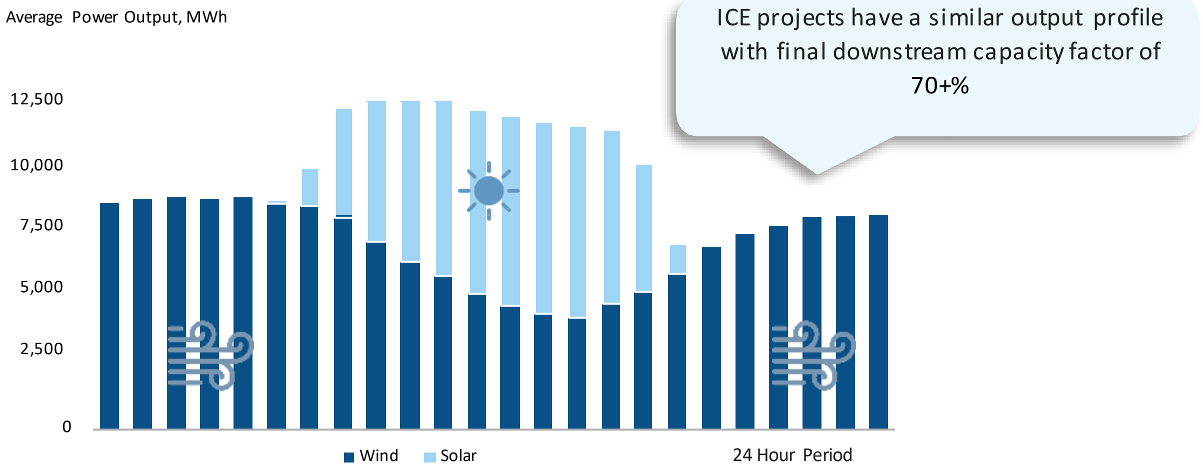
Location, scale, diurnal wind/solar resources, and optimization are key:

Wind and Solar Fluctuatee on Standalone Basis



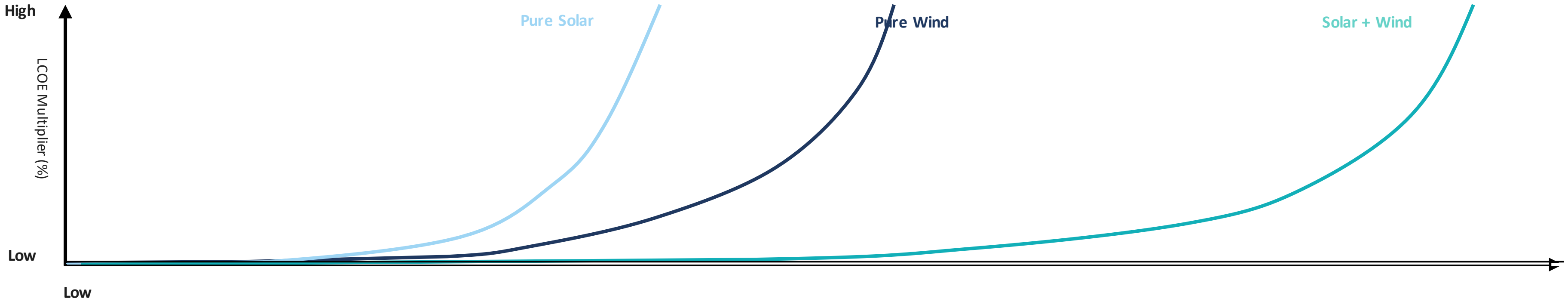
Source: BloombergNEF

Complementary Wind / Solar Output Drives Maximum Capacity Factor



Source: RINA

By Having an Optimized Wind and Solar Hybrid System, ICE Is Able to Maximize System Utilization and Minimize Cost



ICE Integrated Projects Overview

InterContinental Energy

Upstream Wind/Solar, Midstream Green Hydrogen & Downstream Ammonia

GEO (Up to 25GW)

Operator

- Concept Feasibility Study complete
- Shell acquired 35% of GEO in Jan 2023 and will assume operatorship
- Land and development agreements signed with Hydrom and Ministry of Energy and Minerals (2023)

SAREH (Saudi Project)

SAREH

- 3 years of engagement.
- Consortium structure under development.
- Saudi Stakeholder support including MOU with ARAMCO

GIC

- ICE strategic Investor since 2022
- Singapore Sovereign Wealth Fund

AREH (26+GW)

- 100-year land lease signed with Government (1)
- Lead Agency Status granted by Western Australia in 2018
- Major Project Status granted by Federal Government in 2020
- 15GW upstream environmental permit approval in Oct 2020
- BP acquired 40.5% of AREH and has assumed operatorship
- Domestic and export marketing activities underway

bp

Operator

WGEH (50+GW)

InterContinental Energy

Operator

- Development started in 2019
- JV includes native title owners as partners
- ICE secured Land License (2022)
- Lead Agency Status granted by Premier of Western Australia in 2021
- Resource monitoring underway and concept feasibility study completed by ICE (2023)

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ICE GW Scale Development Concept: the P2(H2)Node ™

InterContinental Energy

Siemens is the ICE optimization partner for the ICE IP

- Bringing six years of GW scale green hydrogen development expertise to our partners
- P2(H2)Node™ was developed by InterContinental Energy specifically to address the difficulties of GW scale Green Hydrogen Projects
- Tailored towards optimizing the economics and commerciality of green hydrogen by:
  - Maximizing production
  - Minimizing electrical losses
  - Optimizing system stability whilst minimizing storage capacity
  - Maximizing repeatability, automation, and phased construction
- The ICE nodal development structure has been adopted by bp and Shell in their role of operating shareholder in the AREH & GEO projects = real time validation of the nodal structure for mega scale developments.

ICE Corporate Vision & Strategy

InterContinental Energy

Vision

Developing unrivaled portfolio of green fuel projects which unite local partners, traditional owners, community stakeholders, and ICE shareholders for the long term in pursuit of ICE economic and ESG mission

Robust Partnerships

ICE plans to partner with companies that are aligned on values and have relevant experience and competence to take ICE projects through development, execution, and operations

InterContinental Energy

Long Term Investor

All of ICE portfolio projects are multi-GW, multi-phase development projects. Along with our Strategic Investors, ICE will fund the capex required for the build-out of the projects

ICE Green Hydrogen & Investment Model

Three fundamental pillars that embrace every stage of the asset life cycle

DEVELOP

PARTNER

MANAGE

Lead Developer & Originator	**Secure & Maintain Stakes in Strategic Consortia**	**Project Company Investment Manager**

ICE Role (Develop)

- ICE acts as lead developer in early stages of projects
- Land sourcing, energy yield assessment, design optimization, early stakeholder engagement
- In-house technical and commercial expertise to bring projects to a stage of viability and investment by credit-worthy and experienced consortium partners

ICE Role (Partner)

- ICE brings in credible experienced consortium partners.
- Consortium formed to take projects to successful FID and Financial Close
- ICE transitions to non-operating shareholder, retaining active participation in Boards and all relevant development committees

ICE Role (Manage)

- Long-term funding of the Project Companies
- Support other shareholders in the execution and operation of the Project Companies

ICE Integrated Projects Overview

InterContinental Energy

Upstream Wind/Solar, Midstream Green Hydrogen & Downstream Ammonia

ICE Project Portfolio	AREH, GEO, WGEH, SAREH
Project Developers	ICE + Consortia Partners (bp, Shell, OIA, KIA, CWP Global/CIP, the Mirning Nation, Macquarie, Modern, ARAMCO)
Location	AREH & WGEH (Western Australia), GEO (Oman), and SAREH (KSA)
Stages	Feasibility, Pre-Feed
Target FID	2025+ in modular phases for each project
Value Chain Segment	Fully integrated projects in vast coastal deserts with the ideal diurnal profile of strong sun and heavy nocturnal wind providing highest throughput for the least expensive production of hydrogen and ammonia
Project Technology Type	A combination of domestic green electrons/hydrogen and export ammonia
Contribution to development of global hydrogen trade corridors	End uses expected to be power generation, shipping fuel, heavy industry and heavy transport. Ammonia can also be used as a transport vector for hydrogen to ship more easily to North Asia and Europe. Domestic demand for green electrons and hydrogen including iron ore beneficiation and steel making.
Capacity	Total portfolio ~150GW of upstream renewables = ~10 MTPA of H2 and ~60 MTPA of ammonia

ICE Success Factors & Challenges

ICE Project Portfolio	AREH, GEO, WGEH, SAREH
Key Success Factors	• Quality Resource with 24/7 reliability and inexpensive storage is fundamental to the capacity factor, throughput, and eventually cost • Smooth processes including land, EPA, permitting, and all government approvals • Increased efficiency of electrolyser technology as well as production at scale • Optimization for all stakeholders • Effective policies to encourage green fuels and discourage emissions (e.g. IMO) • Long-term offtake appetite or other demand signaling • Modular build-out by phase and new financing mechanisms • ISO Assessment and Certification of emissions intensity with mutual recognition
Key Challenge: Technology	• Although no technology risk, electrolyser efficiency, scale up, and optimal project integration is required • Electrolyser technologies and geographies must also be diversified for geopolitical and optimization of raw materials • End use markets require technological modifications (e.g. cogen, steel, shipping)
Key Challenge: Global Technical Standards	• Certification is necessary for trade - not just for hydrogen/ammonia emissions intensity but also certification of shipping engines and vessels, power generation facilities, ammonia engines, etc. • Electrolysers must be diversified by technology and geography
Key Challenge: Regulatory	• Lack of certainty, simplicity, and speed

Thank you!

IRENA INNOVATION WEEK 2023

Panel discussion

Moderator:

Dr Gokce Mete

Global Lead, Hydrogen & Industry Transition, South Pole

Panelists:

Ulf Bäumer

Head of Innovation Center & Service & Digitalisation, Thyssenkrupp Nucera

Donal Cannon

Head of Regional Representation for South Asia, EIB

Norela Constantinescu

Head of Section Innovation, Entso-e

María Jaén

European Hydrogen Research Leader, EPRI

Francisco Maza

Hydrogen Director, REPSOL

Mark van Stiphout

Deputy Head of Unit - Research, Innovation, Digitalisation, Competitiveness DG Energy - EC

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