McKinsey & Company

Indaba Energy Leaders Dialogue

Green hydrogen: An opportunity to create sustainable wealth in Africa

AFRICA ENERGY INDABA

Your hosts

Kannan Lakmeeharan

Managing Partner,
McKinsey & Company, Johannesburg
Electric Power & Natural Gas and
Public & Social Sector Practice Leader

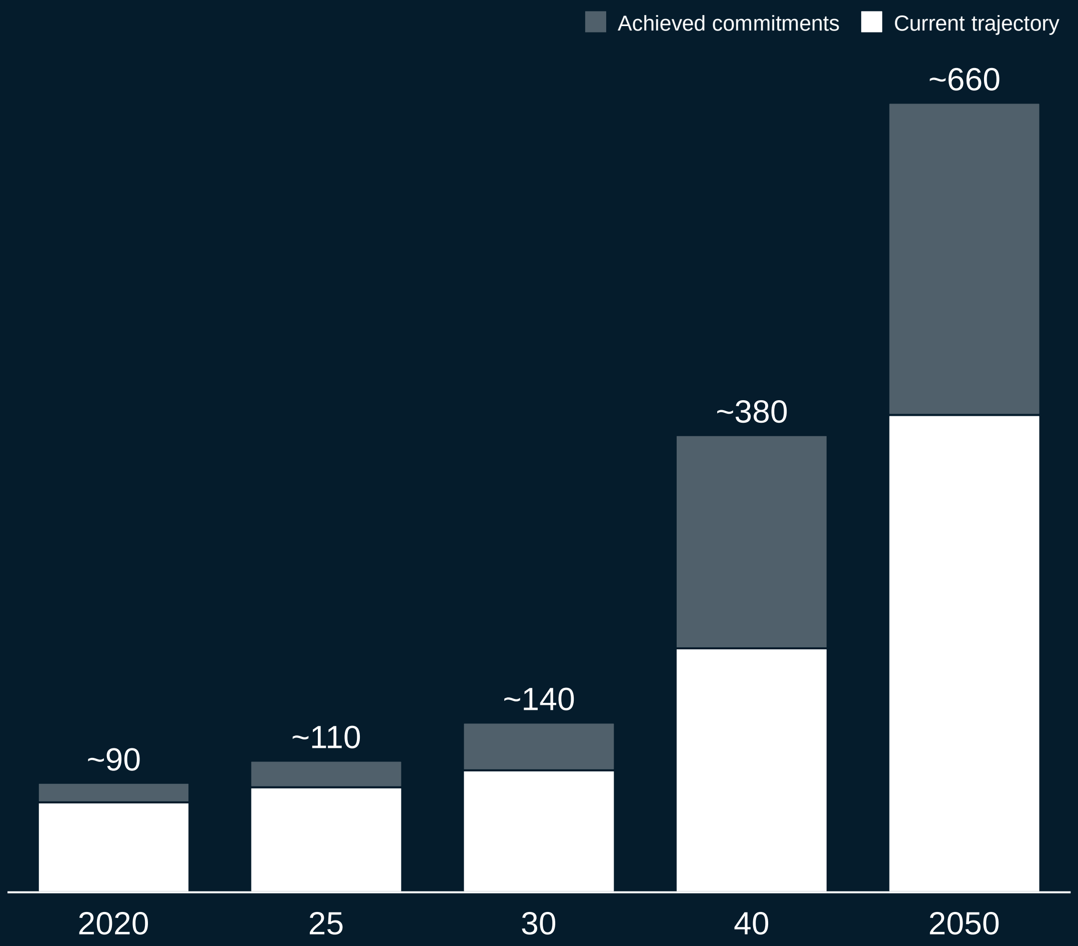
Maurits Waardenburg

Partner, McKinsey & Company, Brussels
Hydrogen Insights Solution Leader

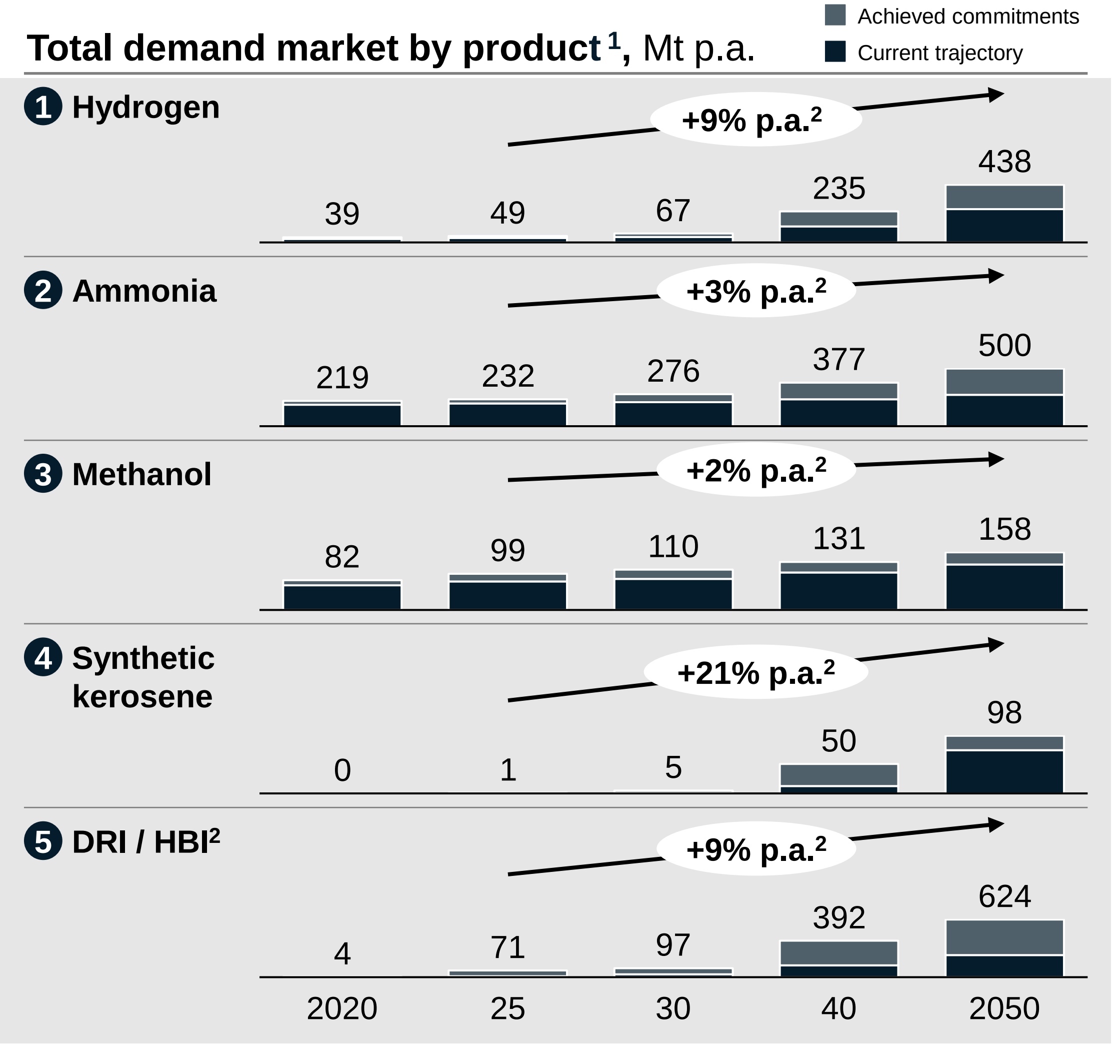
Rapid growth in global hydrogen and derivatives consumption expected 2030+

Total demand varies by climate transition scenario

Total global demand of hydrogen and derivatives[1], Mt p.a. H2 equivalent *Global*



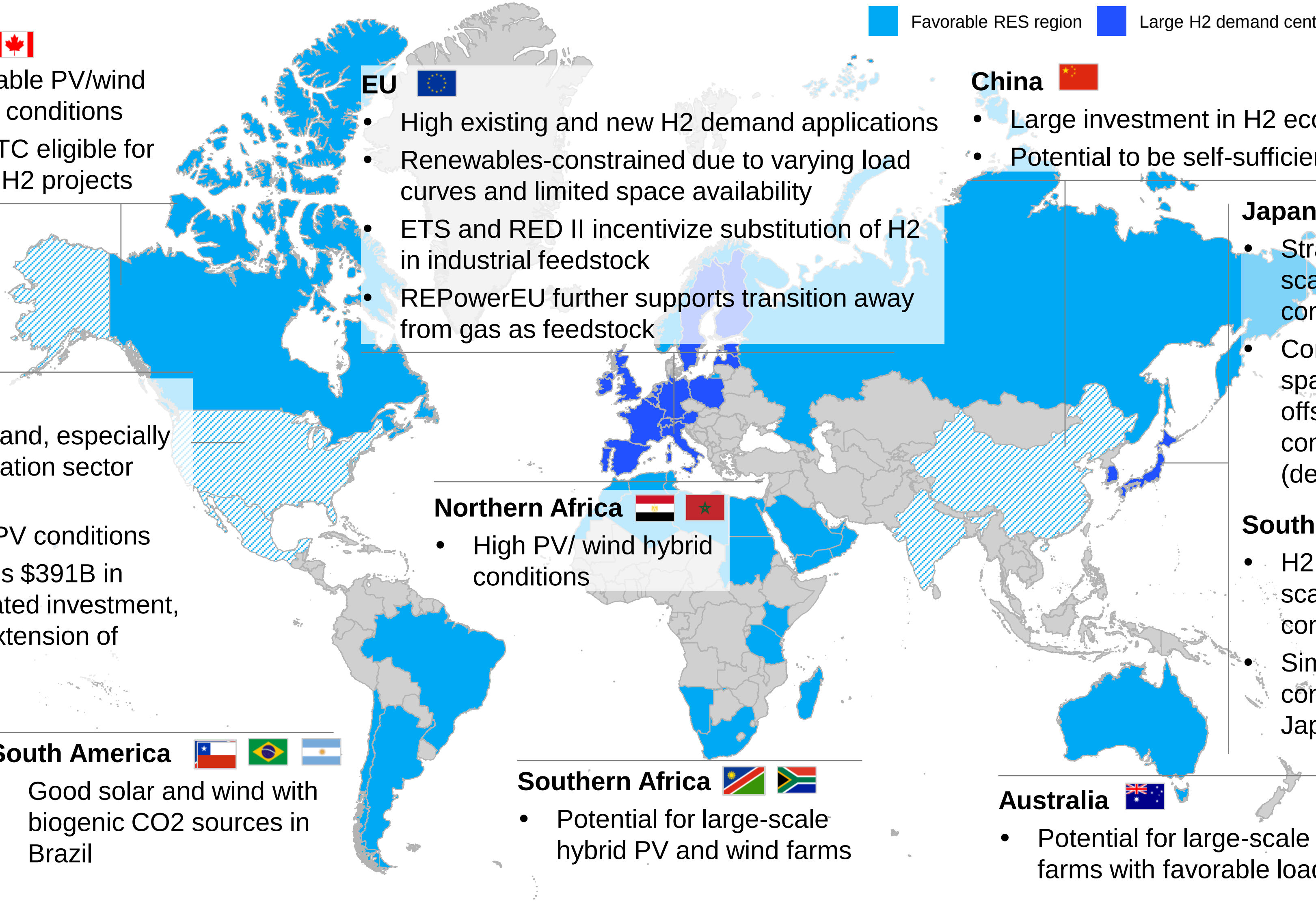
Total demand market by product[1], Mt p.a.



1. From grey, green and blue sources 2. Includes HBI and DRI demand for DRI Steel
2. Achieved commitments scenario

Source: McKinsey

Global supply and demand centers are mismatched, presenting a large potential opportunity for hydrogen/derivative exports



Canada
- Favorable PV/wind hybrid conditions
- 30% ITC eligible for green H2 projects

US
- Rising demand, especially in transportation sector (California)
- Favorable PV conditions
- IRA includes $391B in climate-related investment, including extension of ITC/PTC

South America
- Good solar and wind with biogenic CO2 sources in Brazil

EU
- High existing and new H2 demand applications
- Renewables-constrained due to varying load curves and limited space availability
- ETS and RED II incentivize substitution of H2 in industrial feedstock
- REPowerEU further supports transition away from gas as feedstock

Northern Africa
- High PV/ wind hybrid conditions

Southern Africa
- Potential for large-scale hybrid PV and wind farms

China
- Large investment in H2 economy
- Potential to be self-sufficient

Japan
- Strategy to scale up H2 consumption
- Constrained in space and offshore wind conditions (deep-sea area)

South Korea
- H2 roadmap to scale up consumption
- Similar constraints as Japan

Australia
- Potential for large-scale PV farms with favorable load profiles

Key Insights

Large hydrogen offtake centers are often renewables-constrained and will not be able to self-supply their hydrogen demand, relying on hydrogen imports in the future

Especially **countries with complementary load** profiles of wind and PV can take advantage of green hydrogen export opportunities

Only **few regions** like **China** and the **US** are **both large demand centers and have favorable RES conditions**, providing them with the potential to be independent of hydrogen imports

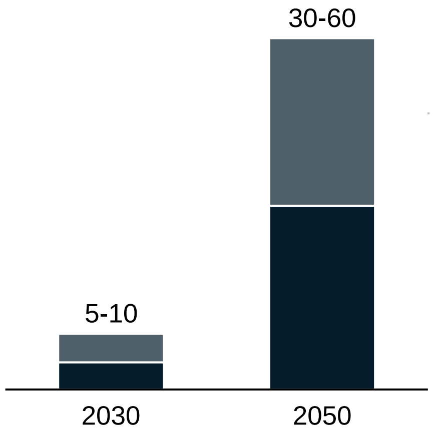
Climate also influences the type of products that a country will be more competitive manufacturing, hot dry countries with good solar and wind resources is best to make ammonia; and hot humid countries best for methanol

Africa is well positioned to meet some of the ~100 mtpa clean H2 import demand in Europe and the Far East…

H2 and derivatives imports in 2030 and 2050, mtpa

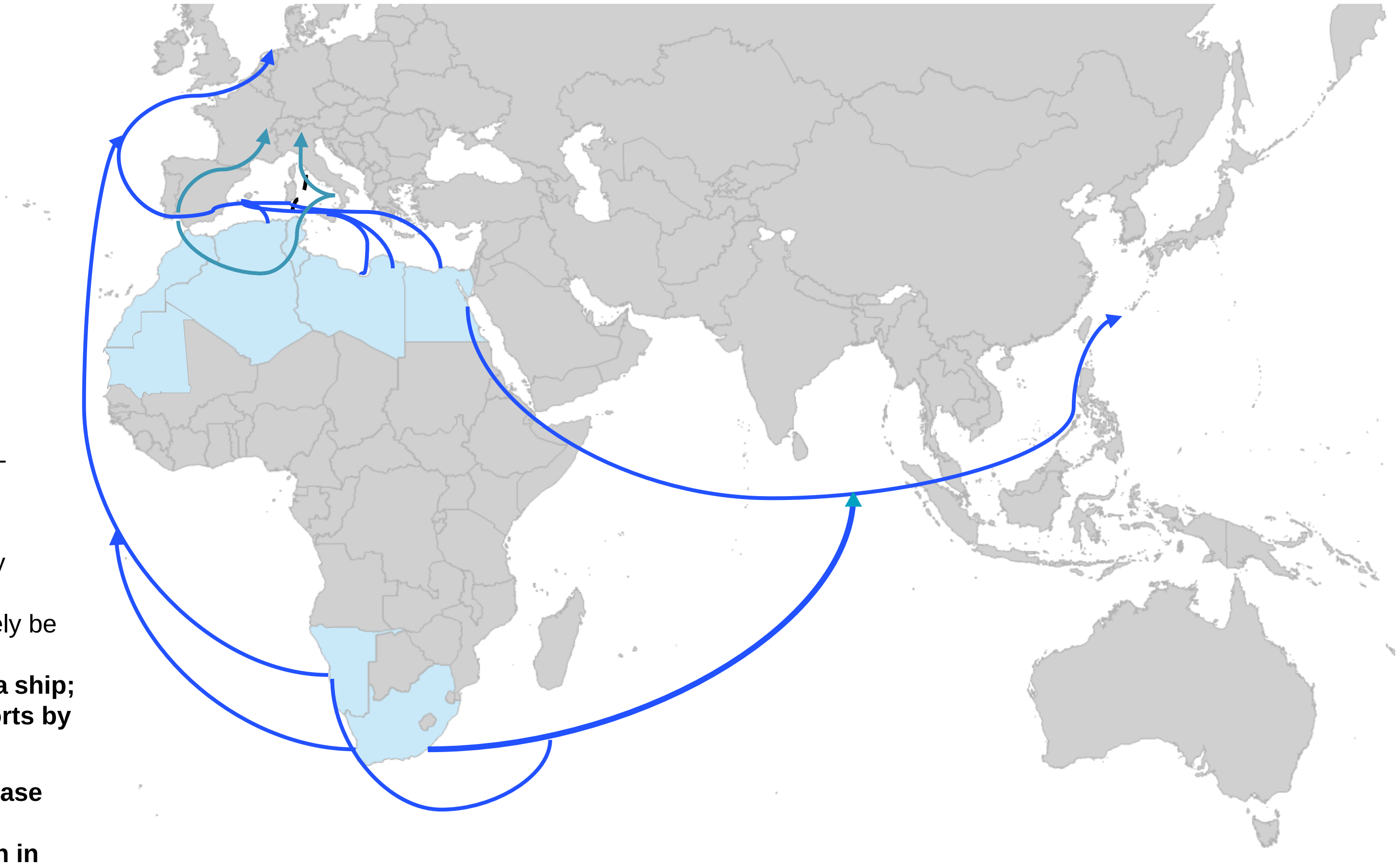
Achieved commitments | Current trajectory | Shipped H2[1]/ H2 derivatives | Piped H2

Europe (incl. UK)

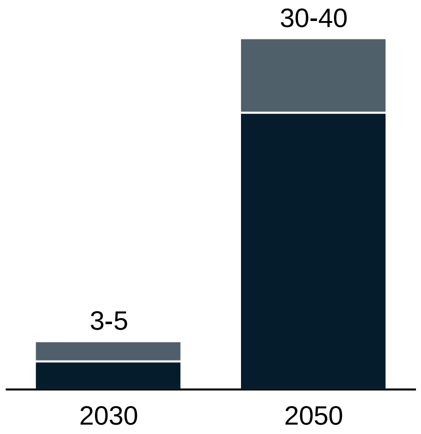


2030: H2 demand strongly driven by **transport applications and conventional uses** which can largely be catered via **direct H2 imports via pipeline and ammonia imports via ship; EU set explicit goal of 10 Mt imports by 2030**

2050: **Pure H2 requirements increase based on heating and power applications**; **synfuel imports gain in importance** based on increasing demand



Japan / South Korea / Taiwan



2030: Conventional industrial uses (i.e., refining) and power generation use cases to require **vector-bound H2 imports as well as ammonia imports via ship**

2050: **Growing demand from power applications incl. ammonia co-firing** further drive demand for ammonia imports

1. Bound to carriers

Source: McKinsey Global Energy Perspective, team analysis

...by leveraging great RES potential, proximity to demand centers, existing infrastructure, and resources access for derivatives production

Northern Africa

Favorable set up for **H2 exports to Europe (esp. via pipeline)** and **ammonia production for exports to key demand centers** based on:

- Great RES potential with achievable LCOE of ~17-19 USD/MWh
- Proximity to demand centers (i.e., Europe)
- Existing pipeline infrastructure

Western Africa

RES profile not optimized for exports - **focus on H2 production for local demand expected**

Southern Africa

Favorable set up for **H2- , synfuel, and potentially ammonia production for exports via ship** to key demand centers based on:

- Great RES potential with achievable LCOE of 16-17 USD/MWh
- Access to biogenic CO2 sources (e.g., pulp/ paper industry)

Eastern Africa

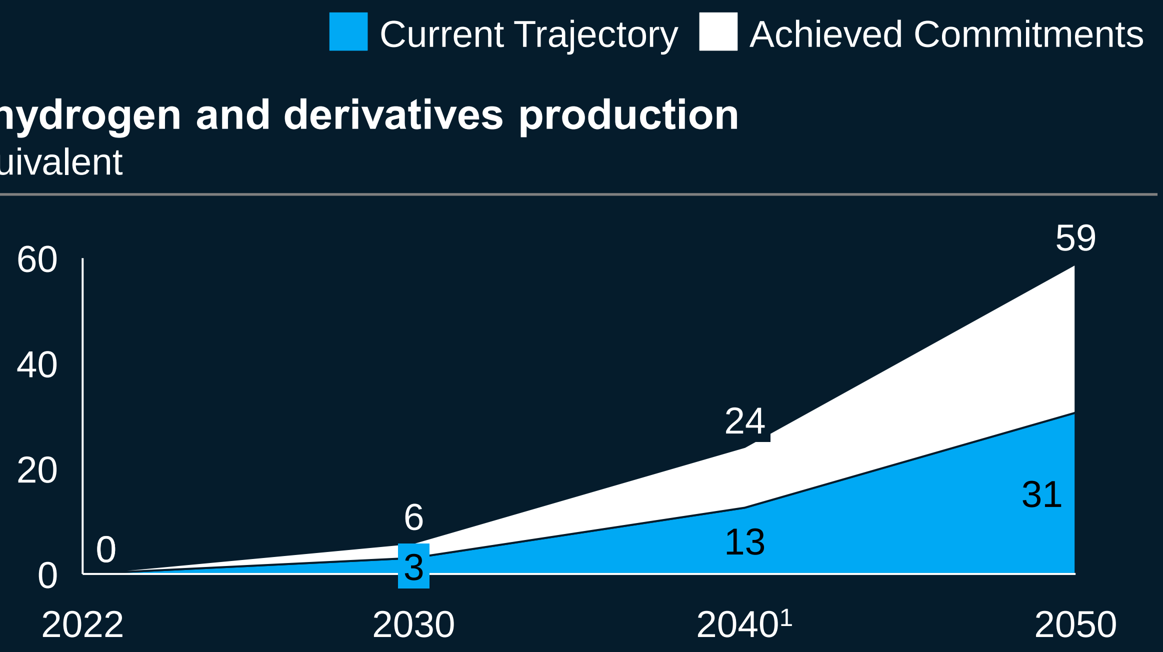
RES profile not optimized for exports - **focus on H2 production for local demand expected**

Source: Team analysis

In total, Africa could produce 30-60 Mt of green hydrogen by 2050

Estimate

Africa's green hydrogen and derivatives production
Mt of hydrogen equivalent



	2030	2040[1]	2050
RES capacity[2], GW	~51–97	~208–400	~507–975
Electrolyzer capacity, GW	~29–56	~119–228	~290–560

1. Potential in 2040 is sensitive to the state of technology readiness, actions by various African nations between now and 2030, national ambitions, and the state of funding.
2. RES capacity should be built in remote/stranded locations with tier-1 renewable endowment and deployed in such a way that it could also facilitate the continent's electrification needs.

Source: McKinsey analysis building on Hydrogen Council's & McKinsey's global hydrogen trade flow model

~10% of the expected global hydrogen demand by 2050

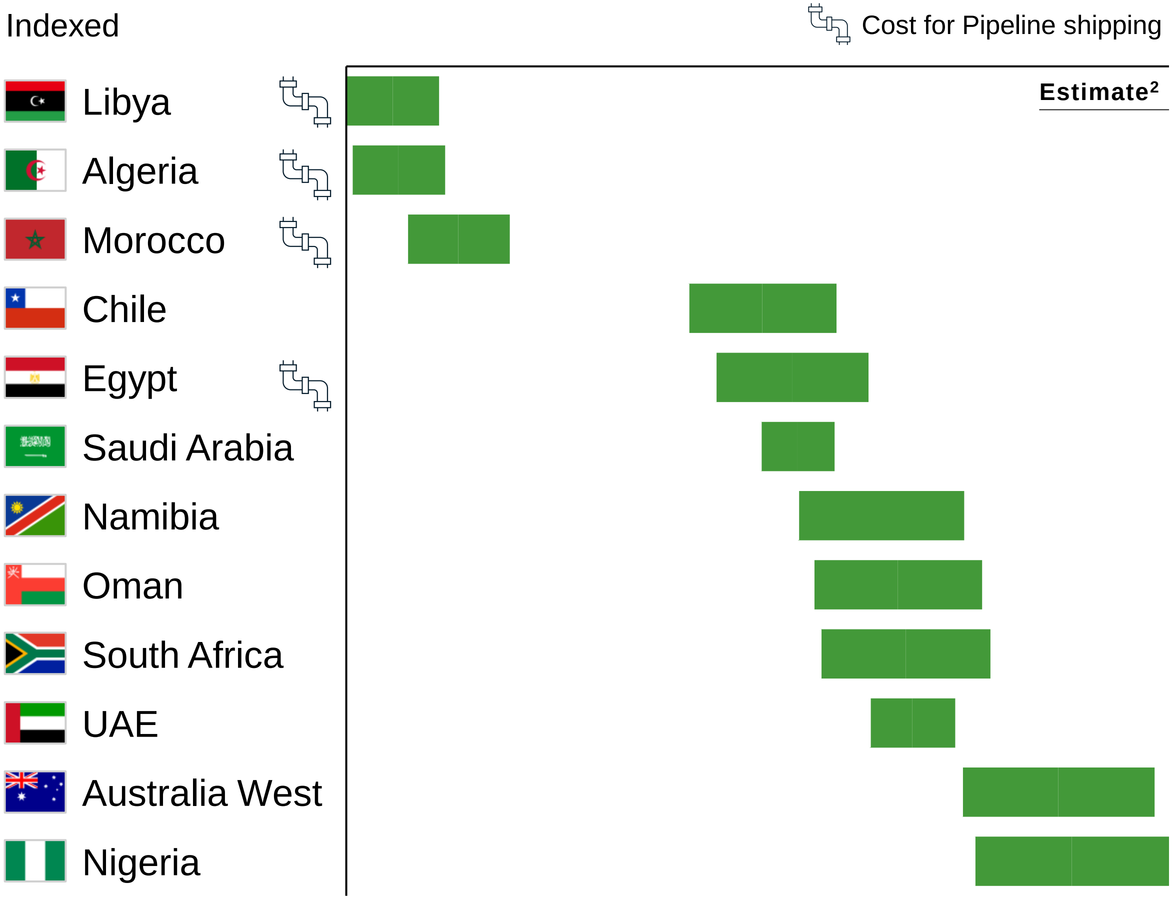
~1/3rd of the opportunity could be domestic

~22% export opportunity's potential share of the expected international cross-border trade by 2050

Several African countries could be among the top 10 seaborne suppliers based on landed cost range, supply diversification needs of the buyers and ability to access low-cost finance

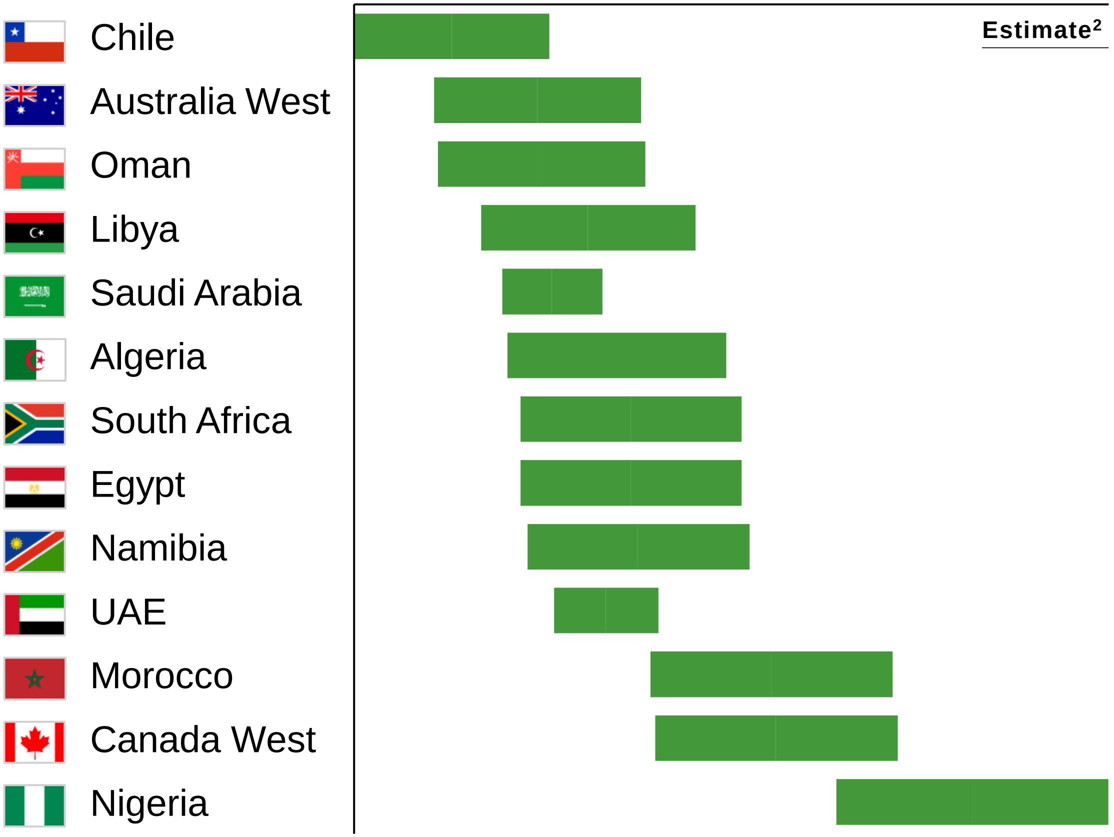
2050 Green hydrogen landed cost range[1] to C. Europe, no subsidy

Indexed



2050 Green hydrogen landed cost range[1] to Japan, no subsidy

Indexed



US may capture some of this opportunity, as IRA PTC incentivizes project launches before 2033

1. Lower bound: WACC + 1% and upper bound: WACC - 1%
2. 2022 analysis. Renewables capex cost estimates have recently risen substantially, affecting the total cost of Green H2 production but not the relative cost by country

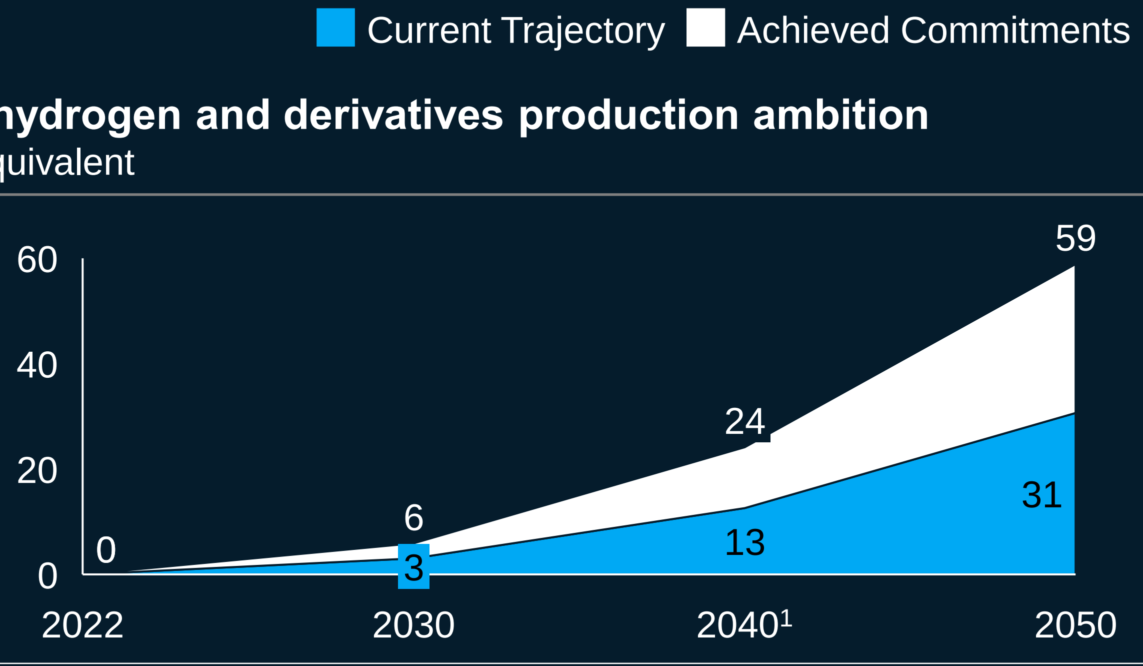
Source: McKinsey and Hydrogen Council: Hydrogen Insights; European Commission

Delivering this potential would require $450-900bn in cumulative investment by 2050

70% of the investment would likely need to be foreign direct investment

Estimate

Africa's green hydrogen and derivatives production ambition
MT of hydrogen equivalent



	2030	2040	2050
Cumulative investment, (2020–20XX), in $ billions	~$30-$55	~$175-$330	~$450-870
Approximate annual investment, USDBn	~$3-$6	~$15-$28	~$28-$55

1. Potential in 2040 is sensitive to the state of technology readiness, actions by various African nations between now and 2030, national ambitions, and the state of funding.

Source: McKinsey hydrogen insights; expert interviews

Comments

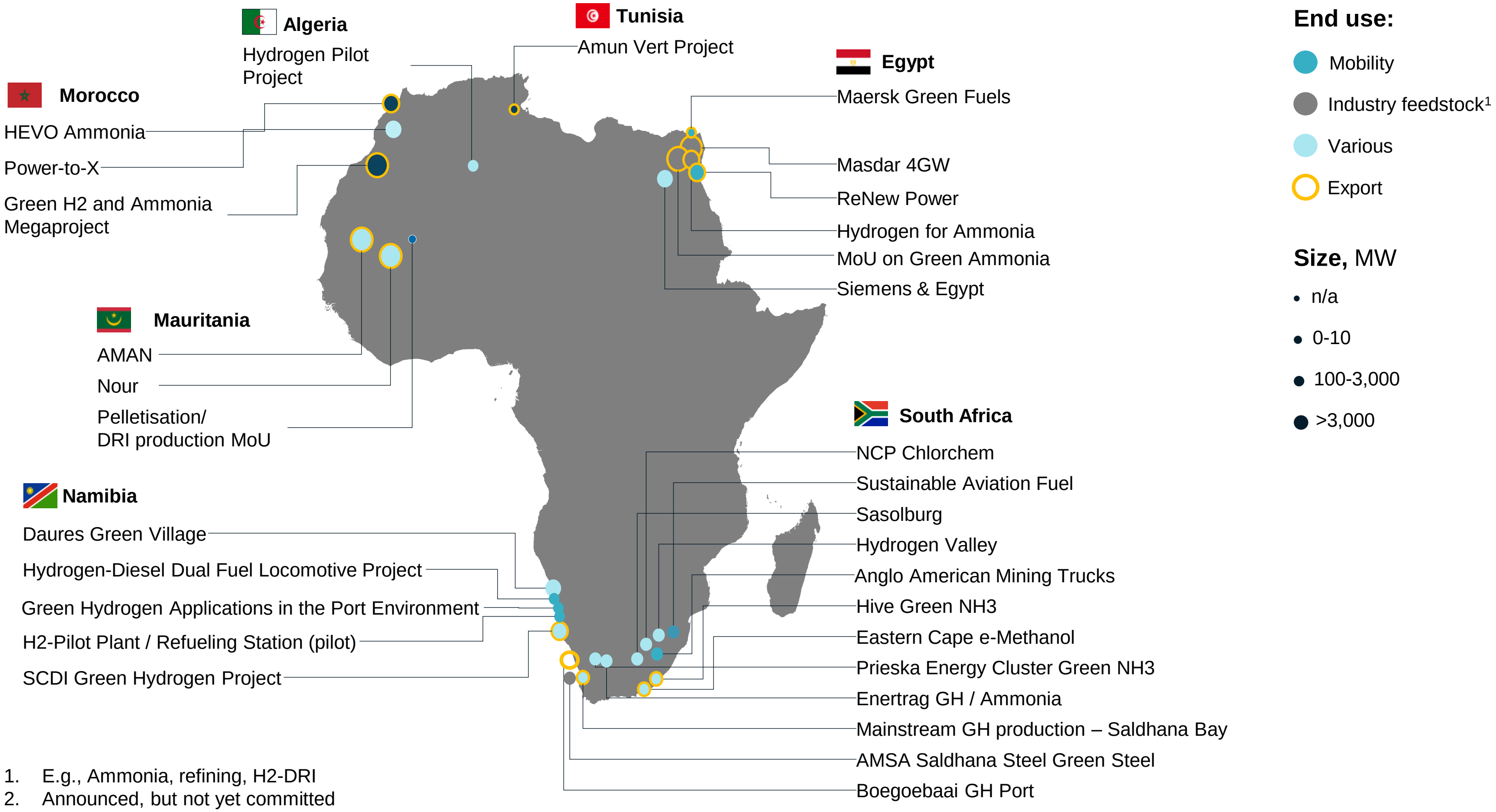
Significant investment needed

- **~$3bn – $6bn needed annually between now and 2030**
- **~ $15bn – $30bn needed annually between 2030 and 2040**
- **~$28bn – $45bn needed annually between 2040 and 2050**
  - Equals ~2–3% of total energy investment needed annually worldwide around the same period to get to net zero
- ~**70%** of the total investment in RES and electrolyzer capacity building

Growing momentum in Africa, but pipeline falling way short of potential

H2 project location and electrolyzer capacity,
MW p.a.

Note: Only electrolysis-based hydrogen projects (excluding e.g., waste-to-hydrogen)



1. E.g., Ammonia, refining, H2-DRI
2. Announced, but not yet committed

Source: Hydrogen Council project & investment tracker

21

green hydrogen projects

3%

of globally announced projects

48 GW

electrolysis capacity

USD 30bn

announced investment in hydrogen value chain[2]

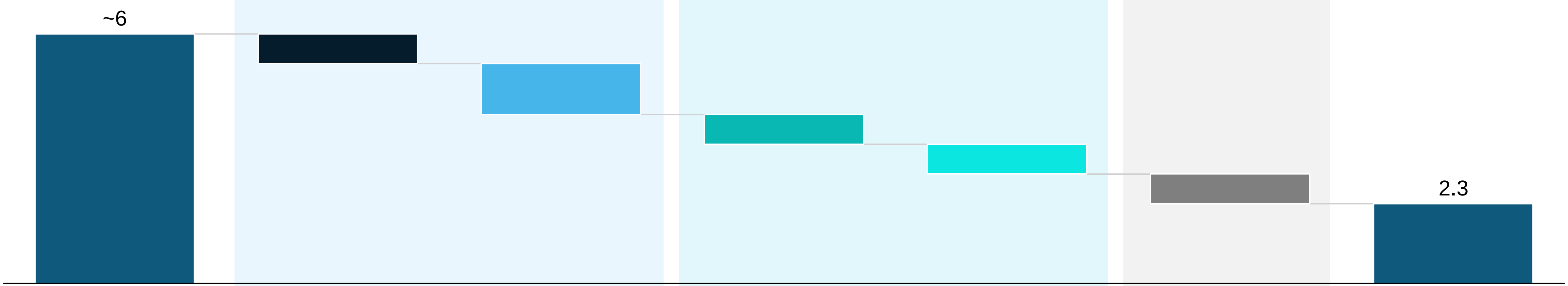
Stakeholders could take concerted action to de-risk projects and unlock large scale, low-cost financing

Not Exhaustive

	Actions stakeholders could take
National governments	✓ Support the uptake of green hydrogen in domestic industries ✓ Make a **compelling national plan** and **increase trust in policies** ✓ **Plug gaps** in regulations and standards, and critical infrastructure (including H2 transportation) ✓ **Mobilize development partners**
Project and infrastructure developers	✓ **Identify infrastructure gaps and financing needs** ✓ **Build strategic partnerships** with off-takers, civil societies, and critical equipment manufacturers (e.g., electrolyzer OEM) ✓ **Optimize projects** upfront to minimize risk ✓ **Mobilize partners** (governments, other stakeholders) to unlock low-cost financing ✓ Support **local talent development**
Off-takers	✓ Collaborate with stakeholders to shape and build **long-term sustainable demand** ✓ Help project developers **mitigate revenue risk** while safeguarding one’s interests ✓ **Aggregate demand** to unlock scale-benefits in shipping and storage ✓ Explore **financing partnerships**

Various risk components drive the high cost of financing in Africa

ILLUSTRATIVE



Cost of capital for RES project in an African country (WACC above risk-free rate)	**Currency risk**	**Off-taker risk**	**Execution risk**	**Political/ institutional risk**	**Other risk**	Cost of capital for RES project in Germany (WACC above risk-free rate)
	related to devaluation of local currency	related to off-taker not fulfilling its contractual obligations	related to availability of skilled workforce, supply chains, EPC[1]	related to political instability, regulatory uncertainty and (lack of) contractual enforcement	remaining after applying de-risking levers	
	Mitigated through seeking creditworthy foreign offtake for hydrogen and derivatives		*Partially mitigated through setup of enforcement mechanisms for hydrogen projects*	*Partially mitigated through political risk insurance and incentive alignments*	*No mitigation levers available*	

1. Engineering, Procurement, and Construction

Source: Steffen, B., 2020. Estimating the cost of capital for renewable energy projects