Namibia's green hydrogen opportunity

# KEY QUESTIONS
# + INITIAL ANSWERS

Jan 2022

THE AFRICAN CLIMATE FOUNDATION

SYSTEMIQ

# KEY MESSAGES

## Green hydrogen is a transformative opportunity for Namibia

- There is widespread acknowledgement that **hydrogen – and "downstream" products like green ammonia – will play a pivotal role in decarbonising the economy.** Volumes could reach 500-800 Mt hydrogen ($H_2$) by mid-century. The world is moving.
  - Certain **"downstream" hydrogen products** are well suited to international trade. These include ammonia, methanol, synfuel, steel and could represent c.50% of the target $H_2$ economy. For these products, there is high confidence that hydrogen-solutions will lead how we decarbonise.
  - In the target off-taker sectors – e.g., fertilizer, shipping, aviation, chemicals – **early moving corporates are already taking steps to consume clean hydrogen.** At the same time, globally competitive suppliers – e.g., Chile, Australia, Saudi Arabia – are moving to meet these markets.

- **Namibia is positioned to be able to achieve highly competitive green hydrogen production costs.**
  - That value can be unlocked by **exporting green ammonia ($NH_3$) at highly competitive prices**: ~$400/t $NH_3$ by 2030, and ~$350/t $NH_3$ by 2040. **Exporting excess clean power** further improves the economics.
  - There is potential longer term to export additional hydrogen "downstream" products (e.g., synfuels, steel / hot briquetted iron).

- **Potential economic benefits to Namibia** would accrue over time and by 2040 could reach and surpass: GDP boost of c.$20bn/year[1], well over 100,000 domestic jobs, $6bn-$8bn contribution to trade balance[2] and national energy independence.

- **Successfully capturing this opportunity will come down to execution in achieving globally competitive cost of green ammonia**
  - Achieving lowest cost of ammonia critically relies on (e.g.): attracting competitive cost of capital, coordinated procurement to negotiate early electrolyser discounts, intelligent phasing and build out of core infrastructure, integrating power exports to improve economics
  - Namibia should seek to establish itself as a relevant player in the 2020s to de-risk scale-up in the 2030s

[1] Assumes Namibia serves 5% of expected global green ammonia market including shipping in 2040 (c.38Mt $NH_3$) at a price of $400/t $NH_3$, plus additional revenues from oversizing renewables and selling 75 TWh of excess power into SAPP/SA at $0.05/kWh. [2] Estimated incremental impact on annual balance of accounts for ammonia and power export revenues less imports/foreign expenditures (CapEx, OpEx, financing costs).

# INTRODUCTIONS: THE AFRICAN CLIMATE FOUNDATION

THE
AFRICAN
CLIMATE
FOUNDATION

- Launched in April 2020 as the first **African-led** climate change regranting organisation on the continent
- Experienced and **growing team** of 14 African individuals and a **broad network of supportive partners** from the continent and abroad
- Providing a mechanism through which **philanthropies** can contribute to Africa's efforts to address climate change
- Supporting interventions at the **nexus of climate change and development**
- Bringing climate change to the forefront of **development thinking** and planning in Africa.
- Our geographical focus is determined by evidence-based assessments of the **opportunities and challenges** that exist on the continent.

## The ACF's Four Key Strategic Focus Areas

**ENERGY ACCESS AND TRANSITIONS**
*Access to energy and to reliable and affordable electricity supply is a precondition for Africa's development*

**RESILIENT URBAN ENVIRONMENTS**
*Renewing urban landscapes in sustainable ways is key to creating thriving and habitable cities*

**SUSTAINABLE LAND-USE & AGRICULTURE**
*An ecologically sustainable trajectory for Africa is fundamental to agricultural productivity, poverty eradication and human well-being*

**BRIDGING INTERVENTIONS:**
*Finance, digitisation, infrastructure, industrialisation, geopolitics and climate diplomacy.*

## The ACF's pan-African Leadership & Advisory Council

**Saliem Fakir (South Africa)**
*Executive Director of African Climate Foundation*

Advisory Council: consists of four of **Africa's leading thinkers**, providing strategic oversight and guidance in matters related to political, economic and development issues in Africa.

**Dr Wanjiru Kamau-Rutenberg (Kenya)**
*Executive Director of Rise*

**Professor Carlos Lopes (Guinea-Bissau)**
*Has occupied several leadership positions across the UN system; AU High Representative*

**Clarisse Iribagiza (Rwanda)**
*CEO of HeHe, leading tech company in Rwanda*

**Adnan Amin (Kenya)**
*DG of IRENA and Senior Fellow at Harvard's Belfar Center*

**Professor Mohamed Salih (Sudan)**
*Professor of Development Politics; Nobel Prize for Peace co- laureate (2007, IPCC)*

# INTRODUCTIONS: SYSTEMIQ

- Setup in 2016 to **drive implementation of the Paris Agreement** and UN SDGs
- Offices in UK, Germany, Indonesia, Brazil, France & Netherlands
- Certified-B Corporation
- **4 platforms** focused on the greatest opportunities for human prosperity:

ENERGY

NATURE

MATERIALS

SUSTAINABLE FINANCE

## Hydrogen expertise

- Chair the **Energy Transition Commission** and published a widely-cited hydrogen report:
  - **Making the Hydrogen Economy Possible** (2021) focused on scaling hydrogen – early sectors, changing economics, etc.
- Lead the **Mission Possible Partnerships:** coalitions of industry players in heavy sectors to collectively advance decarbonisation efforts
  - Includes industry coalitions in shipping, trucking, aviation, steel – sectors where **hydrogen is a critical lever** to decarbonisation
- Lead **projects** with investors and corporates to understand the **investment opportunity in the emerging hydrogen sector**
- Work with governments on **country energy transition strategies**

## Sustainable Finance expertise

- SYSTEMIQ chairs the **Blended Finance Taskforce,** a coalition focused on mobilising private capital for the SDGs
- Case study: we helped the Government of Indonesia launch **"SDG Indonesia One"**
  - **$3bn sustainable infrastructure blended finance platform**
  - **Worked with Ministry of Finance** to develop, fundraise & get to launch
  - Since supported **pipeline development & investor engagement**
  - Continue to support investment scale up including through **carbon finance**
- **Deep network to help access catalytic capital** (climate/development finance, philanthropic funding etc.) and mobilise private investment for the SDGs

# DOCUMENT CONTEXT

- There are a **number of key questions** to be answered as Namibia looks to capture its hydrogen opportunity. This document seeks to provide **initial answers** to these questions based on preliminary analysis.
  - This analysis was conducted by **SYSTEMIQ,** a B-corporation focused on delivery of the Paris Agreement and UN SDGs. Financial support for the work (conducted Oct-Dec, 2021) was provided by the **African Climate Foundation.**

- The objective of such a document is to **enable Government of Namibia to accelerate decisions** in scaling up its hydrogen economy, while more detailed analysis is pursued to pressure test a number of these answers.

- The preliminary analysis herein draws on **SYSTEMIQ's hydrogen expertise & sustainable finance expertise**, leverages & builds upon previous **country-specific studies from Namibia**, and fills certain gaps with **desktop research & expert interview** input from experts in Namibia and from SYSTEMIQ's network. It has been developed **in collaboration with representatives from Government of Republic of Namibia & the Green Hydrogen Technical Committee.**

- The intent is to **demonstrate the tremendous potential for green hydrogen** in Namibia and support discussions inside Namibia and with investors and development partners on how to seize this potential.

# KEY QUESTIONS COVERED

The **'What'**

1. **Export markets**
2. **Domestic markets**
3. **Namibia infrastructure design**
4. **Maximize benefit to Namibia**

The **'How'**

5. **Regulations & incentives**
6. **Financing**
7. **Partnerships**
8. **Roadmap**

# KEY QUESTIONS COVERED

**The 'What'**

1. **Export markets**
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**The 'How'**

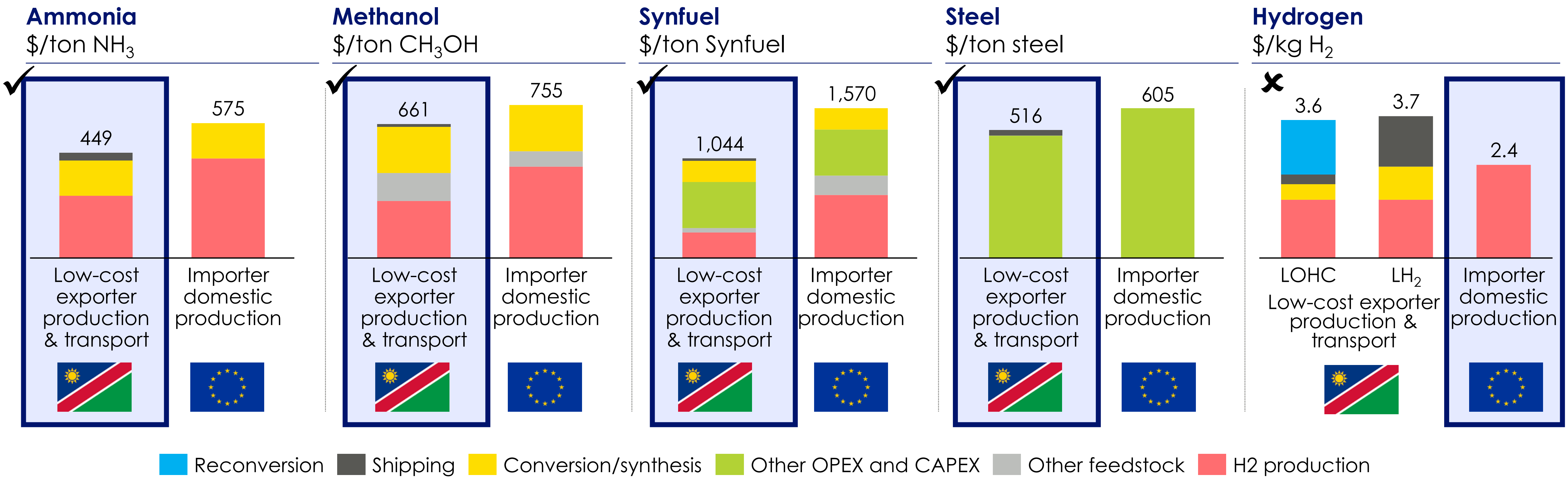
5. Regulations & incentives
6. Financing
7. Partnerships
8. Roadmap

- Namibia $H_2$ products that are **competitive with importers' domestic production**
- **Volumes of $H_2$** to serve target end-sectors, in net-zero mid-century economy
- **Timing of $H_2$ demand scale-up** from 2020 to 2050
- **Economics** of $H_2$ solutions vs. fossil
- **Early movers on demand-side** who Namibia could serve, or partner with
- Namibia's **competitiveness vs. other exporters**
- **Regional** value chains & export opportunities
- **Steel & synfuel** export competitiveness & key challenges to tackle

# PRODUCTS / CHEMICALS MADE WITH LOW-COST HYDROGEN ARE COMPETITIVE VS. DOMESTIC PRODUCTION IN ‘IMPORTER’ COUNTRIES; HYDROGEN AS A GAS / LIQUID IS NOT

**‘Delivered cost’ of product in importer countries (e.g., EU), 2030**

All products are the ‘green’ version



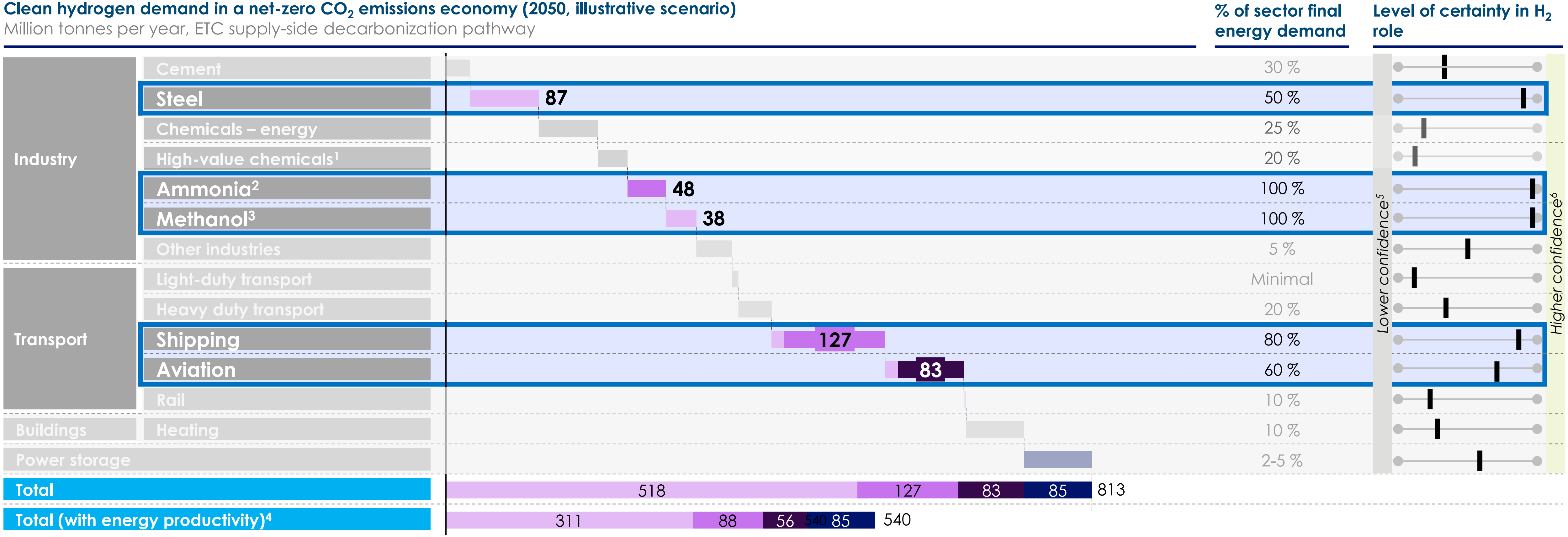
- Where the **end-use is a product that can ship at low-cost**, (e.g., ammonia, methanol, synfuel, steel) **international trade is competitive**
- Where the **end-use is $H_2$, production cost advantage is eroded** by conversion and re-conversion – only expected to play a role **once space constraints create production issues** in importer countries (e.g., Japan, Germany, Netherlands, Belgium); **2035+ market**

All costs are for year 2030. $H_2$ productions costs for Western European Countries. Methanol from Namibia uses DAC for $CO_2$ at a price of $100/ton $CO_2$ and in-country supply uses point-source $CO_2$ at a price of $55/t $CO_2$. For Synfuel the source of carbon in Namibia is BECCS and the source for EU is point source. The technology is SOEC + FET. The synthesis costs of synfuel represents the CAPEX for the corresponding technology. The $H_2$ production costs includes all OPEX costs for the corresponding technology. WEF (2020), Clean skies tomorrow. UNCTAD. Mission Possible Partnership (2021). *Net Zero Steel, Sector transition strategy*.

# IN THE NET-ZERO HYDROGEN ECONOMY, OUR 'TARGET SECTORS' ACCOUNT FOR ~50% $H_2$ DEMAND; HIGH-CONFIDENCE IN $H_2$ SOLUTIONS

- ▨ $H_2$ for final consumption
- ▨ $H_2$ for green ammonia production
- ■ $H_2$ for synfuels production
- ■ $H_2$ for power storage and flexibility
- ☐ Sectors suited to international supply chain

**Clean hydrogen demand in a net-zero $CO_2$ emissions economy (2050, illustrative scenario)**
Million tonnes per year, ETC supply-side decarbonization pathway

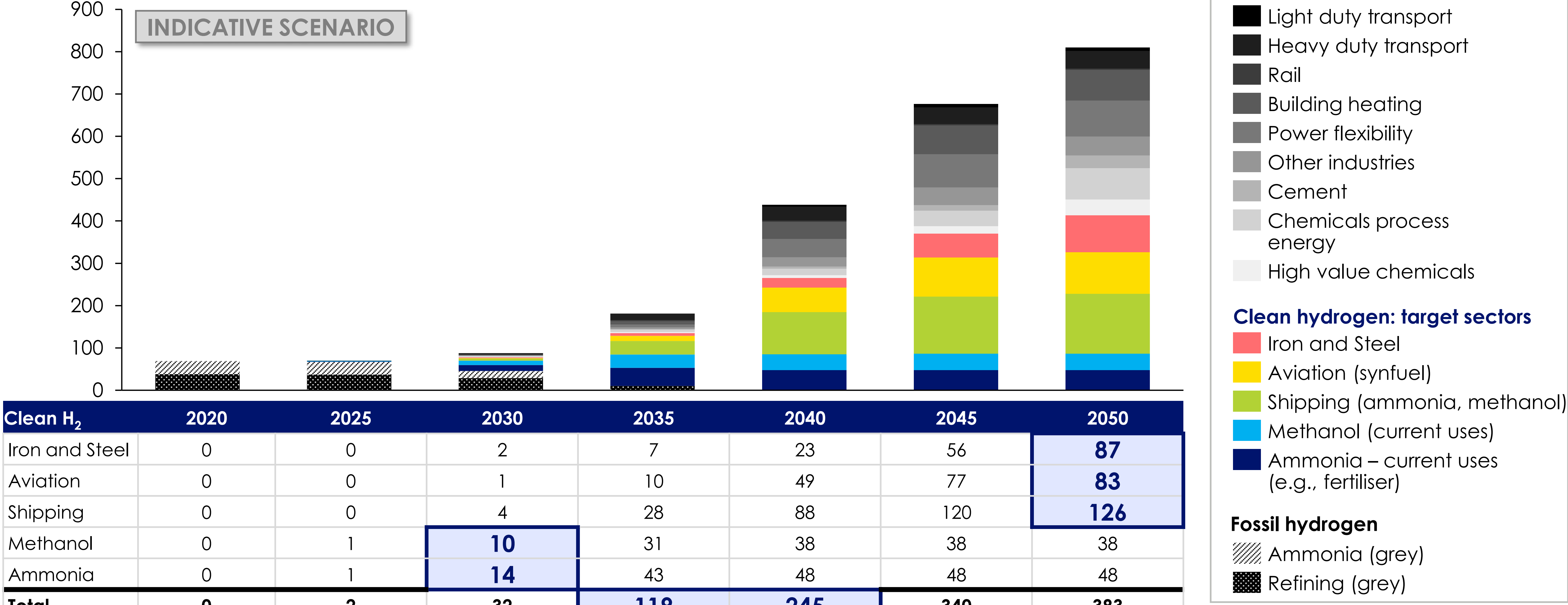


- **47% of total $H_2$ market in NZ**, or 383Mt $H_{2,}$ is in sectors where **international trade could be a competitive supply source**
- These sectors are helpfully those where there is a **higher level of confidence** that $H_2$ solutions will be fundamental to decarbonisation

Notes: 1) High value chemicals predominantly used to produce plastics, which could potentially be produced via hydrogen and $CO_2$ in the future (from methanol and MTO process); 2) Around 80% of ammonia (excl. shipping) is used to produce fertilisers; 3) Methanol is used as intermediate in numerous chemical processes, including plastics production. 4) ETC scenario including maximum energy productivity improvements. Source: SYSTEMIQ analysis for the Energy Transitions Commission (2021); 5) Lower confidence = Multiple decarbonisation routes available, eventual role of $H_2$ likely to vary by region depending on local costs and availabilities; 6) Higher confidence = $H_2$ based routes likely to play a significant decarbonisation role due to, e.g. limits to alternative routes, likely cost evolution, industry actions

# FOR 'TARGET SECTORS', EARLIER DEMAND FROM AMMONIA & METHANOL; FROM 2035 DEMAND SCALES IN SHIPPING, AVIATION, STEEL

**Hydrogen demand** (Mt Hydrogen / year)



| **Clean $H_2$** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|
| Iron and Steel | 0 | 0 | 2 | 7 | 23 | 56 | **87** |
| Aviation | 0 | 0 | 1 | 10 | 49 | 77 | **83** |
| Shipping | 0 | 0 | 4 | 28 | 88 | 120 | **126** |
| Methanol | 0 | 1 | **10** | 31 | 38 | 38 | 38 |
| Ammonia | 0 | 1 | **14** | 43 | 48 | 48 | 48 |
| **Total** | **0** | **2** | **32** | **119** | **245** | **340** | **383** |

Note: scenario shown assumes ~85% green $H_2$ supply in 2050 with blue supply making up the balance.
Source: SYSTEMIQ analysis for Energy Transitions Commission (2021)

BLENDED FINANCE TASKFORCE

SYSTEMIQ

# IMPLIED CARBON PRICE OF $H_2$-SOLUTIONS IS BUT ONE VARIABLE DRIVING DEMAND; END-SECTOR PREMIUMS ARE SMALL, HENCE 'DEMAND PULL' SEEN RECENTLY

Figures reflect **$H_2$ price of $2/kg**

| | **Carbon price** required for $H_2$ to compete with fossil | **Premium** relative to fossil equivalent on **commodity** | **Premium** impact on **end-product** |
|---|---|---|---|
| | $/ton $CO_2$ eq | % price increase | % price increase |
|  **Shipping**<br>($NH_3$, $CH_3OH$) | **145**<br>$/t$CO_2$e | **+170%**<br>compared to ton of VLSFO[2] | **+0.4%**<br>on retail price of **pair of shoes** |
|  **Fertilizer**<br>($NH_3$) | **78**[1]<br>$/t$CO_2$e | **+45%**<br>compared to a ton of amonium nitrate | **+0.8%**<br>per liter of **dairy milk** |
|  **Green steel** | **50**<br>$/t$CO_2$e | **+40%**<br>on a ton of steel | **+0.7%**<br>on retail price of **automobile** |
|  **Synthetic jet fuel** | **150**<br>$/t$CO_2$e | **+130%**<br>compared to ton of kerosene | **+18%**<br>on long-haul **flight ticket** |

Source: ETC (2021), *Global hydrogen report*. 1) Carbon price for ammonia; 2) Very low sulphur fuel oil. Premium relative to fossil equivalent at $H_2$ price of $1.0/kg and $0.5/kg: for shipping +55% and +3%, for fertilizer +3% and -15%, for steel +23% and +15%, for jet fuels +65% and +30% respectively

# IN TARGET SECTORS, EARLY MOVES ARE BEING MADE BY LEADING PLAYERS TO SWITCH TO HYDROGEN-SOLUTIONS; THESE ARE POTENTIAL CUSTOMERS / PARTNERS FOR NAMIBIA

Deep-dives next slides

| | Drivers pushing end-sectors | Moves being made by leading players | Potential Scale<br>2030 | <br>2040 |
|---|---|---|---|---|
|  **Shipping** ($NH_3$, $CH_3OH$) | - Shipping buyers are **greening their supply chains**<br>- **Shipping industry** 2050 target + very long capital turnover | - Companies targeting **first pilot** and **commercial scale** $NH_3$ and $CH_3OH$ **ships** by **2023-24:** Maersk, Hoegh, Gried Edge, Wartsila, NYK line, Japan Engine<br>- **Early demand aggregation groups** launched during COP: 21 countries[1], Amazon, Brooks Running, Frog Bikes, IKEA, Inditex, Patagonia, Tchibo, Unilever | 4 | 88 |
|  **Fertilizer** ($NH_3$) | - Potential for **small ‘green premium’**<br>- Increasing public focus on **agricultural emissions** | - First companies starting **production plans** for **~100-500 kt** green ammonia per year. (e.g., Yara, Fertiglobe) | 14 | 48 |
|  **Green steel** | - **Early buyer demand** from auto, R.E., gov’t construction<br>- **CBAMs[1] being considered** by major steel importing geos | - First **fossil-free steel shipped** in August 2021, with commercial scale expected by 2025. (Hybrit, Volvo)<br>- **New steel player** stepping into market **showcasing** how to build **a green production plant** to produce **5 MT** of steel **per year**. ($H_2$ Green Steel) | 2 | 23 |
|  **Synthetic jet fuel** | - Consumer-facing; increasing **blending mandates**<br>- **HEFA limited in supply** | - **Leading technology** providers are **building synfuel plants** in **Europe**, starting in 2021 and commercial scale in 2025-2027 (Airbus, Synkero, Atmosfair) | 1 | 49 |

[1] CBAM: Carbon Border Tax Adjustments

Sources: public company announcements. 1) Australia, Belgium, Canada, Chile, Costa Rica, Denmark, Fiji, Finland, France, germany Ireland, Italy, Japan, Marshall Islands, Morocco, The Netherlands, New Zealand, Norway, Spain, Sweden, the UK, and the US

# IN TARGET SECTORS, EARLY MOVES BY LEADING PLAYERS: SHIPPING

**Deep-dive [1/2]**

**Shipping**
($NH_3$, $CH_3OH$)

| Leading player(s) | Moves being made |
|---|---|
| **Equinor, Eidesvik and Wärtsilä**[1] | Delivering **fuel cell modules**, with a combined effect of **2 MW**, powered by green **ammonia** on a **long-distance vessel**, to be tested in **2024**. |
| **Höegh Autoliners** | Featuring a **multi-fuel car-carrier** vessel to run on green **ammonia** by 2023, designed for **9,100 car equivalent units**. Delivery of the first ships is expected in **2024**. |
| **Grieg Edge and Wärtsilä** | Delivering a **tanker vessel**, with the help of **$5.1 million** from the Norwegian government, to transport and run on **ammonia** in **2024.** |
| **Maersk** | Delivering **16,000 TEU container vessels** powered by **methanol** in **2023.** |
| **E.g., NYK Lin and Japan Engine Co.**[2] | Formation of **Japanese** and **Korean consortiums** to develop **competitive ammonia-fuelled vessels** and to create **safety guidelines, laws and regulations** for its deployment. |
| **The Clydebank Declaration** (22 countries[3]) | Launched at COP26 to **catalyse adoption** of **zero-emission fuels** by establishing at least six **zero-emission maritime routes** between two or more ports by 2025 and many more by 2030. |
| **CoZEV and First Mover Coalitions** (e.g., Amazon, IKEA, Patagonia, Unilever) | Multiple demand aggregation groups launched around COP to show its **willingness-to-pay** for 'green cargo'. |

Sources: public company announcements. 1) Other patners are NE Maritime Cleantech and Prototech; 2) Other partners are IHI Power Systems and Nihon Shipyard; 3) Australia, Belgium, Canada, Chile, Costa Rica, Denmark, Fiji, Finland, France, germany Ireland, Italy, Japan, Marshall Islands, Morocco, The Netherlands, New Zealand, Norway, Spain, Sweden, the UK, and the US

# IN TARGET SECTORS, EARLY MOVES BY LEADING PLAYERS: FERTILIZER, STEEL, SYNFUEL

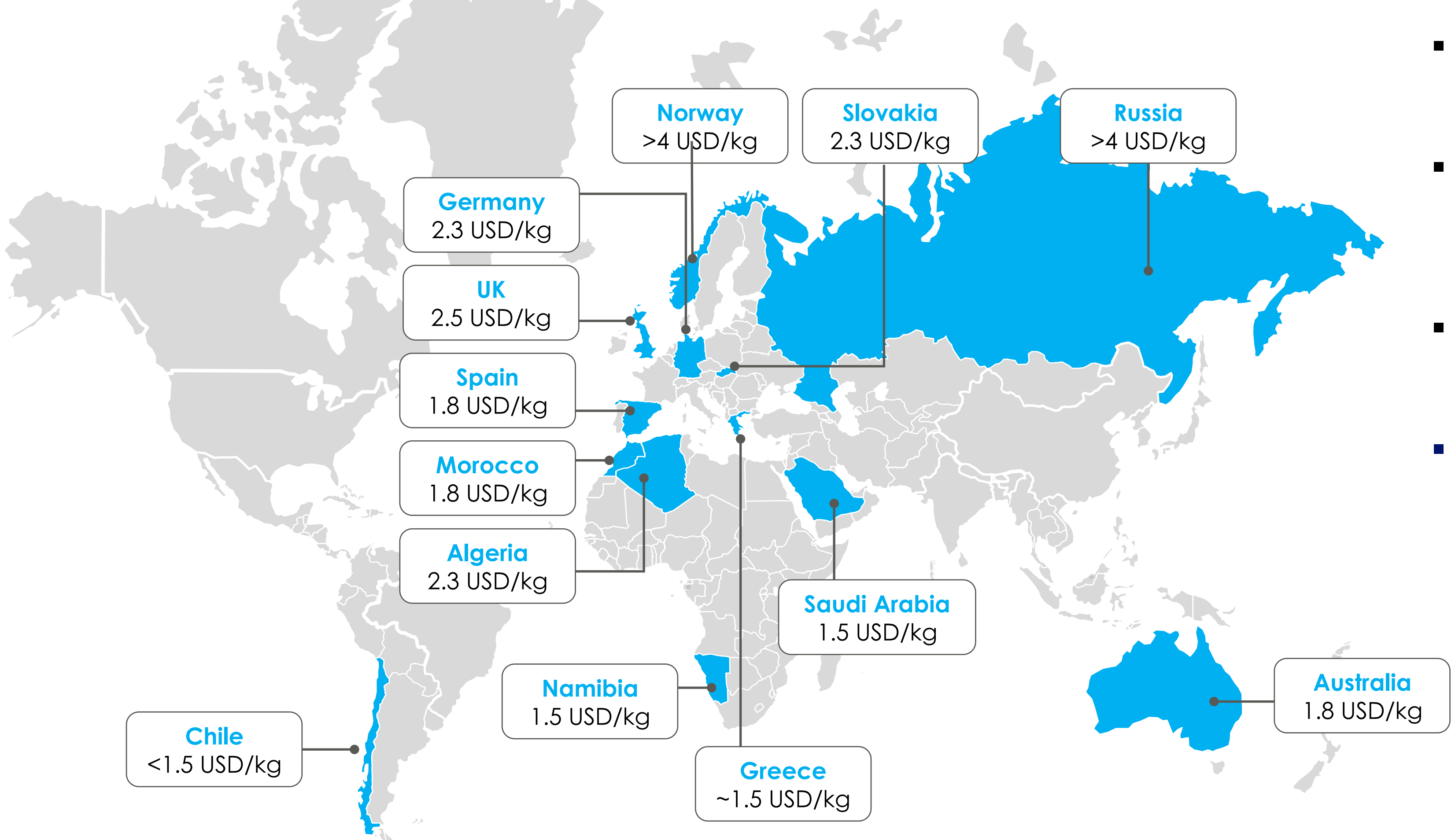
**Deep-dive [2/2]**

| | Leader player | | Moves being made |
|---|---|---|---|
|  **Fertilizer** ($NH_3$) | | **YARA** | Decarbonizing a **500 kt $NH_3$ plant** to produce **green fertilizers** (as well as shipping fuel) in **Norway.** |
| | | **Fertiglobe and Scatec** | Developing a **50-100 MW electrolysis plant** in **Egypt** to produce **90,000 tonnes of green ammonia** per year for fertilizers and industrial applications. |
|  **Green steel** | | **HYBRIT** | Shipping the **first fossil-free steel Volvo** in August **2021** and planning to reach **commercial-scale** by mid-**2025**. |
| | n/a | n/a | As of 2021, **20% of global steel production** is under **net-zero commitment.** |
| | | **Tata Steel** and **Arcelor Mittal** | Switching its **steel production** to **green hydrogen** |
| | | **$H_2$ Green Steel** | Showcasing **how to step into the steel market** by building up a **production plant** of green steel to produce **5 MT of steel per year**. |
|  **Synthetic jet fuel** | | **Airbus** | Showing **confidence** in the **PtL technology** to start production to North America in 2021, expecting **industrial scale in 2025.** |
| | | **Atmosfair** | A nonprofit organization, opening its **first synfuel plant** in Northern Germany with a capacity of **350 tonnes per year** |
| | | **European Commission** | Proposing **SAF blending mandate** to reach **5% fuel consumption by 2030** |

Sources: public company announcements.

# NAMIBIA OFFERS GLOBALLY LEADING LOW-COST HYDROGEN PRODUCTION, ONLY CHILE HAS AN EDGE ON COST OF PRODUCTION BASED ON WIND/SOLAR RESOURCES

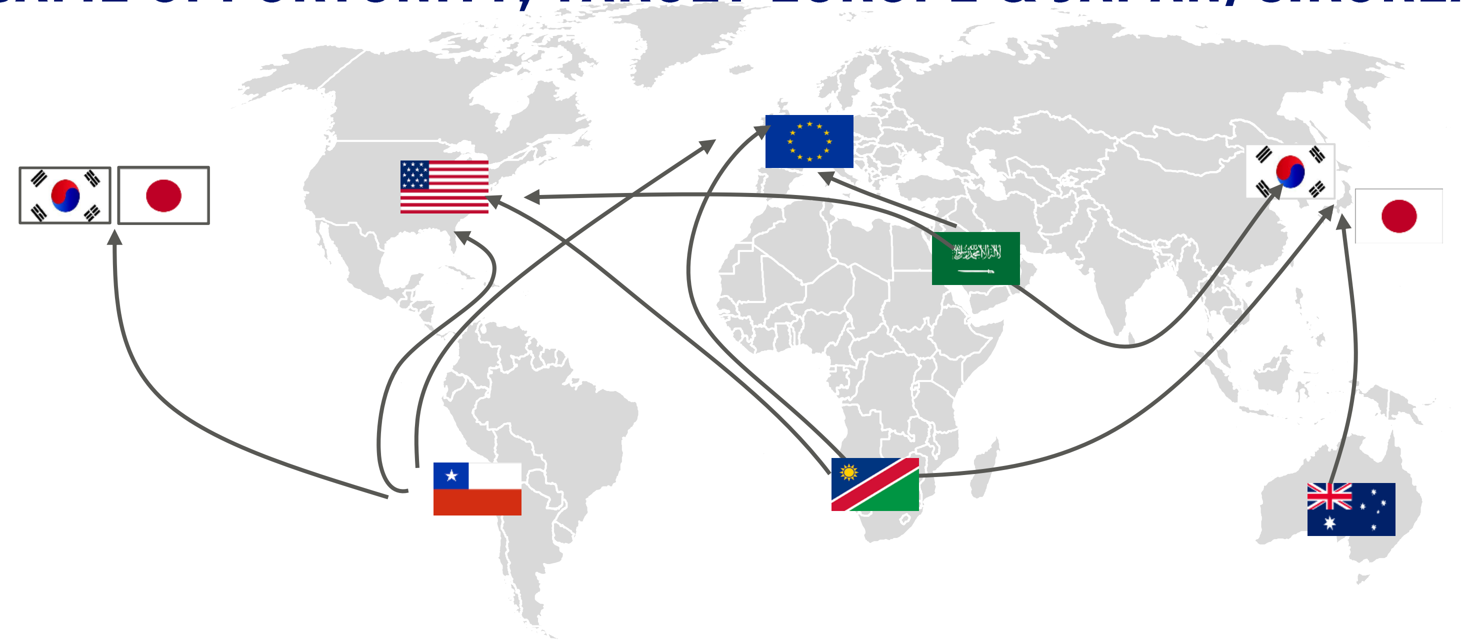
## Power-to-hydrogen production costs by 2030 based on hybrid wind and PV systems



- Namibia benefits from **globally leading wind & solar resource**
- This means Namibia can produce some of the **cheapest electricity on the planet**
- Cost of electricity is the **#1 determinant of cost of green hydrogen**
- **Electrolyser cost** is the other critical variable, however technology costs are falling very fast, **expected to fall >70% by 2030**, and become a less relevant variable in the cost (see details p34)

Notes: Indicative numbers per country based on IEA's Global Hydrogen Review 2021. For countries with multiple different prices, the lowest value is displayed
Source: IEA

# NAMIBIAN AMMONIA: POTENTIAL TO BE A 'HEDGE PRODUCER', THOUGH CHILE & SAUDI HAVE SAME OPPORTUNITY; TARGET EUROPE & JAPAN/S.KOREA AS PRIORITY



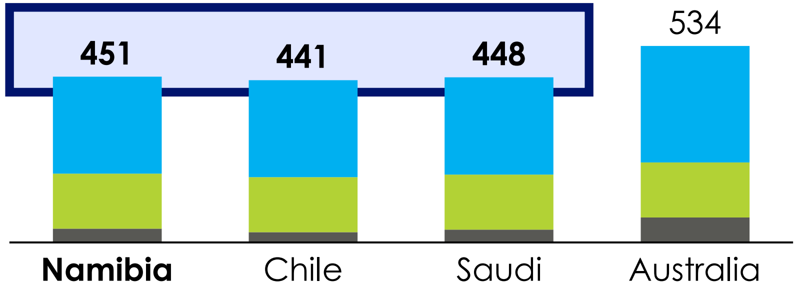
**2030 Ammonia imports (grey & green)**

- **Europe** net importer of grey ammonia (c.25%)
  - Carbon border tax adjustments likely to favour green ammonia
  - C.20-25 Mt ammonia consumption 2030
- **Japan & South Korea** have smaller volumes (c.2-5 Mt $NH_3$), but high import share (c.60%).
- **U.S.** has high demand (c.15-20 Mt $NH_3$), but low import share (10%), own low-cost green $H_2$

*Priority targets*

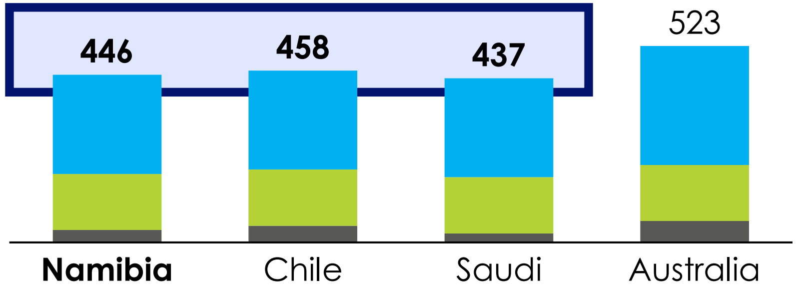
**US East Coast**

$/ton ammonia delivered, 2030



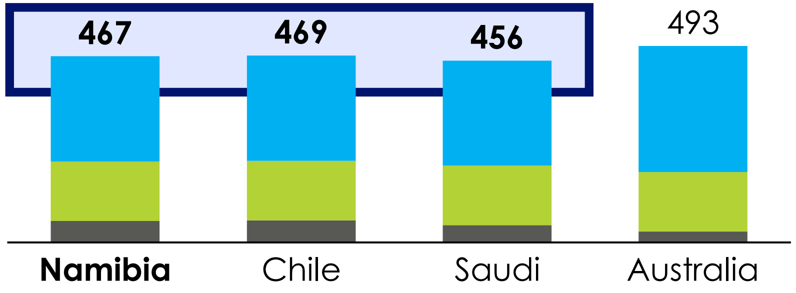
**Europe/UK**

$/ton ammonia delivered, 2030



**Japan/South Korea**

$/ton ammonia delivered, 2030

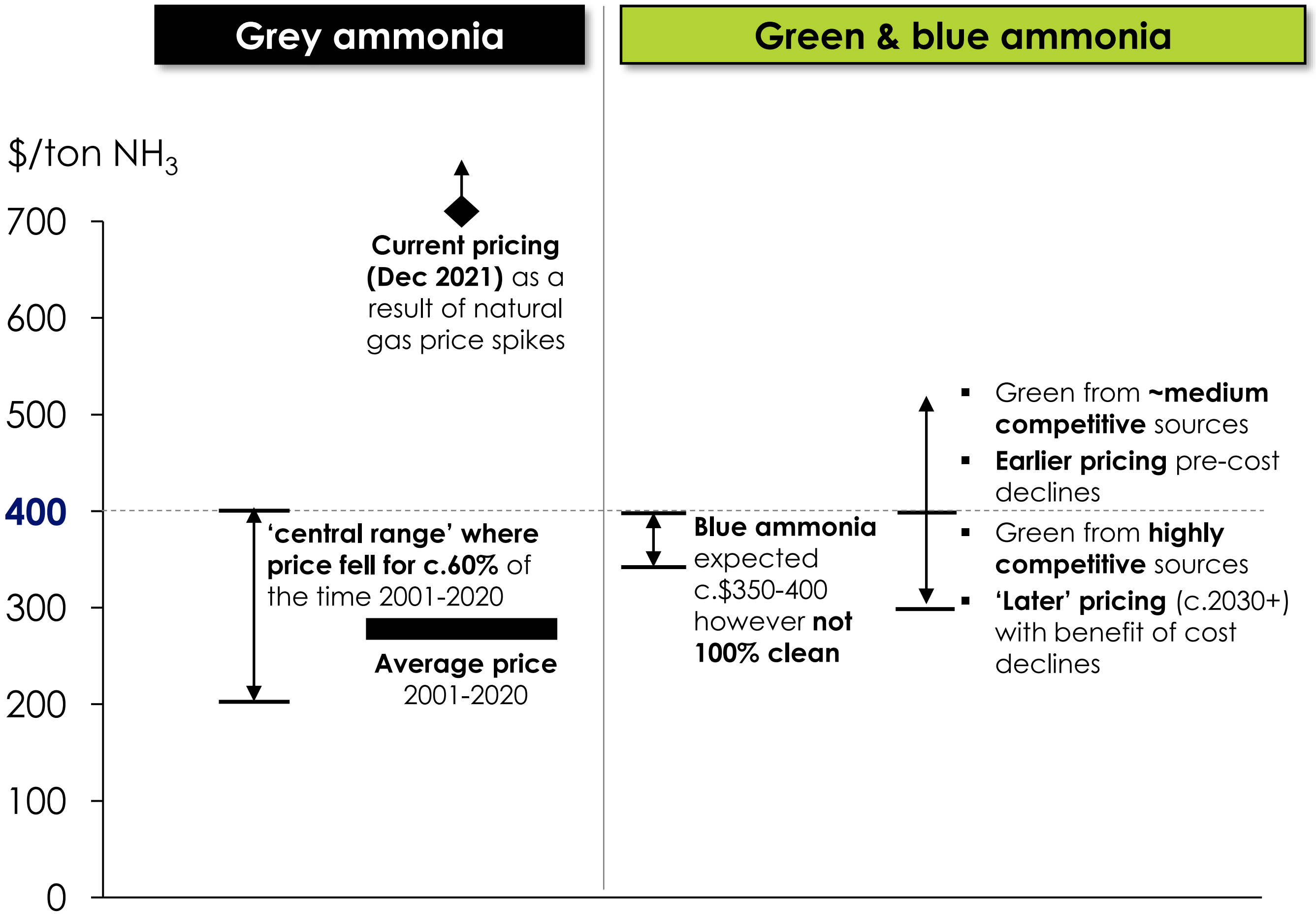


🟦 $H_2$ Production costs 🟩 Ammonia Synthesis Costs ■ Transport Costs

Sources: Hydrogen Europe (2021), Clean Hydrogen Monitor 2020, IEA (2021)

# IF NAMIBIA CAN ACHIEVE EXPORTED AMMONIA AT <$400/T $NH_3$, IT COULD BE COMPETITIVE IN BOTH 'GREEN' AND 'GREY' AMMONIA MARKETS

## Levelised cost of ammonia



**Current pricing (Dec 2021)** as a result of natural gas price spikes

**'central range' where price fell for c.60%** of the time 2001-2020

**Average price** 2001-2020

**Blue ammonia** expected c.$350-400 however **not 100% clean**

- Green from **~medium competitive** sources
- **Earlier pricing** pre-cost declines
- Green from **highly competitive** sources
- **'Later' pricing** (c.2030+) with benefit of cost declines

## Commentary

- **Historic volatility in grey ammonia** driven by link to natural gas pricing which is volatile
  - 'Grey ammonia' prices historically have fluctuated between $100-900/t$NH_3$ (2001-2020)
  - **central range c.$200-400** (c.60% of the time in this range)
- **Blue ammonia** prices expected to be $350-400/t$NH_3$ though volatile with natural gas, **not 100% clean**
  - Current natural gas price spikes mean pricing would be well above $400/t$NH_3$
- **'Green ammonia'** pricing will come down over time as solar / wind / electrolysers all reduce in cost

- **Above $400/t $NH_3$,** Namibia might still serve a 'green ammonia' market, though competition is tight
- **Below $400/t $NH_3$,** Namibia would be competitive not just in 'green' but also 'grey ammonia' market

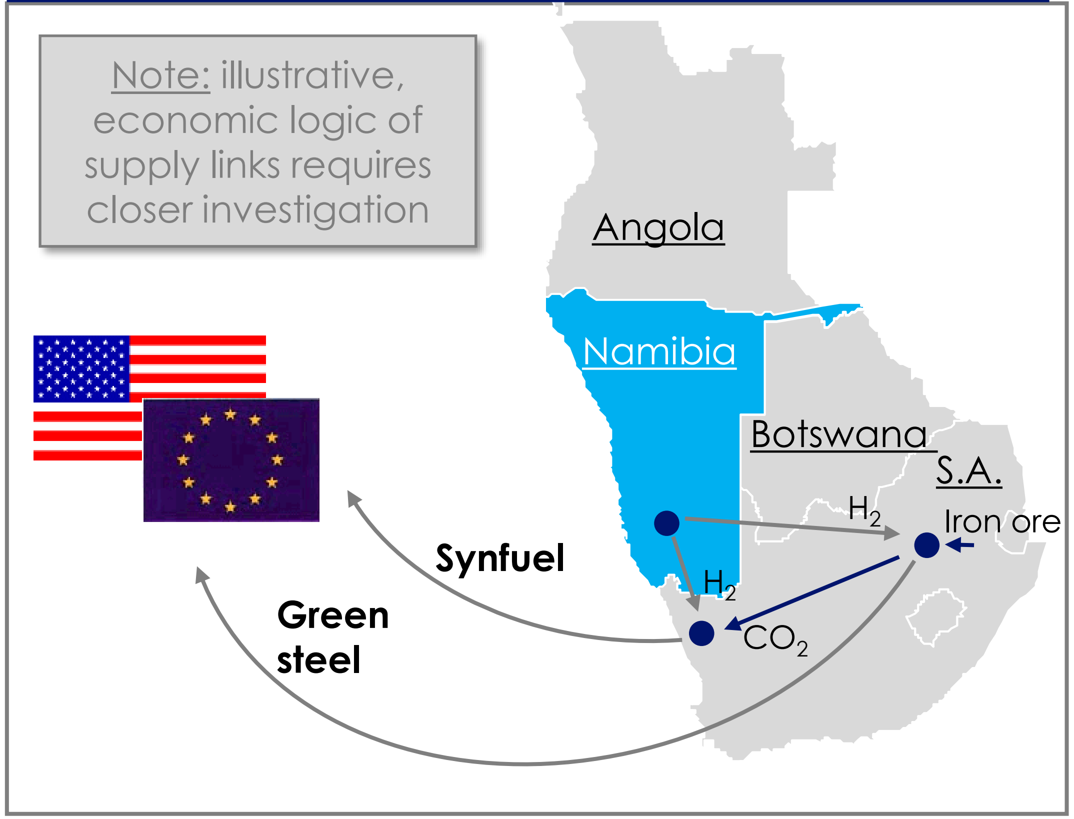
Source: Vestas & Siemens Gamesa (2020), *'Ammonfuel: an industrial view of ammonia as a marine fuel'*

# THERE MAY BE JOINT VALUE CHAIN OPPORTUNITIES WITH SOUTH AFRICA LEVERAGING THEIR RESOURCES IN STEEL (IRON ORE, MFG. CAPABILITY) AND SYNFUELS (POINT SOURCE CARBON)

**Key:** ✔ **High confidence** in compelling value case ✓ Uncertain, closer investigation to **reveal robustness of value case**

## Regional flows and exports [INDICATIVE]

Note: illustrative, economic logic of supply links requires closer investigation



## Regional value chain drivers

| Export | Cost drivers | Regional advantage |
|---|---|---|
| ✓ **Green steel** | ▪ $H_2$ (11%)<br>▪ **Iron ore (26%)** | ▪ $\$/\mathrm{kgH}_2$[1]: <1.50 🇳🇦 vs. 2+ 🇪🇺<br>▪ \$/t iron ore: 90 🇳🇦🇿🇦 vs. ~100 🇪🇺 |
| ✓ **Synfuel** | ▪ $H_2$ (26%)<br>▪ **$CO_2$ (5+%)** | ▪ $\$/\mathrm{kgH}_2$: <1.50 🇳🇦 vs. 2+ 🇪🇺<br>▪ $\$/\mathrm{tCO}_2$: 0-60[2] 🇳🇦🇿🇦 vs. 100-400+ (D.A.C.) |

### Regional demand: South Africa

| | |
|---|---|
| ✔ S.A. **electricity** | ▪ Selling electricity to Southern Africa's power pool at **~5-6 US¢/kwh** |
| ✓ S.A. **hydrogen** | ▪ Cost advantage in Namibia $H_2$ over South Africa **~\$50ct/kg $H_2$ in 2030, compresses to**~\$25ct by 2050[3]<br>▪ $H_2$ transport costs Luderwitz to Boegoebaai (c.250km) **~\$19ct/kg** |

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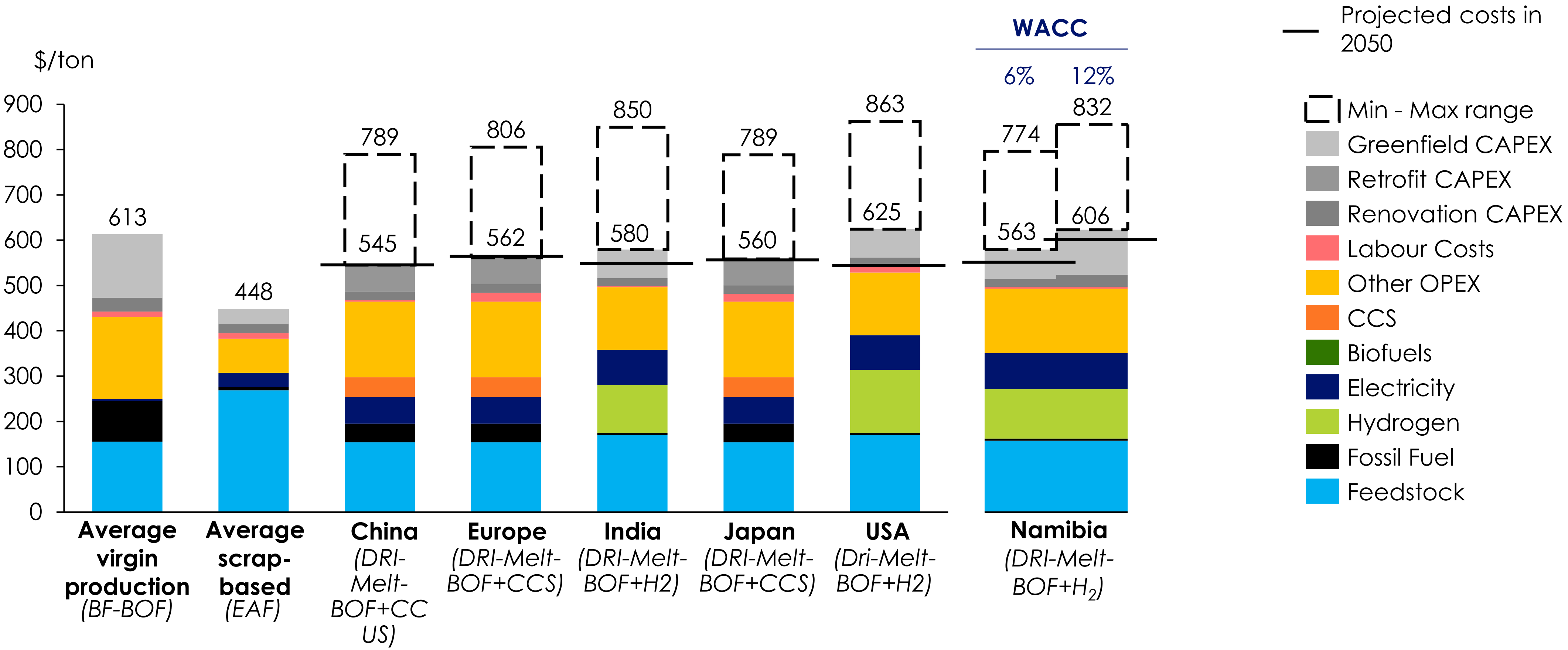
[1] 2030 green $H_2$ costs; [2] e.g., industrial point source emissions from Secunda; if Namibia can secure volumes of sustainable biomass it could potentially source low-cost 'circular' $CO_2$ via BECCU: Bio-Energy (for power) with CCU – note: sustainable bio-source and highly efficient combustion are both critical; [3] The cost advantage of hydrogen supply of Namibia over South Africa is only at a supply volume of more than [100] t $H_2$/d. Transport cost assumes delivering hydrogen to the new port in Boegoebaai (250km from Luderitz)

Sources: ETC (2021), *Global Hydrogen Report*. IEA (2021). *Global Hydrogen Review*.

# NAMIBIA COULD HAVE GLOBALLY COMPETITIVE GREEN STEEL, THOUGH MANY 'IFS': COMPETITIVE IRON ORE PRICE, STEEL MANUFACTURING CAPABILITY

**Total Steel Production Costs by Location 2030 – Range Across Net-Zero Compatible Technologies**
*$/ton Steel*



Source: SYSTEMIQ calculation based on Net-Zero Steel Initiative ST-STSM (2021), Bloomberg NEF, SNIM, Eurofer. Note: figures refer to current forecast adjusted for country specific iron, labour, and energy costs. Range refers to minimum and maximum costs across all possible production techniques in each country for both greenfield and retrofit sites. BF-BOF is Blast Furnace – Basic Oxygen Furnace; EAF is Electric Arc Furnace; DRI-Melt-BOF is Direct Reduced iron – Melt – Blast Oxygen Furnace. Average numbers are for Europe. $H_2$ prices are based upon IEA (2021), *Global Hydrogen Review*.

# NAMIBIA'S COMPETITIVENESS IN SYNFUEL DEPENDS ON LOW-COST SUSTAINABLE CARBON SOURCE

## Sustainable Aviation Fuel (SAF) production costs, 2030: range of solutions

*$/ton Sustainable Aviation Fuel*

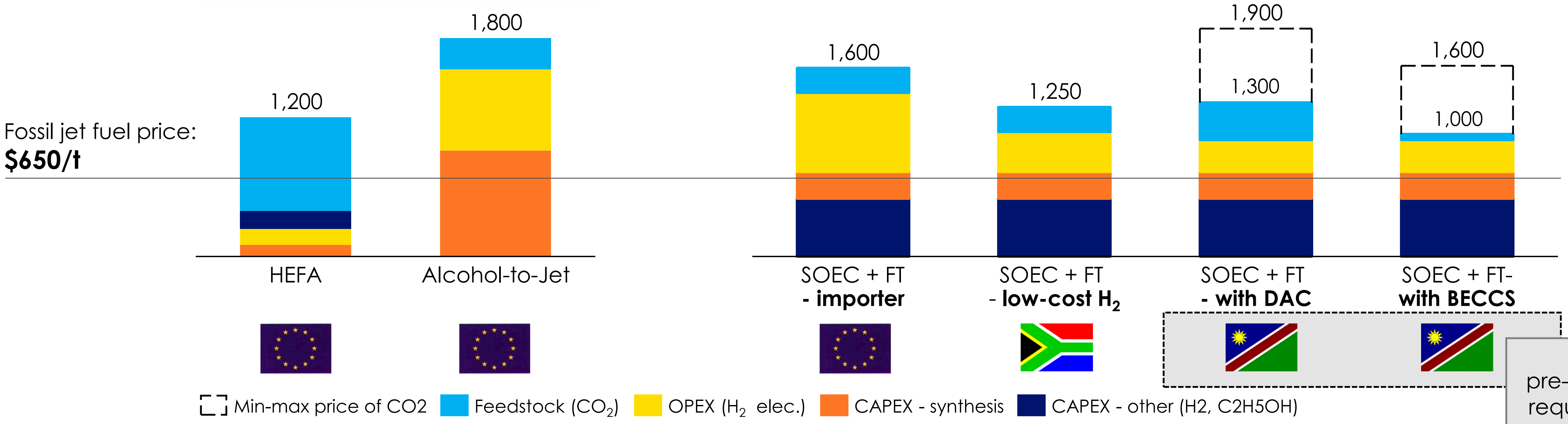
### Biofuels

- Biofuels are lowest cost, but **global sustainable supply is limited**
- HEFA supply especially limited; **other routes (e.g., AtJ) less proven**

### Synthetic jet fuel

- Source of **low-cost & ideally circular carbon** is critical for competitive synfuel

| **Carbon source & price:** | Recycled carbon | Circular carbon | |
|---|---|---|---|
| | **Industrial point-source** | **D.A.C.** | **B.E.C.C.S.** |
| | $66/t | $100-400/t | $15-200/t |



TBC: pre-feasibility required into carbon sources

Source: WEF (2020), *Clean Skies for Tomorrow. Assumptions: HEFA with used cooking oils. Alcohol-to-jet with sugarcane bagasse, Gasification/Fischer-Tropsch with MSW. SOEC stands for Solid Oxide electrolyser Cell, FT stands Fischer-Tropsch, HEFA stands for Hydroprocessed Esters and Fatty Acids, DAC stands for Direct Air Capture, BECCS stands for Bio Energy with Carbon Capture and Storage, SAF stands for Sustainable Aviation Fuel. Assumed power costs for solar $3.3ct/kWh and for Namibia $1.3ct/kWh, assumed hydrogen costs $3.20/kg and $1.5/kg for Namibia*

# KEY QUESTIONS COVERED

The **'What'**

1. Export markets
2. **Domestic markets**
3. Namibia infrastructure design
4. Maximize benefit to Namibia

The **'How'**

5. Regulations & incentives
6. Financing
7. Partnerships
8. Roadmap

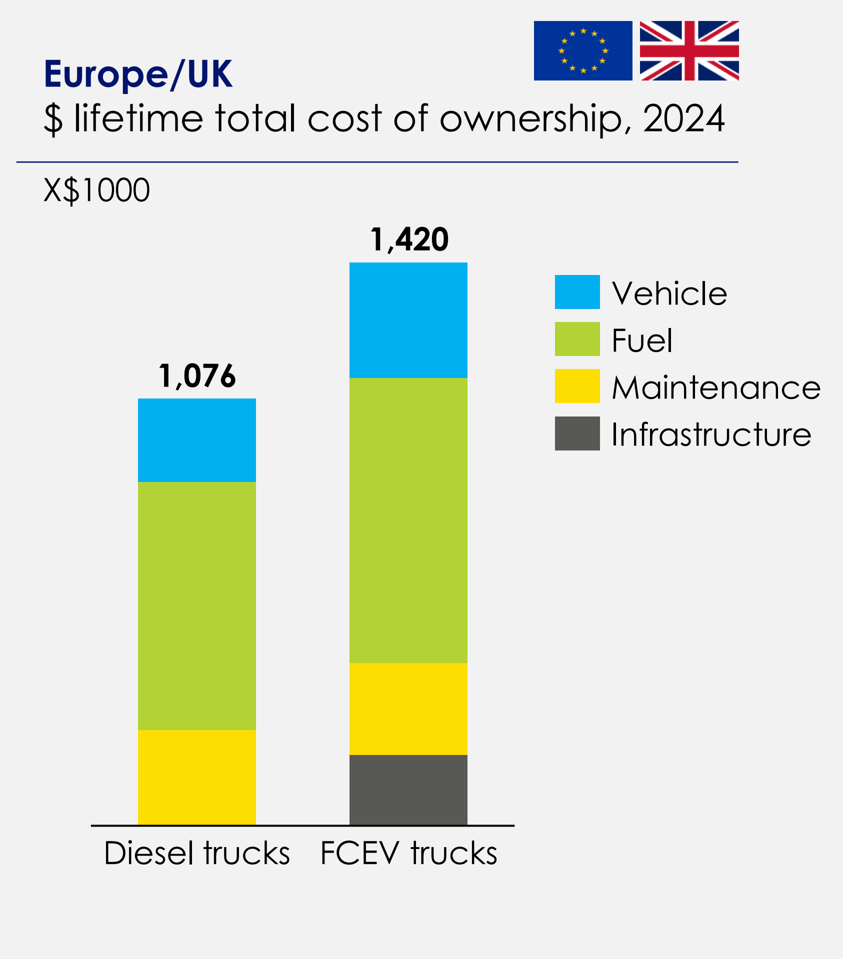
- Volume potential from **domestic demand sectors**, including deep-dives
- Sectors:
  - **Long-haul trucks**
  - **Mining trucks**
  - **Fertiliser**
  - **Rail**

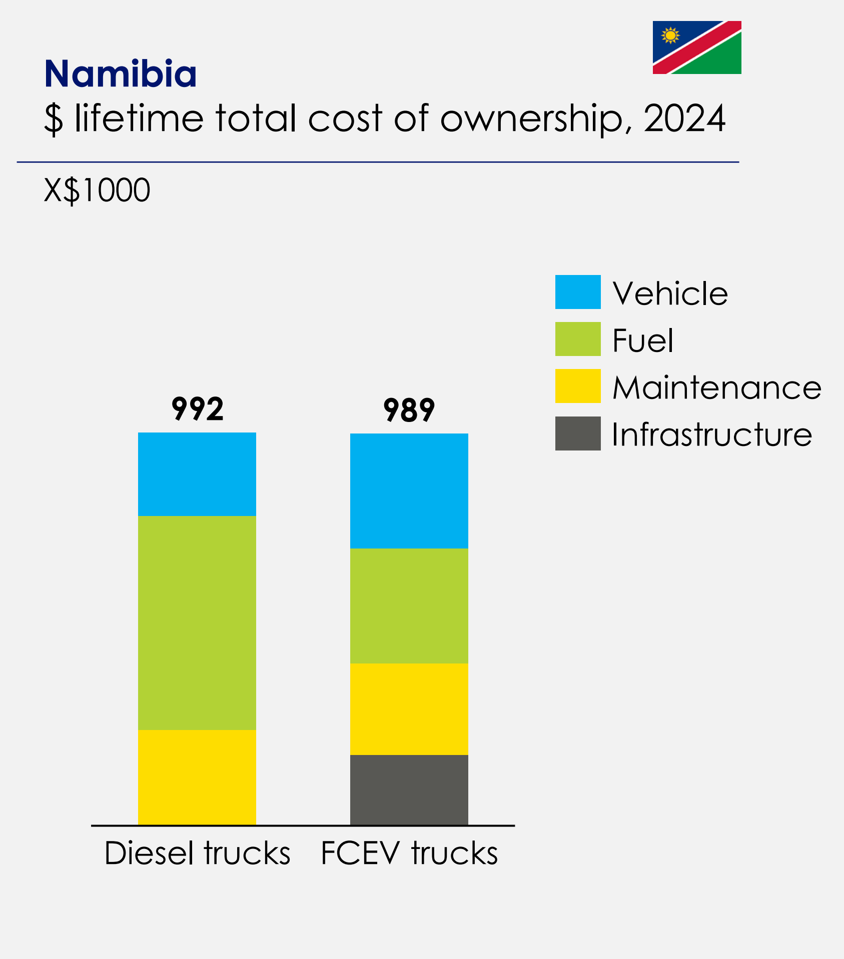
# DOMESTIC SECTORS WHERE ECONOMICS FAVOUR HYDROGEN TOTAL ~0.1MT $H_2$ (VS. 4-8MT EXPORT IF 1-2% GLOBAL MARKET SERVED); NAMIBIA CAN START IMPLEMENTING DOMESTIC SECTORS NOW

| Sector | Economics, timing & early moves | Scale (kt $H_2$) | |
|---|---|---|---|
| | | Total | 2030 |
| **Heavy duty trucks and buses** *(FCEVs)* | ▪ **TCO parity in Namibia <u>by 2024</u>** with \$2.2/kg $H_2$ – can start preparing now (note: this compares to TCO in 2028 in Europe)<br>▪ **Regional mine haulage routes (5 kt demand) can serve as early adopters**; long-distance favours FCEV vs. EV, point-to-point limits re-fueling infra needed | up to **85** | 7 - **40** |
| **Mine-site trucks** | ▪ **Anglo American <u>already piloting</u> FCEV mining trucks in South Africa (Q1 2022);** aims to switch entire fleet to hydrogen by 2030<br>▪ **Large Chinese mining operations in Namibia could be early adopters,** incl. early customers of Chinese FCEV mining trucks from Weichai | **15** | 1 - 8 |
| **Green ammonia for fertilizer** | ▪ Green ammonia for **fertilizer attractive <u>in 2030s</u>**, at \$1.4/kg $H_2$.<br>▪ This is based on average historical grey ammonia prices; **current natural gas price spikes** could make grey ammonia uncompetitive **even earlier** | **14** | 4 - 7 |
| **Railway** | ▪ Ideal rail use-cases are for rail **currently powered with diesel** and running on **long rail lines** – i.e., not in tight mesh network / expensive to electrify<br>▪ Attractive pricing at <\$4/kg $H_2$ thus **already attractive <u>today</u>** | **4** | 1 - 2 |

Hydrogen Council (2021), hydrogen insights. Sources: Government of Republic of Namibia (2021), *Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change*. Projected $H_2$ demand for FCEVs and railway based on (i) National total diesel energy consumed by heavy-duty trucks & buses and railway respectively in 2016 : back-calculated from annual $CO_2$ emissions (kg-$CO_2$) and diesel emission factor for $CO_2$ (kg-$CO_2$/KJ-diesel) (RNM update to UNFCCC, 2021) (ii) Aggregate brake-specific energy output by heavy-duty trucks and buses, factor in tank-to-wheel diesel truck efficiency (iii) Hydrogen energy equivalent energy consumed: apply tank-to-wheel FCEV truck efficiency and thermal efficiencies for a compression ignition engine for railway (iv) Global projections for scale up of $H_2$ consumption in heavy transport sector and railway respectively (ETC, 2021) and assuming no change to fleet size. Projections for green ammonia based on (i) Ammonia (components) use as fertilizer in NM (FAOstat, 2021); (ii) Projection for scale up of Ammonia (ETC, 2021).

# FCEV LONG HAUL TRUCKS: WITHIN 2 YEARS, TCO PARITY ON LONG-HAUL TRUCKS IN NAMIBIA; CAN START PREPARING NOW (E.G., RE-FUELING INFRASTRUCTURE)


**Europe/UK**
$ lifetime total cost of ownership, 2024

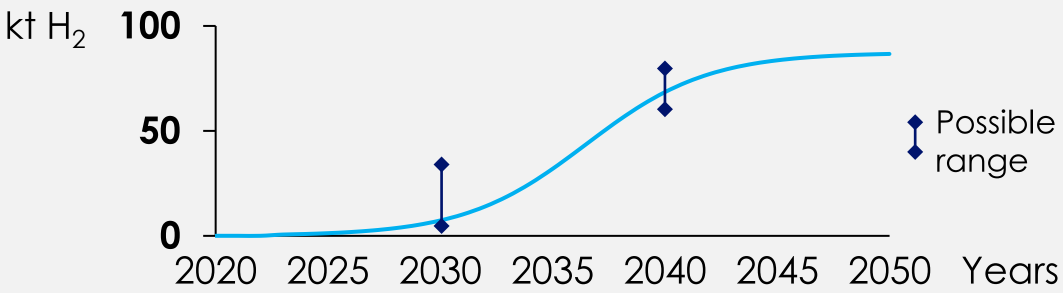

**Namibia**
$ lifetime total cost of ownership, 2024

ICCT (2019). Estimating the infrastructure needs and costs for the launch of zero-emission trucks

# FCEV LONG HAUL TRUCKS: ~85 KT $H_2$ DEMAND IN 2050; MINE ROUTES AS EARLY ADOPTERS

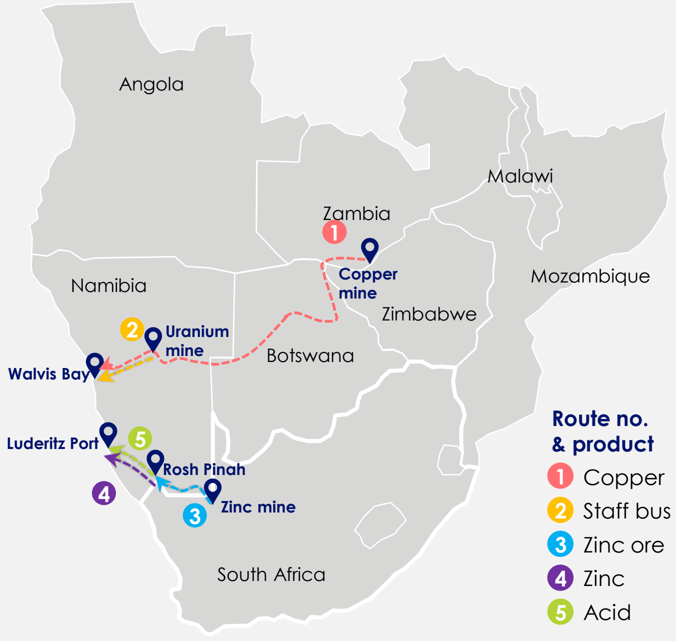
**Key figure**

**Expected hydrogen demand for trucking**



**Case studies**

| | Case study | Number of trips | Distance (km) | $H_2$ (kt/ year) |
|---|---|---|---|---|
| ① | Copper trucks from Zambia to Walvis bay | 5200 | 1800 | 3 |
| ② | Uranium mines in Namibia to Walvis Bay | 7300 | 90 | 0.2 |
| ③ | Zinc ore SA to Namibia to Rosh Pinah | 10333 | 600 | 1.7 |
| ④ | Zinc to Lüderitz port | 5000 | 290 | 0.4 |
| ⑤ | Acid from process plant to Lüderitz | 2500 | 290 | 2 |
| **Total** | | | | **5 kt** |



Sources: Government of Republic of Namibia (2021), *Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change;* Government of Republic of Namibia

BLENDED FINANCE TASKFORCE SYSTEMIQ

# MINE TRUCKS: $H_2$ MINING TRUCKS ARE ALREADY BEING DEVELOPED ELSEWHERE

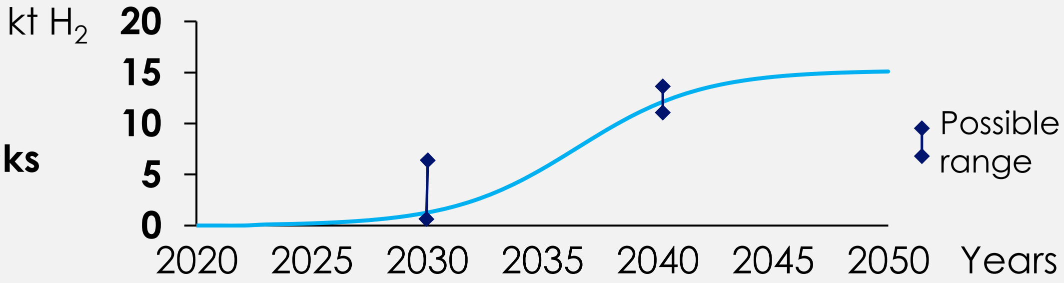
**Global case studies**

- Anglo American is developing a large **hydrogen mining truck in South Africa** in collaboration with global energy service ENGIE
- The fuel cell electric haul truck will be the world's largest to run on hydrogen. The company aims to **switch its entire fleet to hydrogen by 2030.** $H_2$ production at mine site, using solar & waste water.

- Chilean authorities aim to have **87% (1390 haulage trucks) of the mining sector's truck powered by hydrogen by 2050**

**Namibia: potential**

**Potential hydrogen demand for mining trucks**



**Namibia: Relevant players**

- **De Beers** (largest producers of diamonds) is setting out to achieve **carbon neutrality by 2030** (including at its mines in Namibia).

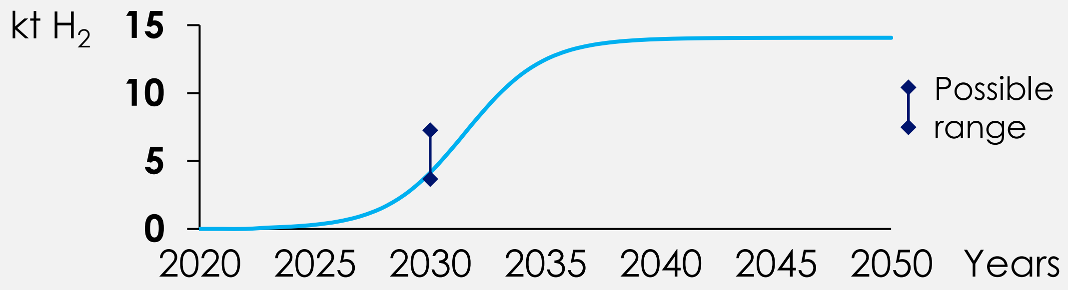
- **Large Chinese mining companies are operating in Namibia**; their operations in China may be already moving to deploy hydrogen – China is moving at pace on $H_2$ and has set net-zero 2060 target.
- The **Chinese Engine major, Weichai** will role out its first production of an **FCEV** (hydrogen fuel with lithium battery) 200-ton mining truck in **2021** – *possible early customers Chinese mining sites in Namibia?*

Sources: Government of Republic of Namibia (2021), *Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change*. De Beers (Nov. 2020), *De Beers announces ambitious 2030 goals to build a positive lasting impact for Communities and The Natural World*. Mining Weekly (Jan. 2021). De Beers adopts strategy to meet carbon-neutral ambition. IEA (Sept, 2021). *China has a clear pathway to build a more sustainable, secure and inclusive energy future*. International Mining (Aug, 2021), *Weichai's first production FCEV 200 ton mining truck to roll out of factory $H_2$ 2021*. E&E News.

# AMMONIA: NAMIBIA COULD DECREASE ITS HIGH DEPENDENCY ON IMPORTS FOR FERTILIZERS

**Key figure**

**Expected ammonia demand for fertilizers**



**Oppor-tunities**

- Currently, most of **Namibia's fertilizer** use is **imported**, mainly from South Africa (88%) with the remainder from the Russian Federation and China.[1]
  - A small quantity is **exported** to **Zambia**, South Africa, Belgium, France, Angola, Germany and Israel.
- Opportunity to **develop domestic ammonia and fertilizer manufacturing capabilities**
  - Reduce dependency on imports
  - **Potentially increase exports to trade partners,** with focus on Belgium, France, Germany – each have public emissions targets & green $H_2$ strategies.

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[1] UN Comtrade Database

# KEY QUESTIONS COVERED

The
**‘What’**

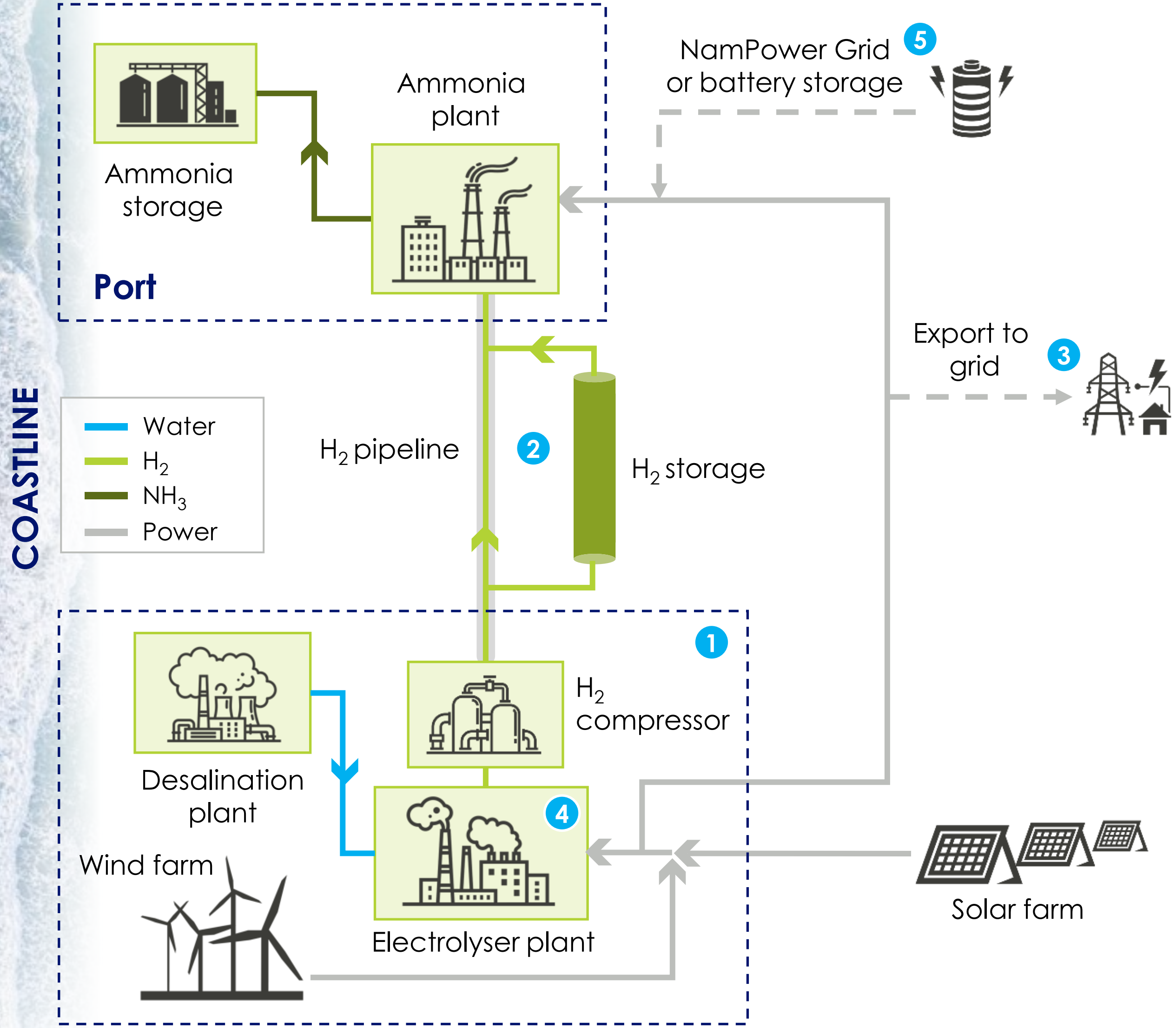
1. Export markets
2. Domestic markets
3. **Namibia infrastructure design**
4. Maximize benefit to Namibia

The
**‘How’**

5. Regulations & incentives
6. Financing
7. Partnerships
8. Roadmap

- Key system components
- General system dynamics & interdependencies analysed in Reference Scenario
- Prioritised cost management levers
- Realistic system costs presented in Baseline Scenario
- Power export opportunities

# GREEN AMMONIA SUPPLY CHAIN IN NAMIBIA'S COASTAL AREAS



**Key design considerations**

① Possible co-location opportunity:

- Desal plant located on the coast to avoid costs of transporting sea water; Electrolyser plant collocated with desal plant to avoid costs of transporting desalinated water; Wind farm collocated with electrolyser plant since Namibia's best wind resources are on the coast and to avoid costs of power transmission
- Therefore, desal and electrolyser plant could be sited near the most suitable wind farm location

② Possible opportunities to **share system elements across developers or phases** to unlock cost savings (e.g., $H_2$ pipeline and storage)

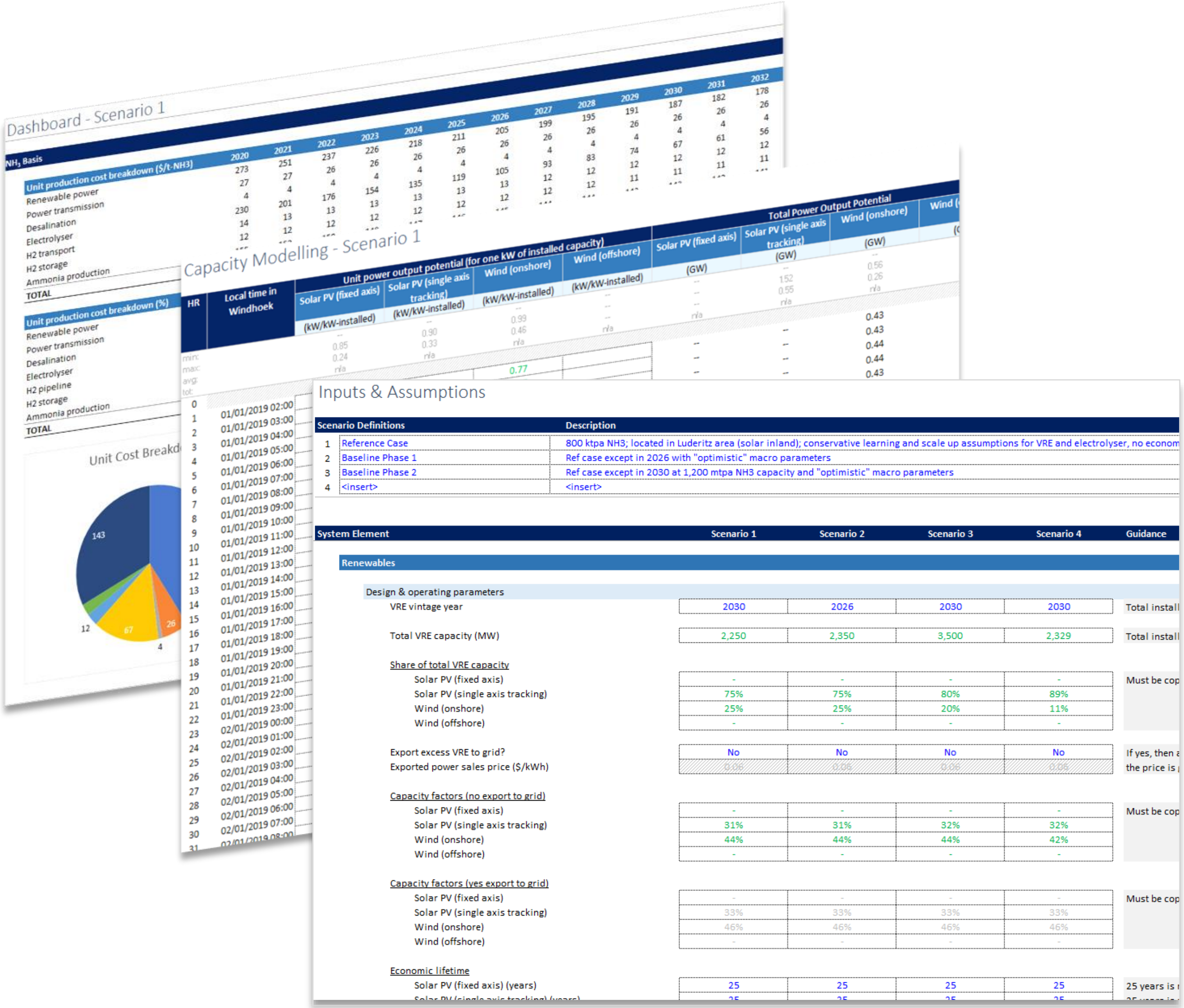
③ Possible opportunity to **oversize renewable power elements** and **export** to public power utilities to create co-benefits (e.g., higher capacity factors for project, increased clean energy access for utilities)

④ **No substantial power storage for electrolyser** is needed to achieve target utilisations due to **Namibia's strong solar** and **wind resources**[1].

⑤ **Ammonia plants** cannot ramp up or down quickly, so they **need stable $H_2$ and power supplies.** $H_2$ supply addressed by storage. Power supply address by complementing $H_2$ project-related VRE with (i) battery storage and/or (ii) **NamPower** grid connection.[2]

Note: Simplified schematic. Distances between system components not to scale. [1] PEM electrolysers already well-suited to variable electricity supply today; indications that alkaline electrolysers will reach suitable dynamic response in future; [2] Assumed power price paid by ammonia plant is twice project LCOE, which is consistent with findings by ETC that flexibility cost will be approximately equal to VRE generation costs by 2030.

# THE INTEGRATED INFRASTRUCTURE MODEL



Inputs & Assumptions

| Scenario Definitions | | Description |
|---|---|---|
| 1 | Reference Case | 800 ktpa NH3; located in Luderitz area (solar inland); conservative learning and scale up assumptions for VRE and electrolyser, no econom |
| 2 | Baseline Phase 1 | Ref case except in 2026 with "optimistic" macro parameters |
| 3 | Baseline Phase 2 | Ref case except in 2030 at 1,200 mtpa NH3 capacity and "optimistic" macro parameters |
| 4 | <insert> | <insert> |

| System Element | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Guidance |
|---|---|---|---|---|---|
| Renewables | | | | | |
| Design & operating parameters | | | | | |
| VRE vintage year | 2030 | 2026 | 2030 | 2030 | Total install |
| Total VRE capacity (MW) | 2,250 | 2,350 | 3,500 | 2,329 | Total install |
| Share of total VRE capacity | | | | | |
| Solar PV (fixed axis) | - | - | - | - | Must be cop |
| Solar PV (single axis tracking) | 75% | 75% | 80% | 89% | |
| Wind (onshore) | 25% | 25% | 20% | 11% | |
| Wind (offshore) | - | - | - | - | |
| Export excess VRE to grid? | No | No | No | No | If yes, then a |
| Exported power sales price ($/kWh) | 0.06 | 0.06 | 0.06 | 0.06 | the price is |
| Capacity factors (no export to grid) | | | | | |
| Solar PV (fixed axis) | - | - | - | - | Must be cop |
| Solar PV (single axis tracking) | 31% | 31% | 32% | 32% | |
| Wind (onshore) | 44% | 44% | 44% | 42% | |
| Wind (offshore) | - | - | - | - | |
| Capacity factors (yes export to grid) | | | | | |
| Solar PV (fixed axis) | - | - | - | - | Must be cop |
| Solar PV (single axis tracking) | 33% | 33% | 33% | 33% | |
| Wind (onshore) | 46% | 46% | 46% | 46% | |
| Wind (offshore) | - | - | - | - | |
| Economic lifetime | | | | | |
| Solar PV (fixed axis) (years) | 25 | 25 | 25 | 25 | 25 years is |

- Flexible, bottom-up **cost model for integrated green ammonia production in Namibia** based on user inputs and local hourly wind/solar data. Includes wind/solar farms, power transmission, desalination plant, electrolyser plant, hydrogen storage and pipeline, and ammonia production.
- Local wind/solar data based on NASA MERRA reanalysis and CM-SAF's SARAH dataset[1]. System capacity and cost modelling based on mix of industry and government reports, academic papers, SYSTEMIQ analysis, and interviews with industry experts[2].
- Model results substantiate previous coarse, high-level estimates that indicated attractive green $H_2/NH_3$ opportunity in Namibia while providing additional **insights on most impactful design levers, key risks, and system optimisation opportunities.**
- Going forward, **GRN can use the model in-house** to underpin key analysis, e.g., **input into national infrastructure planning incl. Tsau / Khaeb masterplan** and for national power transmission and hydrogen pipelines; **input into negotiations** with counterparties or other stakeholders to provide GRN an informed position and to promote creative collaboration.

[1] Accessed via https://www.renewables.ninja/ [2] Examples: UK Department for Business, Energy & Industrial Strategy, *"Hydrogen Production Costs 2021"*, (August 2021); IEA, *"The Future of Hydrogen - Seizing today's opportunities"*, (June 2019); Mahdi Fasihi, Robert Weiss, Jouni Savolainen, Christian Breyer, *"Global potential of green ammonia based on hybrid PV-wind power plants"*, (April 2021); discussions with Mott MacDonald Southern Africa power team, Vestas Africa team, Wood Mackenzie solar & wind ops team.

# REFERENCE SCENARIO

INDICATIVE RESULTS
SUBJECT TO CHANGE
UPON DETAILED STUDY

- Starting point for grasping system dynamics and inter-dependencies
- Generic, non-optimised benchmark and baseline for sensitivity analysis

## Inputs & assumptions

| | | |
|---|---|---|
| **System date** | | |
| Start of commercial operations | 2030 | Good point of comparison (frequently quoted date for LCOA) |
| **System capacity** | | |
| Ammonia production capacity (kt-$NH_3$/yr) | 800 | 780 ktpa - recently proposed Nelson Mandela Bay project<br>700 ktpa - HYPHEN Phase 1 production potential |
| $H_2$ production capacity (kt-$H_2$/yr) | 235 | |
| Electrolyser type | Alkaline | |
| Electrolyser capacity (MW) | 1,305 | |
| Renewable energy capacity (MW) | 2,250 | 75% solar and 25% wind |
| *Solar - single-axis tracking (MW)* | *1,688* | Higher CAPEX of single-axis tracking over fixed axis is offset by higher capacity factor |
| *Wind - onshore (MW)* | *562* | CAPEX advantage of solar over wind + quality of solar resource offsets higher power transmission and H2 storage costs |
| $H_2$ storage capacity (t-$H_2$) | 250 | 100 cm diameter above ground pipeline storage |
| $H_2$ compressor (MW-$H_2$ throughput) | 597 | |
| $H_2$ pipeline - max flow rate (t-$H_2$/hr) | 18 | 25 cm diameter above ground pipeline |
| Power transmission capacity (MW) | 1,700 | |
| Desalination plant capacity (million $m^3$/yr) | 1.1 | |
| **Relative locations** | | |
| Ammonia plant and storage | At port | No ammonia transport necessary pre-export |
| Desalination plant | Co-located | No sea water or desalinated water transport necessary |
| Wind farm | 50 km from port | No transmission line to electrolyser necessary |
| Electrolyser | | $H_2$ transported by pipeline to $NH_3$ plant |
| Solar farm | c.50 km inland | Namibia's solar improves with distance from coast - trade-off against increasing power transmission cost with distance |
| Power transmission line #1 | 55 km | Power from solar farm to electrolyser area |
| Power transmission line #2 | 55 km | Power from electrolyser area to ammonia plant |
| $H_2$ pipeline length (km) | 55 km | Transports $H_2$ from electrolyser plant to ammonia plant |

| | | |
|---|---|---|
| **System costs** | | |
| Renewables CAPEX | | |
| *Solar - single-axis tracking ($/kW)* | *525* | Conservative learning rate assumed for experience curve |
| *Wind - onshore ($/kW)* | *824* | Conservative learning rate assumed for experience curve |
| Renewables WACC | | |
| *Solar - single-axis tracking* | *6.8%* | 25-year useful economic life |
| *Wind - onshore* | *6.8%* | 25-year useful economic life |
| Electrolyser CAPEX ($/kW) | 274 | 0% discount applied for large, long-term order; Conservative learning rate and Medium global deployment scenario assumed for experience curve adjustment |
| Electrolyser WACC | 8.0% | 30-year useful economic life |
| Ammonia plant CAPEX ($/t-$NH_3$) | 685 | Scale-adjusted; includes compressor, syn loop, ASU, and storage |
| Ammonia plant WACC | 8.0% | 30-year useful economic life |
| $H_2$ pipeline CAPEX ($/km) | 530,265 | Dependent on diameter |
| $H_2$ pipeline WACC | 8.0% | 30-year useful economic life |
| $H_2$ pipeline & storage compressor CAPEX ($/kg-$H_2$-per-hour) | 858 | Based on max $H_2$ throughput capacity |
| $H_2$ pipeline & storage compressor WACC | 8.0% | 20-year useful economic life |
| $H_2$ storage CAPEX ($/kg-storage capacity) | 301 | |
| $H_2$ storage WACC | 8.0% | 30-year useful economic life |
| Power transmission line CAPEX ($/kW/km) | 0.24 | |
| Power transmission line WACC | 8.0% | 50-year useful economic life |
| Power transmission converter CAPEX ($/kW) | 88 | |
| Power transmission converter WACC | 8.0% | 50-year useful economic life |
| Desalination plant CAPEX ($/$m^3$-annual - capacity) | 20 | |
| Desalination plant WACC | 8.0% | 30-year useful economic life |
| System-wide weighted average WACC | 7.3% | |

*Note: OPEX costs also included in model, but not listed here.*

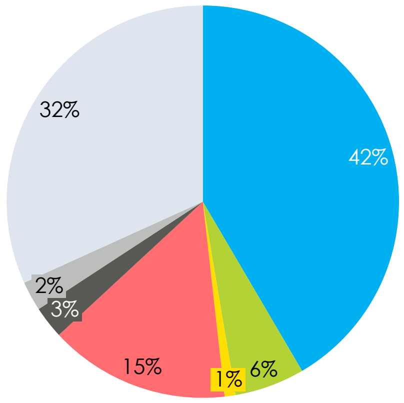
# REFERENCE SCENARIO

INDICATIVE RESULTS SUBJECT TO CHANGE UPON DETAILED STUDY

- Starting point for grasping system dynamics and inter-dependencies
- Generic, non-optimised benchmark and baseline for sensitivity analysis

## Outputs & results

### LCOA breakdown

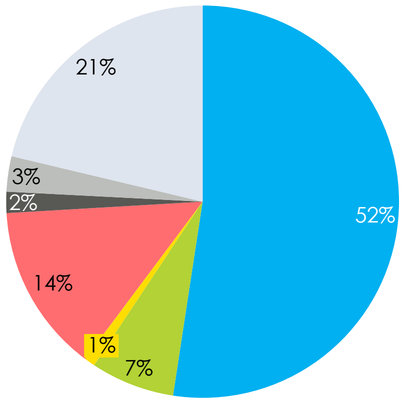


LCOA = \$450 / tonne $NH_3$

LCOA & CAPEX driven by: renewables, ammonia, electrolyser

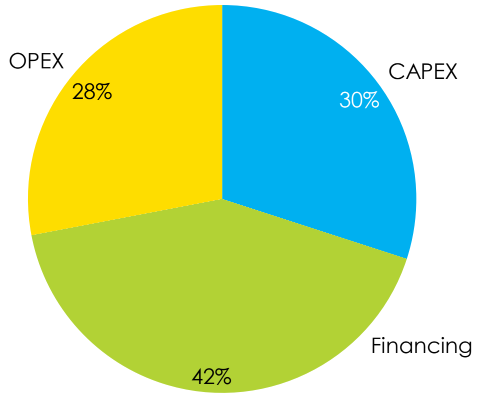
🟦 Renewable power
🟩 Power transmission
🟨 Desalination
🟥 Electrolyser
⬛ H2 transport
▨ H2 storage
⬜ Ammonia production

### Overnight CAPEX breakdown



Overnight CAPEX = \$2.6b (before financing)

### LCOA breakdown



Financing represents largest share of levelized unit cost

| **Renewables** | LCOE (\$/MWh) | CUF[1] | Curtailed Power (GWh)[2] |
|---|---|---|---|
| **Wind (onshore)** | 25 | 44% | 98 |
| **Solar (single axis tracking)** | 20 | 31% | 219 |
| **Blended [total]** | 21 | 34% | [317] |

| **Hydrogen** | \$/kg-$H_2$ |
|---|---|
| **LCOH, excl. local transp & storage** | 1.58 |
| **LCOH, incl. local transp & storage** | 1.72 |
| **CUF of electrolyser** | 54% |

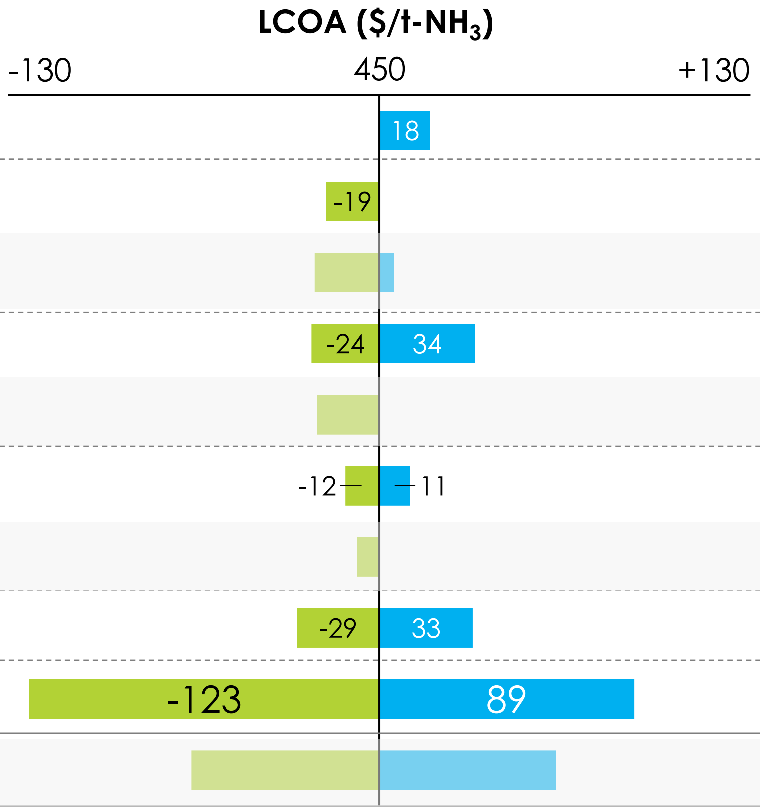
| **Ammonia** | \$/t-$NH_3$ |
|---|---|
| **LCOA, excl. shipping** | 450 |
| **CUF of $NH_3$ plant** | 85% |
| **CUF of $H_2$ storage pipeline** | 44% |

[1] Capacity Utilisation Factor. For renewables, the CUFs shown are after curtailments required for integrated $H_2$/$NH_3$ system balancing (e.g., ramp-up/down constraints by $H_2$ or $NH_3$ plants, $H_2$ storage tank full).
[2] Curtailed power is essentially "unused power" (i.e., any power that could have been generated and consumed/exported according to solar/wind conditions and installed generation capacity, but was not generated or consumed/exported because it was in excess of downstream system capacities).

# COST SENSITIVITIES: WHERE & HOW TO DRIVE DOWN COST (1/2)

INDICATIVE RESULTS
SUBJECT TO CHANGE
UPON DETAILED STUDY

White rows are “active cost levers” that GRN could influence
Grey rows are “passive cost levers”, driven by macro trends



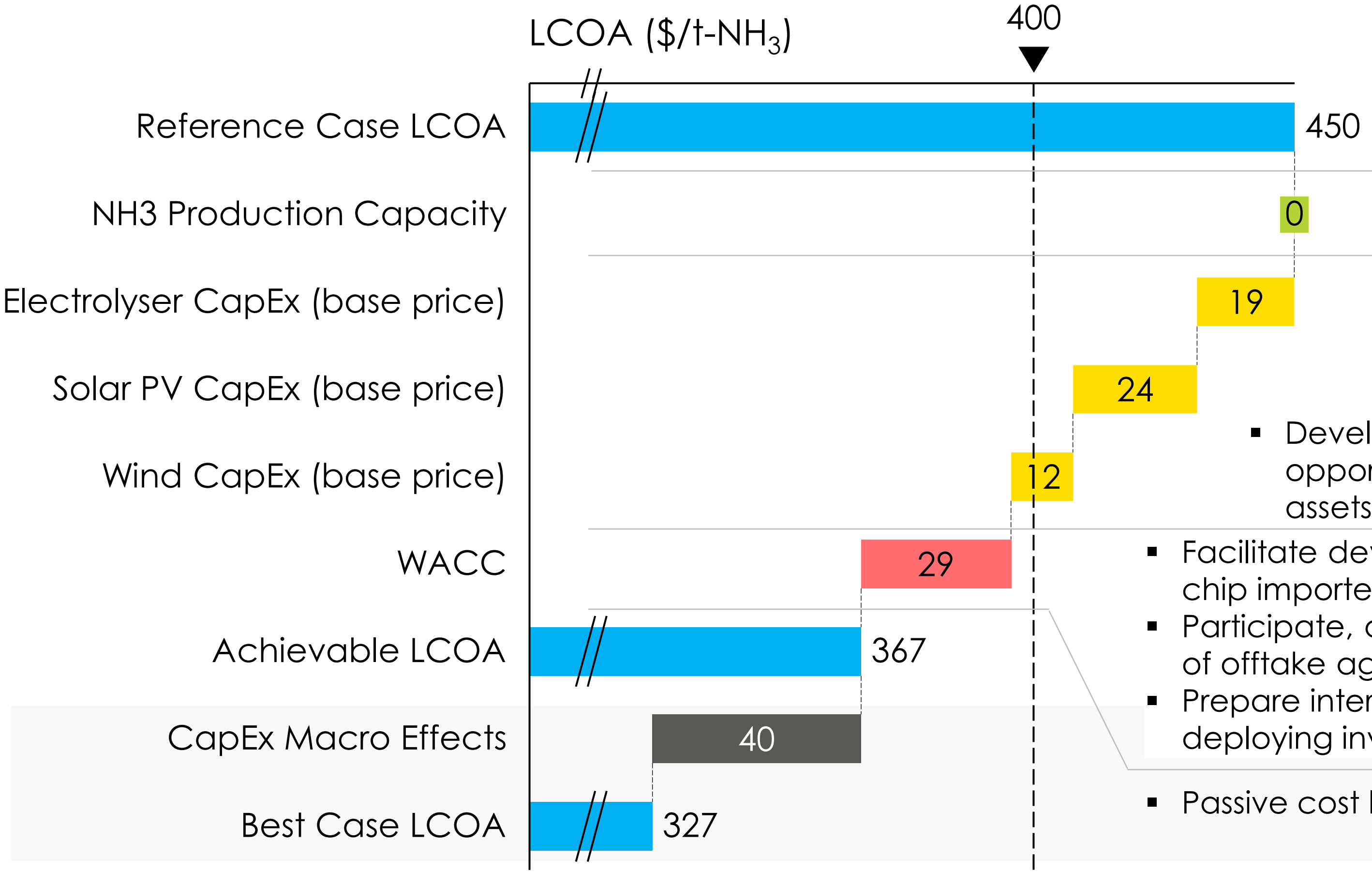
| WHERE | LCOA ($/t-NH$_3$) | |
|---|---|---|
| NH$_3$ production capacity | 18 | Economies of scale for 300 ktpa to 1,200 ktpa NH$_3$ plants |
| Electrolyser CapEx – base price | -19 | 30% discount for large (>20 MW), long-term (>10 years) orders |
| Electrolyser CapEx – macro effects[1] | | Optimistic learning rate and med-high deployment scenario vs conservative LR and medium deployment assumption |
| Solar PV CapEx – base price | -24<br>34 | +/-15% relative to Ref Case (recent local projects) |
| Solar PV CapEx – macro effects[1] | | 18% learning rate on experience curve vs 13% in Ref Case |
| Wind CapEx – base price | -12<br>11 | +/-15% relative to Ref Case (recent local projects) |
| Wind CapEx – macro effects[1] | | 18% learning rate on experience curve vs 13% in Ref Case |
| WACC | -29<br>33 | +/- 1 percentage point (project wide) relative to Ref Case |
| **Total LCOA impact** | -123<br>89 | $330/t best-case scenario against $540 worst-case |
| Commercial operation date (COD) | | 2040 and 2026 commercial operation dates vs 2030 in Ref Case |

- **GRN could drive unit cost reductions of $83/t-NH$_3$ via “active cost levers”, resulting in an LCOA of ~$370/t-NH$_3$ by 2030;** “passive cost levers” could reduce unit costs by a further $40-50/t-NH$_3$, leading to a best-case LCOA of ~$330/t-NH$_3$ by 2030.
- **Key active cost levers are CapEx for renewables & electrolysers[2] and WACC** – ideas to activate these levers on next slide.
- Projects with later CODs will have lower LCOAs as **electrolyser CapEx decreases rapidly over the next 10 years** (>10% per year through 2030)and renewables CapEx also continues to decline significantly.

[1] Macro effects consist of “learning rates” (i.e., the expected % decrease in electrolyser manufacturing cost for every doubling of deployed electrolyser capacity globally) and the assumed pace of electrolyser deployment globally as projected by ETC. Analogous points for solar and wind capex, except only includes learning rates since global deployment projections are based on IEA’s “Net Zero by 2050” scenario only. [2] Ammonia plant CapEx also large cost contributor, but opportunities for bulk discounts are less relevant and would be limited due to the maturity of the technologies/processes.

INDICATIVE RESULTS SUBJECT TO CHANGE UPON DETAILED STUDY

# COST SENSITIVITIES: WHERE & HOW TO DRIVE DOWN COST (2/2)



**HOW**

- Use caution if considering projects smaller than ~700 ktpa $NH_3$ where dis-economies of scale are significant (e.g., $H_2$ pipelines). NB: incremental benefits of building >700 kt appear to be small.
- Pursue discounts on electrolyser capex on the order of 30%[1] by coordinating or centralising procurement across project developers and project phases. Crucial to lock-in for earliest phases where electrolyser costs are highest.
- Develop relationships with solar and wind equipment suppliers to cultivate opportunities for local manufacturing/assembly or redeploying refurbished assets from EU. Procurement coordination opportunity also applicable.
- Facilitate development of long-term $NH_3$ offtake agreements with foreign blue chip importers via foreign policy[2], awareness generation, and diplomatic action[3].
- Participate, alongside other financiers (e.g., DFIs, climate financiers), in guarantees of offtake agreements or FX risk mitigation mechanisms.
- Prepare international and domestic financial sector players for establishing and deploying investment lines to GRN and other project sponsors[4].
- Passive cost levers, not under control of GRN or other stakeholders

Start of commercial operations (COD)

- Manage project phasing: project sizes and development timelines should capture economies of scale from earliest stages, but weight largest investments towards future to capture benefits of industry learning curves.

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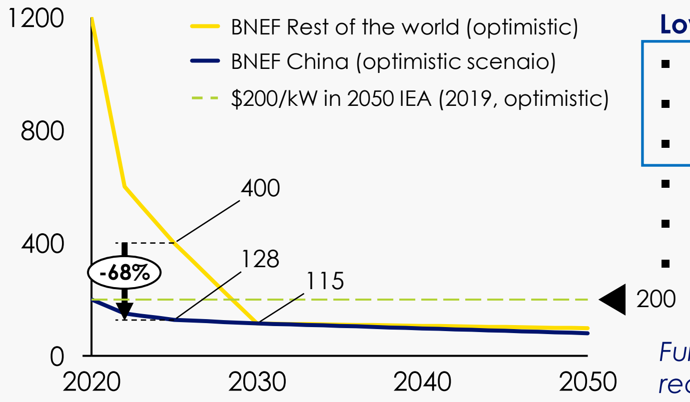
[1] Discount for large, long-term orders relative to industry cost projections for Rest of World (excluding China) – support for magnitude and achievability of discount on next slide [2] Foreign policy measures could include negotiating multi-lateral free-trade agreements or bilateral partnerships to facilitate exports of Namibia's green ammonia or related products, and imports of the raw materials, technologies, and labour force needed to build/operate Namibia's green $H_2$ economy. [3] Diplomatic action could include liaising with foreign Export Credit Agencies or administrators of double auction market mechanisms subsidised by foreign, importing governments. [4] Promotes liquidity, market access, competition and market efficiency/transparency.

# ECONOMIES OF SCALE LEAD TO LARGE COST SAVINGS IN ELECTROLYSER MANUFACTURING – A COORDINATED PROCUREMENT OPPORTUNITY

## International electrolyser cost expectations

**Fully installed system capex forecast of large alkaline electrolysis projects in China**[1]

US$/kW



**Low manufacturing costs in China:**

- Higher factory utilisation rates
- Standardized product offerings
- Lower soft costs
- Cheaper labour and raw materials
- Lower required gross margin
- Lower cost of capital

*Further opportunity of c. 40% cost reduction through scale increase*

**Western manufacturers expect similar cost reductions to those achieved in China** driven by economies of scale, factory automation and standardization/prefabrication

> *"Nel declared in January that its new factory will **cut the cost of its electrolysers by about 75%,** helping the price of green hydrogen to fall to $1.50/kg by 2025 ... automation and **economies of scale** at its new factory … **accounts for roughly half of the reduction"***

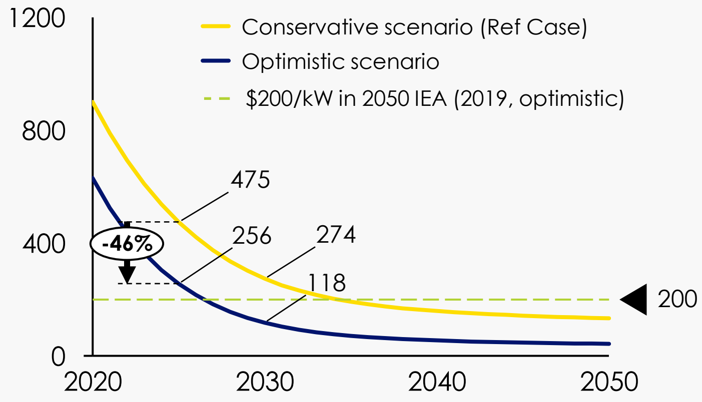
nel

Source: Nel Hydrogen CEO in interview with Recharge News, Dec 2021

## Namibia electrolyser cost expectations (as modelled)

**Fully installed system capex forecast of large alkaline electrolysis projects in Namibia**

US$/kW



**Namibia cost model assumptions:**

- Selecting "optimistic" inputs results in **45-60% discount** relative to "conservative" inputs reflecting bulk order discounts of 30% + favourable macro trends
- **Comparable to China's 70% discount** relative to RoW in 2025 due to economies of scale (plus other factors that are less available to Namibia)

| | Optimistic | Conservative |
|---|---|---|
| Learning rate | 18% | 13% |
| Global green $H_2$ scale-up | Medium-high | Medium |
| Bulk order discount | 30% | 0% |

*See Namibia Baseline Scenarios on subsequent slides for impacts of "optimistic" discounts on system costs and LCOA*

- Electrolyser capex discounts observed in China can be achieved by Namibia and its suppliers through economies of scale and automation.
- Key is for Namibia to lock in large, long-term orders by coordinating or centralising electrolyser procurement across projects developers and project phases.

---

[1] CAPEX figures include full installation costs for a large scale(>20 MW) alkaline electrolyser including stack, balance of plant (power electronics for voltage transformation, hydrogen purification and compression), construction and mobilisation and soft costs (project design, management, overhead, contingency and owners cost). Source: ETC (2021), *Making the Hydrogen Economy Possible*.

# BASELINE SCENARIO

**INDICATIVE RESULTS SUBJECT TO CHANGE UPON DETAILED STUDY**

- Incorporating insights from Reference Scenario to build a realistic, semi-optimised scenario
- Includes project phasing, but no shared infrastructure; optimistic CapEx for renewables and electrolysers relative to Ref Scenario

## Inputs & assumptions

| **System date** | **Phase 1** | **Phase 2** | |
|---|---|---|---|
| Start of commercial operations | 2026 | 2030 | |
| **System capacity** | | | |
| Ammonia production capacity (kt-$NH_3$/yr) | 800 | 1,200 | 2,000 kt = ~2.5% of global green NH3 demand 2030 |
| $H_2$ production capacity (kt-$H_2$/yr) | 244 | 392 | |
| Electrolyser type | Alkaline | Alkaline | |
| Electrolyser capacity (MW) | 1,375 | 2,175 | |
| Renewable energy capacity (MW) | 2,350 | 3,500 | 75% solar and 25% wind |
| *Solar - single-axis tracking (MW)* | *1,763* | *2,800* | Higher CAPEX of single-axis tracking over fixed axis is offset by higher capacity factor |
| *Wind - onshore (MW)* | *587* | *700* | CAPEX advantage of solar over wind + quality of solar resource offsets higher power transmission and H2 storage costs associated with solar plant |
| $H_2$ storage capacity (t-$H_2$) | 325 | 475 | 100 cm diameter above ground pipeline storage |
| $H_2$ compressor (MW-$H_2$ throughput) | 597 | 896 | |
| $H_2$ pipeline - max flow rate (t-$H_2$/hr) | 18 | 27 | 25 cm and 50 cm diameter above ground pipelines |
| Power transmission capacity (MW) | 1,800 | 2,800 | |
| Desalination plant capacity (million $m^3$/yr) | 1.2 | 1.8 | |

| **System costs** | **Phase 1** | **Phase 2** | |
|---|---|---|---|
| Renewables CAPEX | | | |
| *Solar - single-axis tracking ($/kW)* | *503* | *446* | Optimistic learning rate assumed for experience curve |
| *Wind - onshore ($/kW)* | *809* | *729* | Optimistic learning rate assumed for experience curve |
| Renewables WACC | | | |
| *Solar - single-axis tracking* | *6.8%* | *6.8%* | 25-year useful economic life |
| *Wind - onshore* | *6.8%* | *6.8%* | 25-year useful economic life |
| Electrolyser CAPEX ($/kW) | 216 | 118 | 30% discount applied for large, long-term order; Optimistic learning rate and Medium-high global deployment scenario assumed for experience curve adjustment |
| Electrolyser WACC | 8.0% | 8.0% | 30-year useful economic life |
| Ammonia plant CAPEX ($/t-$NH_3$) | 685 | 674 | Scale-adjusted; includes compressor, syn loop, ASU, and storage |
| Ammonia plant WACC | 8.0% | 8.0% | 30-year useful economic life |
| $H_2$ pipeline CAPEX ($/km) | 530,265 | 1,125,235 | Dependent on diameter |
| $H_2$ pipeline WACC | 8.0% | 8.0% | 30-year useful economic life |
| $H_2$ pipeline & storage compressor CAPEX ($/kg-$H_2$-per-hour) | 858 | 751 | Based on max $H_2$ throughput capacity |
| $H_2$ pipeline & storage compressor WACC | 8.0% | 8.0% | 20-year useful economic life |
| $H_2$ storage CAPEX ($/kg-storage capacity) | 305 | 284 | |
| $H_2$ storage WACC | 8.0% | 8.0% | 30-year useful economic life |
| Power transmission line CAPEX ($/kW/km) | 0.24 | 0.24 | |
| Power transmission line WACC | 8.0% | 8.0% | 50-year useful economic life |
| Power transmission converter CAPEX ($/kW) | 88 | 88 | |
| Power transmission converter WACC | 8.0% | 8.0% | 50-year useful economic life |
| Desalination plant CAPEX ($/$m^3$-annual - capacity) | 20 | 20 | |
| Desalination plant WACC | 8.0% | 8.0% | 30-year useful economic life |
| System-wide weighted average WACC | 7.3% | 7.3% | |

*Note: OPEX costs also included in model, but not listed here.*

## Phasing rationale

- Early mover to establish market presence, **capture market share**, and **drive decarbonization in most critical years**
- Build and produce at scale to **capture economies of scale**
- Phase development over time to match gradual increase in demand and **capture cost declines of experience curve**
- **Reduce upfront risk** by deferring larger investment to future, more developed/certain market conditions

# BASELINE SCENARIO

INDICATIVE RESULTS SUBJECT TO CHANGE UPON DETAILED STUDY

- Incorporating insights from Reference Scenario to build a realistic, semi-optimised scenario
- Includes project phasing, but no shared infrastructure

**Outputs & results**

## Phase 1 (2026 COD, 800 kt $NH_3$/year)

| Renewables | LCOE ($/MWh) | CUF[1] | Curtailed Power (GWh)[2] |
|---|---|---|---|
| Wind (onshore) | 25 | 44% | 107 |
| Solar (single axis tracking) | 20 | 31% | 244 |
| Blended [total] | 21 | 34% | [352] |

| Hydrogen | $/kg-$H_2$ |
|---|---|
| LCOH, excl. local transp & storage | 1.50 |
| LCOH, incl. local transp & storage | 1.64 |
| CUF of electrolyser | 53% |

| Ammonia | $/t-$NH_3$ |
|---|---|
| LCOA, excl. shipping | 433 |
| CUF of $NH_3$ plant | 87% |
| CUF of $H_2$ storage pipeline | 44% |

## Phase 2 (2030 COD, additional 1,200 kt $NH_3$/year)

| Renewables | LCOE ($/MWh) | CUF[1] | Curtailed Power (GWh)[2] |
|---|---|---|---|
| Wind (onshore) | 22 | 44% | 118 |
| Solar (single axis tracking) | 17 | 32% | 281 |
| Blended [total] | 18 | 34% | [399] |

| Hydrogen | $/kg-$H_2$ |
|---|---|
| LCOH, excl. local transp & storage | 1.23 |
| LCOH, incl. local transp & storage | 1.38 |
| CUF of electrolyser | 50% |

| Ammonia | $/t-$NH_3$ |
|---|---|
| LCOA, excl. shipping | 380 |
| CUF of $NH_3$ plant | 88% |
| CUF of $H_2$ storage pipeline | 46% |

## Combined

| | |
|---|---|
| Weighted average LCOA ($/t-$NH_3$) | 401 |
| Weighted average LCOH ($/kg-$H_2$) | 1.33 |
| Overnight capex ($b) | 6 |

- **At $400/t-$NH_3$, weighted avg LCOA competitive in 2030 global export markets**
- Sharing infrastructure such as $H_2$ transport pipeline, $H_2$ storage pipeline, power transmission infra, water desalination plant likely to result additional small decrease in unit costs
- ~750 GWh of curtailed power per year for both phases combined (equiv. to almost 20% of Namibia’s final electricity consumption in 2019[4]).

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[1] Capacity Utilisation Factor. For renewables, the CUFs shown are after curtailments required for integrated $H_2$/$NH_3$ system balancing (e.g., ramp-up/down constraints by $H_2$ or $NH_3$ plants, $H_2$ storage tank full). [2] Curtailed power is essentially “unused power” (i.e., any power that could have been generated and consumed/exported according to solar/wind conditions and installed generation capacity, but was not generated or consumed/exported because it was in excess of downstream system capacities). [4] IEA online database accessed January 2022: https://www.iea.org/countries/namibia

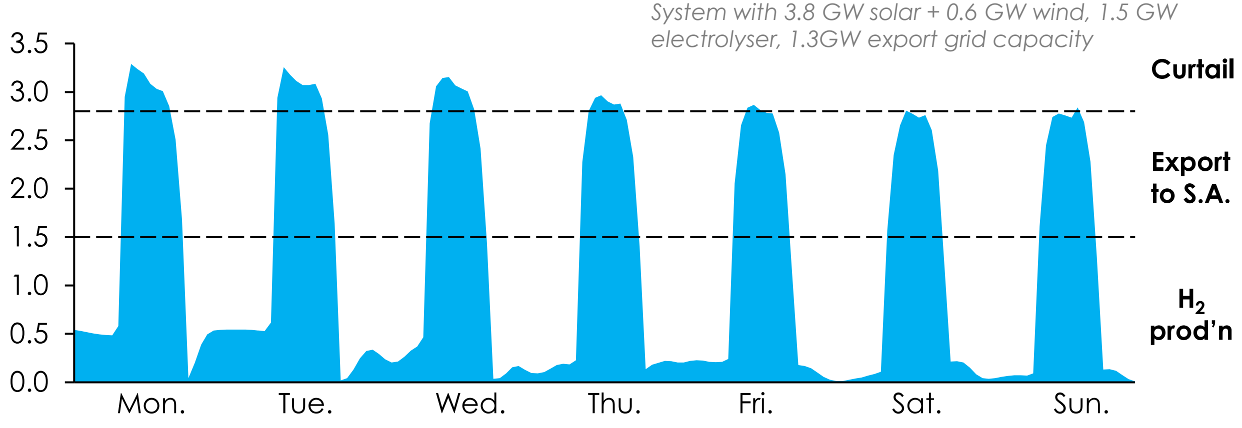
# POWER EXPORT: COMPELLING PROPOSITION & BENEFITS BACK INTO HYDROGEN PRODUCTION

**PROFILE NOT OPTIMISED FOR OUTPUT TO S.A.**

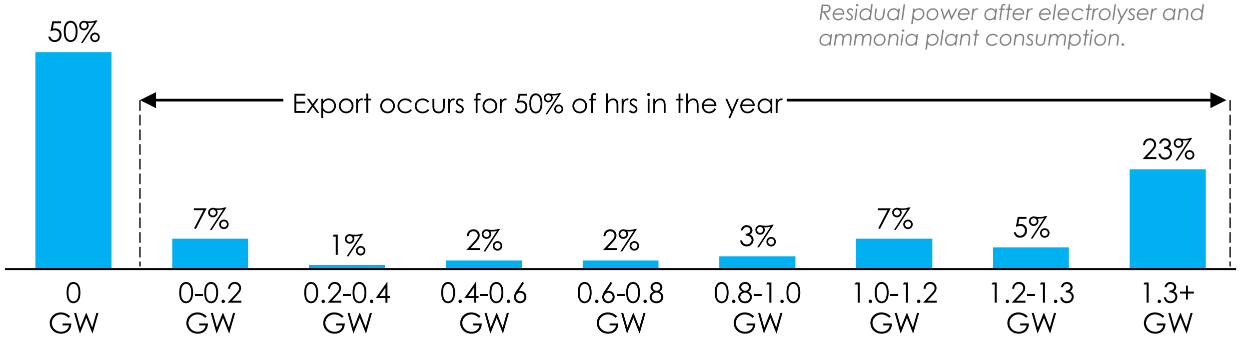
## Key messages

- **Oversizing renewables + exporting power** to South Africa **creates value**: electricity sales, hydrogen production efficiency *[see next slides]*
- **South Africa has a considerable challenge in scale & speed of solar & wind deployment** to address load shedding[1, 2], bringing online new clean generation at an unprecedented pace to replace increasingly faltering and uncompetitive coal plants
- South Africa might be interested to procure clean power from Namibia at **US¢4-6/kWh,** delivered into load centres (Jo'burg, CT)[3] – i.e., generation + transmission costs
- **Supply to South Africa likely to be highly variable;** requires flexibility in SA system, though hybrid contract possible[4]

## Power production: typical winter week (GW)


*System with 3.8 GW solar + 0.6 GW wind, 1.5 GW electrolyser, 1.3GW export grid capacity*

## Frequency distribution of power available for export (% hours of year)


*Residual power after electrolyser and ammonia plant consumption.*

Export occurs for 50% of hrs in the year

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[1] Even in best case scenario, by 2025 South Africa could still be experiencing infrequent load shedding that could cut off as much as 20% of electricity (in a system with average 30GW demand today); under US$8.5 billion deal with international funders, South Africa would pivot faster to renewables, close coal earlier;

[2] 6GW p.a. is what is required in terms of installation rate of new wind/solar from c.2023-24 going forward to deliver an accelerated transition to renewables for South Africa;

[3] solar & wind LCOEs in South Africa forecast to be US¢3 & US¢4 respectively in 2030, however this excludes transmission costs, and feasibility of transmission which is currently challenging given NIMBYism.

[4] South Africa experiencing both 'energy' shortages (e.g., total coal) and 'capacity' shortages during daily morning / evening peaks. Namibia imports could potentially be structured to help with both. Namibia's power generation mix between wind & solar could be optimised to serve a combined load from South Africa + electrolysers.

Sources: 'Setting up for the 2020s' (CSIR, 2020); 'Vital Ambition' (Meridian Economics, 2020).

# POWER EXPORT OPTIONS: CLEAR VALUE IN RE-ENFORCEMENT INVESTMENTS (SMALL) & C.12 GW SCALE LONG-TERM EXPORTS (LARGE)

INDICATIVE RESULTS SUBJECT TO CHANGE UPON DETAILED STUDY

| Option | Net power Exported[1] | Power project economics | | | | | Incidental benefits to ammonia project | | | | | Aggregate benefit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Investment required[2] | Levelized cost[3] | Power sales price | Margin | Profit[4] | LCOA | | Ammonia production | | Incremental profit[4] | Total additional profit[4] | Effective LCOA |
| | | | | | | | Baseline Scenario | After oversizing[5] | Baseline Scenario | After oversizing | | | |
| **1** | **Small investment** - Maximizing existing infra use – oversize renewables by 1.9GW on top of the 2.4 GW Phase 1 baseline scenario, build in 2026 | | | | | | | | | | | | *"No regrets option"* |
| | 1.3 GW<br>4.2 TWh/yr | $1.4b | $0.034/kWh | $0.04/kWh<br>$0.06/kWh | $0.006/kWh<br>$0.026/kWh | **$24m/yr**<br>**$108m/yr** | \$433/t-$NH_3$ | \$406/t-$NH_3$ | 700 ktpa | 770 ktpa | **$21m/yr** | **$44m/yr**<br>**$129m/yr** | \$349/t-$NH_3$<br>\$239/t-$NH_3$ |
| **2** | **Moderate investment** - Potential 2028 scenario – oversize renewables by 5.5GW on top of the 3.5 GW Phase 2 baseline scenario | | | | | | | | | | | | *"Start progressing today"* |
| | 4.0 GW<br>12.7 TWh/yr | $7.5b | $0.060/kWh | $0.04/kWh<br>$0.06/kWh | -$0.020/kWh<br>$0.000/kWh | **-$256m/yr**<br>**-$1m/yr** | \$380/t-$NH_3$ | \$355/t-$NH_3$ | 1,150 ktpa | 1,160 ktpa | **$29m/yr** | **-$227m/yr**<br>**$28m/yr** | n/a<br>\$331/t-$NH_3$ |
| **3** | **Large investment** - Potential 2040 scenario – oversize renewables by 28GW on top of the 3.5 GW Phase 2 baseline scenario | | | | | | | | | | | | *"Long-term ambition"* |
| | 12 GW<br>76 GWh/yr | $29.5b | $0.040/kWh | $0.04/kWh<br>$0.06/kWh | -$0.000/kWh<br>$0.020/kWh | **-$10m/yr**<br>**$1,511m/yr** | \$380/t-$NH_3$ | \$335/t-$NH_3$ | 1,150 ktpa | 1,160 ktpa | **$52m/yr** | **$42m/yr**<br>**$1,563m/yr** | \$299/t-$NH_3$<br>\$0/t-$NH_3$ |

- At $0.06/kWh, **Options 1 & 3 are clearly attractive** with Option 1 a "no regrets" opportunity requiring minimal grid CapEx and related execution risk
- Option 2 appears to be profitable, but requires more detailed study; it could be treated as intermediate step to Option 3
- $0.06/kWh assumption needs to be tested with SAPP/ESKOM given the variable generation profile, but **Options 1 & 3 remain attractive at $0.04/kWh**

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[1] Annual energy export volumes are indicative and will depend on actual solar/wind conditions, ammonia project operations, and importer's demand side constraints. Figures shown are net of line losses and converter losses. Assumes ammonia project has priority for any additional power generated (within the ammonia project's capacity constraints). Only the residual power, after maximising supply to the ammonia project, is assumed to be exported and sold. This assumption is considered in more detail on a slide later in this section. [2] Overnight CapEx for the additional renewables and power grid assets required to achieve target power export volume (before financing costs). [3] Includes incremental renewables CapEx and power grid CapEx required for the additional power export, as well as financing costs (8% WACC, 25 & 50 economic lifetimes for renewables and power grid assets, respectively), and OpEx costs (e.g., line losses, O&M), levelized over exported power volumes only. [4] Indicative profit before tax-related impacts such as corporate income tax expense, tax shield on depreciation, deferred tax assets. [5] Reflects incidental benefits to project that arise after oversizing the renewables from the increased availability of power to the ammonia project, including: increase in capacity utilisation factors for electrolysers and ammonia plant, decreased CapEx on electrolyser plant for smaller plant (afforded by increased utilisation), decreased CapEx and OpEx on hydrogen storage infrastructure.

# POWER EXPORT OPTIONS (INDICATIVE)

INDICATIVE POTENTIAL SOLUTION; DETAILED NETWORK STUDY WOULD BE REQUIRED

## 1 Smallest investment

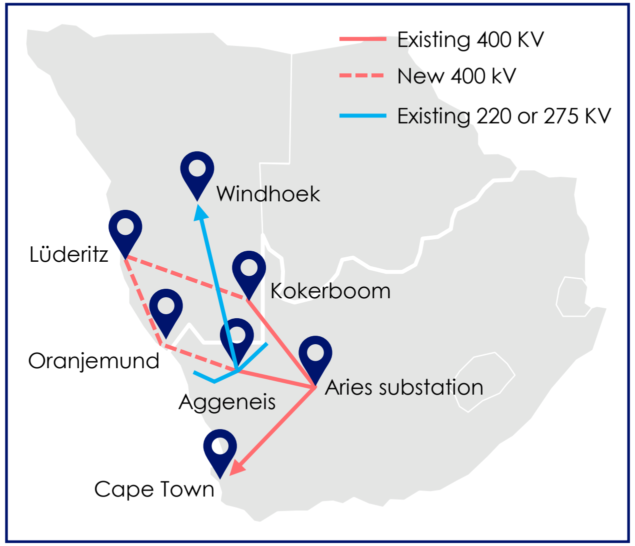
*Maximizing existing infra use*

1.3 GW

| | |
|---|---|
| NamPower domestic load | |
| ▪ Displace imports from Eskom | 100 MW |
| ▪ Displace imports from Hydro Cahora Bassa via Zambia | 50 MW |
| Exports to South Africa | |
| ▪ Lüderitz to Kokerboom to Aries 400 KV substation | 500 MW |
| ▪ Lüderitz to Oranjemund to Aggeneis 400 KV substation | 500 MW |
| ▪ Kokerboom to Aggeneis 220 KV substation | 150 MW |

### Infrastructure and investment (USD Bn)

| | |
|---|---|
| 400 KV line from Lüderitz to Kokerboom + substations | 0.09 |
| 400 KV line from Lüderitz to Oranjemund + substations | 0.08 |
| 400 KV line from Oranjemund to Aggeneis + substations | 0.09 |
| **Total** | **0.3** |



## 2a Moderate investment

*Potential 2028 scenario*

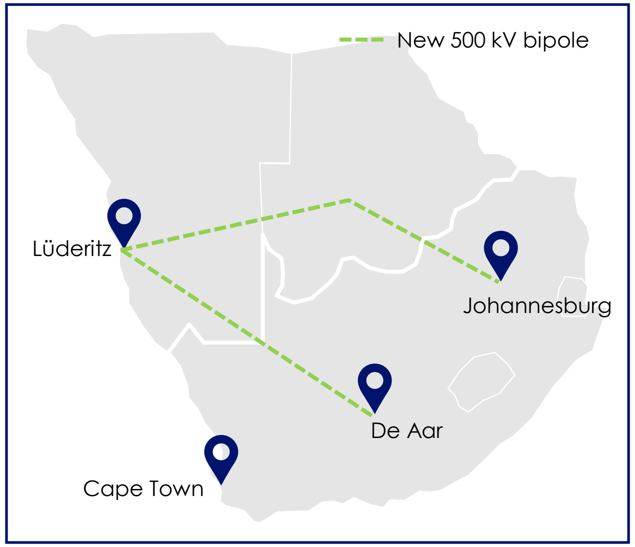
4 GW

**Sub-option A** – Export to Johannesburg and De Aar

| | |
|---|---|
| ▪ Lüderitz to Johannesburg's Pluto substation | 2 GW |
| ▪ Lüderitz to De Aar's Hydra substation | 2 GW |

### Infrastructure and investment (USD Bn)

| | |
|---|---|
| 500 KV bipole to Pluto | |
| 2 x 2 GW converters | 1.3 |
| 4 x HVDC lines | 1.3 |
| 500 KV bipole to Hydra | |
| 2 x 2 GW converters | 1.3 |
| 4 x HVDC lines | 0.9 |
| **Total** | **4.8** |



Note: Indicative options derived without input from NamPower or Eskom based on high-level analysis and coarse cost estimates by MPAMOT Africa Power team (as interpreted by SYSTEMIQ)

# POWER EXPORT OPTIONS (INDICATIVE)

INDICATIVE POTENTIAL SOLUTION; DETAILED NETWORK STUDY WOULD BE REQUIRED

## 2b **Moderate investment** (cont'd)

*Potential 2028 scenario*

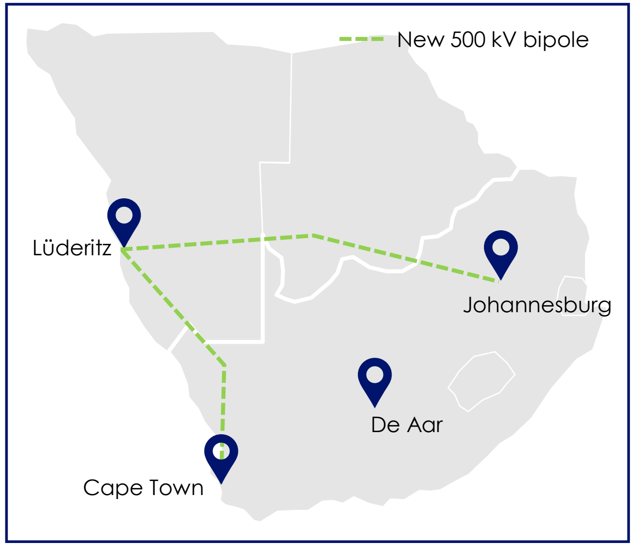
**4 GW**

**Sub-option B** – Export to Johannesburg and Cape Town

- Lüderitz to Johannesburg's Pluto substation 2 GW
- Lüderitz to Cape Town's Omega substation 2 GW

### **Infrastructure and investment** (USD Bn)

| | |
|---|---|
| 500 KV bipole to Pluto | |
| 2 x 2 GW converters | 1.3 |
| 4 x HVDC lines | 1.3 |
| 500 KV bipole to Omega | |
| 2 x 2 GW converters | 1.3 |
| 4 x HVDC lines | 0.9 |
| **Total** | **4.8** |



## 3 **Largest investment**

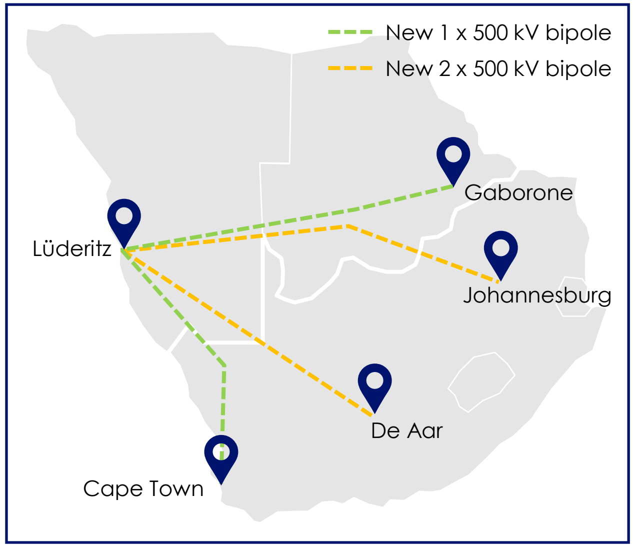
*Potential 2040 scenario*

**12 GW**

- Lüderitz to Johannesburg's Pluto substation 4 GW
- Lüderitz to De Aar's Hydra substation 4 GW
- Lüderitz to Cape Town's Omega substation 2 GW
- Lüderitz to Botswana's Isang substation near Gaborone 2 GW

### **Infrastructure and investment** (USD Bn)

| | | | |
|---|---|---|---|
| 765 KV bipole to Pluto | | 765 KV bipole to Hydra | |
| 4 x converters | 2.6 | 4 x converters | 2.6 |
| 8 x HVDC lines | 2.6 | 8 x HVDC lines | 2.6 |
| 500 KV bipole to Omega | | 500 KV bipole to Isang | |
| 2 x converters | 1.3 | 2 x converters | 1.3 |
| 4 x HVDC lines | 1.3 | 4 x HVDC lines | 1.3 |
| **Total** | | | **15.6** |



Note: Indicative options derived without input from NamPower or Eskom based on high-level analysis and coarse cost estimates by MPAMOT Africa Power team (as interpreted by SYSTEMIQ)

BLENDED FINANCE TASKFORCE

SYSTEMIQ

# KEY QUESTIONS COVERED

**The ‘What’**

1. Export markets
2. Domestic markets
3. Namibia infrastructure design
4. **Maximize benefit to Namibia**

- Maximising **value chain** localisation
- **Jobs** opportunity & investment in **skills** to maximise local hiring
- Scale of **economic benefits**
- **Re-investment of funds** – principles for stable & broad economic uplift

**The ‘How’**

5. Regulations & incentives
6. Financing
7. Partnerships
8. Roadmap

# SUMMARY: NAMIBIA CAN POTENTIALLY LOCALISE CERTAIN VALUE CHAIN ELEMENTS UPSTREAM & DOWNSTREAM; CRITICAL TO UPSKILL DOMESTIC WORKFORCE TO MAXIMISE LOCAL HIRING

**Maximise local investment & spending**

**Value Chain Localisation**

- **Upstream**, there are **select opportunities** for local parts manufacturing & assembly **to be explored** namely: (i) wind foundations & blades manufacturing, (ii) turbine assembly and (iii) copper cable manufacturing.
  - AfCFTA and other **trade agreements – particularly with South Africa** – could help to create a larger market that local manufacturing could serve, and thus **attract more local manufacturing**
- **Downstream** as seen previously depends on complementary assets & capabilities per downstream option, e.g.: synfuel & methanol – **low-cost source of carbon**; green steel – **manufacturing expertise & iron ore**.

**Jobs & Training**

- **In excess of 100,000 jobs (direct & indirect) could be envisioned before 2040:** potential for c.90% to be met with domestic workforce; c.35% of domestic jobs 'skilled' highlighting critical need to **train skilled domestic workforce**
- To upskill domestic workforce, recommend combination of: **[1] local dedicated training academy;** [2] overseas educational programmes; **[3] work-based learning as explicit objectives under PPPs;** [4] certifications.
  - The NGHRI can take the lead on much of the above, and act as central coordinator.

**Leverage to build broader economy**

**Economic Benefit**

- Under reasonable assumptions (e.g., 5% green ammonia market[1]), Namibia could see **upwards of $15bn green ammonia exports in 2040[2]**, relative to current GDP of $11bn
  - Indirect & induced GDP uplift can add another c.40-50% to GDP growth.
- **Upsides** include: Namibia serving a **greater share** of green ammonia market; Namibia serving more downstream sectors, e.g., **synthetic jet-fuel, methanol**; exporting considerable volumes of **power and $H_2$ to South Africa**.

**Re-investment of funds**

- As Namibia's $H_2$ revenues scale, to uplift the broader economy options for revenue deployment include: [a] direct dividend payments to Namibians; [b] national budget allocation; [c] national resource fund.
- Given Namibia's limited capital stock, a **balanced approach** would focus on both **investments into broader sectors** (e.g., Ag.) and a degree of **savings to create stability** (e.g., smooth any ammonia price volatility effects)

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[1] Note: assuming Namibia serves 5% of expected green ammonia market including shipping (which assumes shipping industry ends up primarily using ammonia over methanol as a clean fuel), this equates to c.38Mt $NH_3$ export in 2040 for Namibia; at a price of $400/t $NH_3$ this translates to c.$15bn; [2] with power exports, could reach c.$20bn

# VALUE CHAIN: COMPONENTS THAT COULD BE LOCALISED AND KEY CONSIDERATIONS

Key: ✔ **High likelihood / certainty** of being able to localise ✓ **Potential case** for localising [closer investigation required] ✗ **Highly unlikely** to be localised

| Value chain | Select sub-component | Key considerations | Likelihood of localizing (any part) |
|---|---|---|---|
| **UPSTREAM:** Solar, wind, $H_2$ equipment manufacturing & parts assembly | **Solar / wind parts manufacturing** | ▪ **Need sufficient market scale** – Namibia alone likely not enough; AfCFTA and/or 'cross-border' LCRs[1] with S.A. might help<br>▪ **Namibia-specific blades** for intense wind-speed potentially call for local manufacturing *[HYPHEN hypothesis]* | ✗ *most parts*<br>✓ *possibly blades* |
| | **Wind turbine assembly** | ▪ **Parts assembly** can be localised, as can **foundations** | ✓ |
| | **Copper cabling plant** | ▪ **Local copper trade** could help localise cable manufacturing | ✓ |
| | **Electrolyser manufacturing** | ▪ Unlikely to be localised; **highly technically complex** production and achieving **economies of scale requires global market** | ✗ |
| **Construction:** R.E., hydrogen | **Solar, wind, hydrogen, roads, ports, etc.** | ▪ *LOCALISED BY DEFINITION* | ✔ |
| **DOWNSTREAM:** $H_2$ value chain | **Ammonia** | ▪ **Most assured** exportable $H_2$-product | ✔ |
| | **Synfuel, Methanol** | ▪ Requires **low-cost source of carbon** (circular, at least recycled) | ✓ |
| | **Steel** | ▪ Requires **steel manufacturing expertise**, competitive **iron ore** | ✓ |
| | **Fertiliser** | ▪ Depends on scale of **regional demand** | ✓ |

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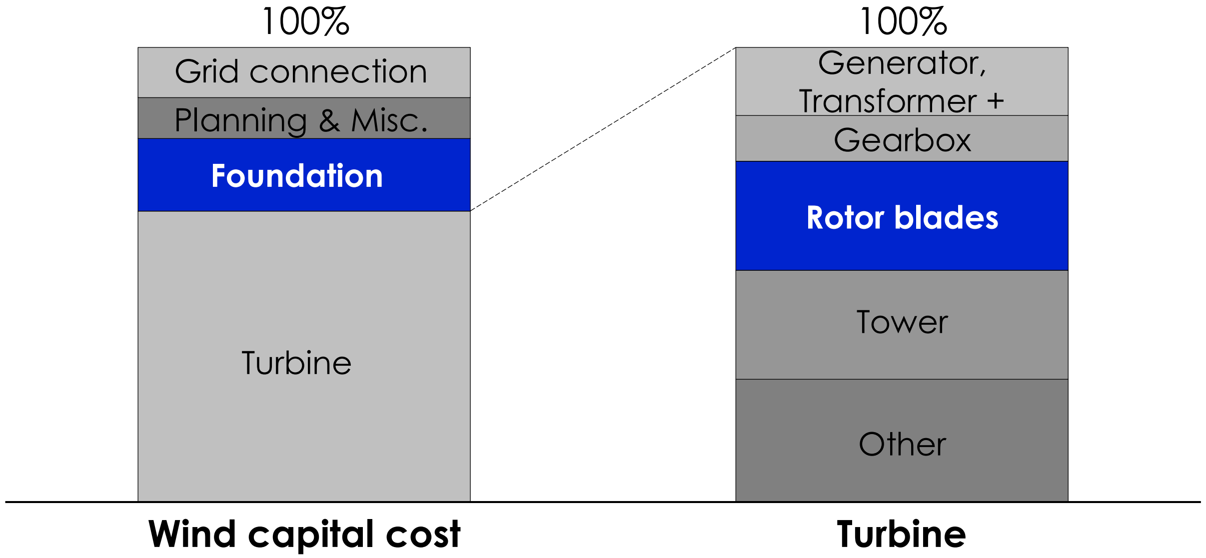
[1] LCR: Local Content Requirement – if Namibia and South Africa respectively define spend in each others' countries as 'local content' when it comes to renewables, this could create a larger market that a manufacturing plant in either country could serve while meeting LCRs

# VALUE CHAIN – MANUFACTURING & PARTS ASSEMBLY: SELECT SEGMENTS COULD POTENTIALLY BE LOCALISED [REQUIRES CLOSER INVESTIGATION]

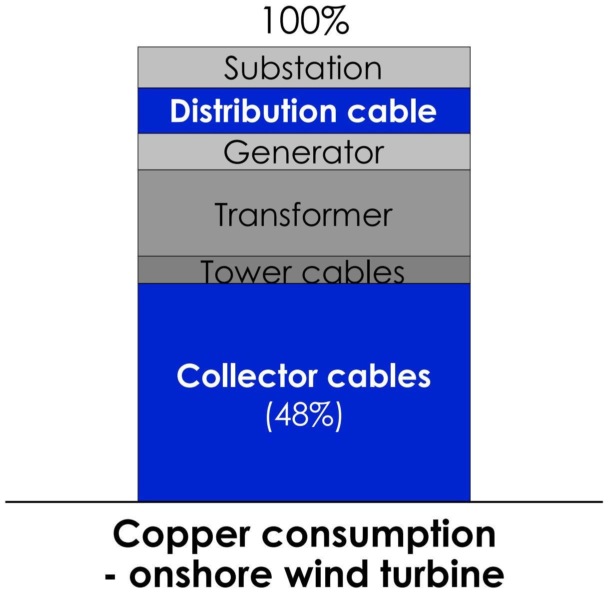
## a Solar / wind manufacturing & assembly

- **Majority of equipment will be imported** from countries with tech expertise & plants achieving economies of scale
- Potential for localisation with [a] **wind turbine foundations,** [b] Namibia-specific **blades** (HYPHEN hypothesis)
- Some opportunities to localise in **solar** as well (e.g., racking)
- NB: **Algeria** been successfully localising solar PV development



## b Copper cabling

- **Copper is vital to the energy transition**, e.g., 4.7 tonnes copper per wind turbine, approx. 58% in collector & distribution cables
- In 2019, Namibia **exported $1.5B copper, $0.3B of it refined**; vast majority ($1.0B) imported from Zambia
- Could be valuable to **investigate feasibility of local cable manufacturing** leveraging local copper supply chain
- Will require **skills & infra investment** to ensure sufficient quality



Sources: IRENA (2012), PV Magazine, Wood Mackenzie, OEC, American Experiment

# VALUE CHAIN – CREATE LARGER 'LOCAL' MARKET: APPLYING AFCFTA PRINCIPLES TO HYDROGEN ECONOMY CAN HELP TO SCALE; PARTICULARLY IMPORTANT WITH SOUTH AFRICA

## AFRICAN CONTINENTAL FREE TRADE AREA

Launched on 1st of January 2021, for the **"Development and promotion of regional and continental value chains"**, the AFCFTA could help scale Namibian $H_2$ industry and localise $H_2$ value chains.

**Regulations that could help $H_2$ industry to scale** ➔

### …Eliminating tariffs and non-tariff barriers on neighbouring trade

- **No tariffs** on $H_2$ molecules, electricity
- **Cross border LCRs**[1]
  - ▶ Creates larger market to attract local manufacturing
  - ▶ Pair with free movement of labour to share employment benefits

### …Enhancing efficiency of custom procedures, trade facilitation and transit

- Efficiency in establishing **transit infrastructure** to enable trade:
  - ▶ I.e., hydrogen pipelines, electricity transmission lines
  - ▶ Requires **close collaboration of energy transmission companies** (e.g., NamPower & Eskom)

### …Improving cooperation on technical barriers

- Aligned **safety standards**, certification of '**green' sourcing**
- **Talent development** with $H_2$ expertise

*NB: It is differentially important to tackle the above with **South Africa**, given electricity & $H_2$ export links and possibility for 'localised' manufacturing serving both markets*

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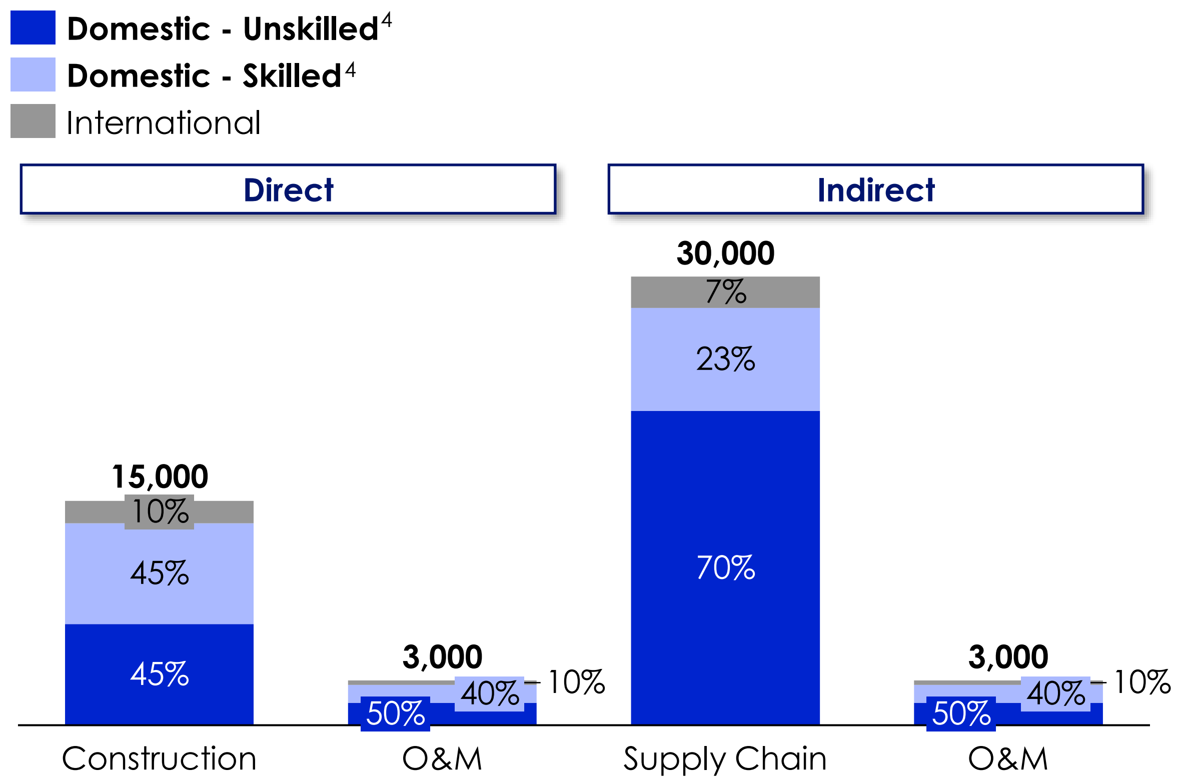
[1] Local Content Requirements

# JOBS & TRAINING: IN EXCESS OF 100,000 DIRECT & INDIRECT JOBS COULD BE ENVISIONED BEFORE 2040; TRAINING TO CREATE SKILLED DOMESTIC WORKFORCE IS CRITICAL

**Jobs Breakdown:** represents HYPHEN project scale ($10bn, 300kt $H_2$)
*some value chain localisation[3]*



- Indirect jobs: could be **~2x direct jobs** through construction phase
- Domestic jobs share: **potential for c. 90%** jobs served by domestic workforce (assumes required training is implemented)
- Skilled jobs share: represents c.35% of all potential domestic jobs, highlighting **critical need to create a skilled domestic workforce**
- Scale-up with more projects & value-chain localisation:
  - ▶ Arguably the **45,000 construction stage jobs** (direct + indirect) will **remain or scale** as further projects deployed[1]
  - ▶ The 6,000 **O&M jobs** could scale to **80,000+** if serving 4Mt $H_2$ production[2] (equates to ~3% 2040 green $NH_3$ market)

[1] depends on scale of construction & phasing
[2] 4 Mt hydrogen represents c.1% share of global demand from 'target sectors' in net-zero economy
Source: SYSTEMIQ calculations, HYPHEN Energy
[3] scenario assumes some onshoring (e.g., tower assembly)
[4] 'Skilled' includes for example engineers (e.g., civil, industrial, chemical) and experts (environmental, HSE, quality control); 'Unskilled' includes for example factory workers, machine operators, administrative employees.

# JOBS & TRAINING: UPSKILLING THROUGH COMBINATION OF DEDICATED TRAINING ACADEMY, ON-THE-JOB TRAINING & OVERSEAS PROGRAMMES; CERTIFICATION CAN HELP STANDARDISE

- To upskill domestic workforces, a combination of two options are often employed in such circumstances
  - ① **Local dedicated training academy**
  - ② **Overseas educational programmes**

- As part of the above, or in complement, to develop foundational skills the government can take further actions:
  - ③ Integrate **work-based learning** and apprenticeships as explicit objective of **PPPs with developers**
  - ④ Create a **certification system** – for academy and on-the-job trainees – to standardise technical knowledge base

- **NGHRI being launched to upskill Namibians**
  - **University of Namibia** housed & supported
  - Will also engage **other local & international institutions** and **private sector**
- NGHRI to further **build research** (e.g., desalination), and **develop local $H_2$ SMEs**

**Two options often employed to upskill workforces**

| | ① **Local dedicated training academy** | ② **Overseas educational programmes** |
|---|---|---|
| **Description** | ▪ In-country **technical training centre** | ▪ Programme at foreign institutions for **select skills** |
| **Examples** | ▪ Middle East **Desalination** Research Center (Oman)<br>▪ Ouarzazate **Renewables** Training Institute | ▪ **Technical University of Munich** is establishing a 'Future Lab for Green Hydrogen' |
| **Pros & Cons** | ⊕ **Can be tailored** to local context, national goals<br>⊕ **Flexibility to adapt** to new requirements<br>⊖ **Cost** of establishing new institution<br>⊖ Challenge in **attracting teaching staff** | ⊕ Less **upfront investment** vs. local institution<br>⊕ **Broader training** can increase productivity<br>⊖ **Not tailored and cannot adapt** (lack of control)<br>⊖ **Risk of brain drain** |

Source: FitchSolutions

# RE-INVESTMENT: INVESTMENT IN BROADER ECONOMY + SAVINGS TO CREATE STABLE UPLIFT

## Options for use of revenues

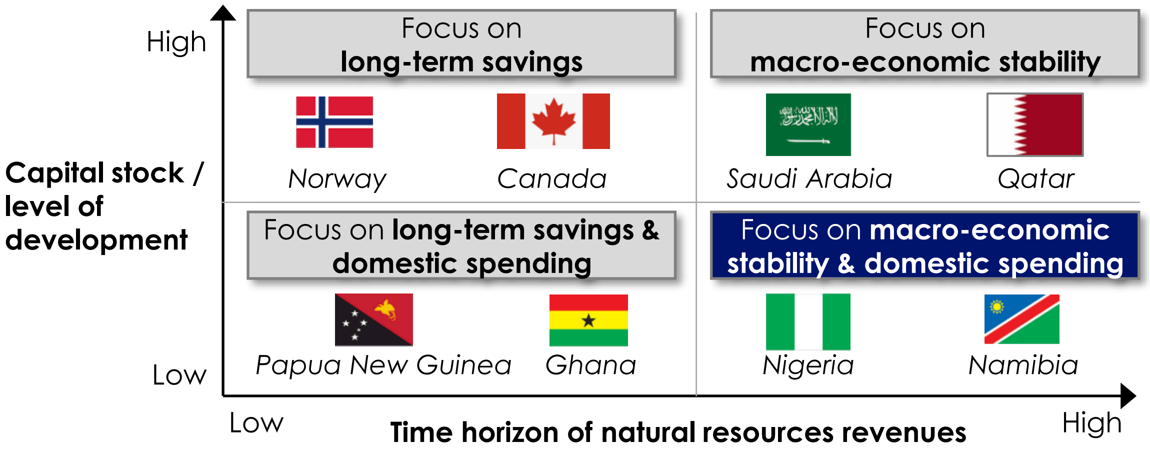
- Challenge: investing into broader economy to drive wholesale uplift

**OPTIONS**

| | ⓐ **Direct Dividend Payments** | ⓑ **National Budget Allocation** | ⓒ **National Resource Fund** |
|---|---|---|---|
| *Description* | | | |
| | - **Cash transfers** directly to citizens | - Invest in development via **budget process**<br>- **Annual or multi-year** development plans | - **Extra-budgetary fund** domestic & foreign<br>- **Fiscal rules** set by multi-year govt. objectives |
| *Examples* | | | |
| | - **Alaska** Permanent Fund **Dividend Scheme**<br>- Mongolia Cash Transfer Program | - Nigeria Excess Crude Account<br>- **Botswana Sustainable Budget Index** | - Norwegian Oil Fund<br>- Abu Dhabi **Investment Authority** |
| *Pros & cons* | | | |
| | ⊕ **Direct poverty alleviation**, especially if targeted<br>⊕ Limits risk of political instability if equitable<br>⊖ Increase to expenditure, **not investment**<br>⊖ Limited domestic absorptive capacity risks **inflationary pressure & currency appreciation** | ⊕ Supports **strategic spending programmes**<br>– e.g.: education, infrastructure<br>⊕ Lifts civil service salaries → **attract & retain talent**<br>⊖ Limited domestic absorptive capacity risks **inflationary pressure & currency appreciation** | ⊕ **Limits risk** of domestic economic **overheating**<br>⊕ Secures **revenue continuity** including counter-cyclical<br>⊖ **Risk** of mismanagement against multi-year objectives **if fiscal rules not consistently followed**<br>⊖ Lack of direct benefit to public can disenfranchise |

## Balanced strategy

**Optimal Resource Revenue Management Priorities Matrix –**
based on Example Country Characteristics



High

Low

**Capital stock / level of development**

Focus on **long-term savings**

*Norway* *Canada*

Focus on **macro-economic stability**

*Saudi Arabia* *Qatar*

Focus on **long-term savings & domestic spending**

*Papua New Guinea* *Ghana*

Focus on **macro-economic stability & domestic spending**

*Nigeria* *Namibia*

Low **Time horizon of natural resources revenues** High

- Namibia presently holds **limited capital stock**, meanwhile resource **revenue from hydrogen is long-term** and will grow in coming decades
- This implies revenues should be used for both **short-term spending and savings** to ensure long-term macroeconomic stability, **diversify economy**
- Example: Ghana implemented a policy of investing oil & gas revenues in funds that provided a balanced spending strategy:
  - *Heritage Fund* saves for **future generations**
  - *Sustainability Fund* **smooths effects of commodity price volatility**
  - *Annual Budget Funding Amount* supports priority sectors (e.g., Ag.)

Source: SYSTEMIQ based on OECD, IMF (2018), NRGI, Baunsgaard et al (2018)

# KEY QUESTIONS COVERED

The **'What'**

1. Export markets
2. Domestic markets
3. Namibia infrastructure design
4. Max. benefit to Nam. economy

The **'How'**

5. **Regulations & incentives**
6. Financing
7. Partnerships
8. Roadmap

- **Engagement models** – e.g., private-led industry build, public-private partnerships
- **Case studies –** capital financing & government support in Chile, Australia
- **Regulations & incentives –** range of options & high-priority for Namibia, no regrets
- **Organising government –** $H_2$ leadership in Chile & Australia, similarities in Namibia

# SUMMARY: THERE IS ENOUGH CLARITY ON PATH FORWARD THAT MULTIPLE MINISTRIES & ENTITIES IN NAMIBIA CAN MOVE FROM PLANNING & GETTING ORGANISED, TO BEGIN IMPLEMENTING

| | |
|---|---|
| **Engagement model** with developers to build a new industry | ▪ There are a **range of potential approaches** including:<br>a. “hand over the keys” in **single private contract**<br>b. create **private-sector led ecosystem**, with private developers designing & advancing projects<br>c. government engages in **PPPs** & steer towards target outcome<br>d. owned & led by **public state-owned-entity** (akin to a controlling National Oil Company)<br>▪ Namibia has started by testing the market via an **auction with award to single developer** (draws on models ‘a’ & ‘b’). To establish foundations of the industry at speed, and maintain control of industry direction, the **next step may focus more on a small set of key strategic PPPs** (draws on models ‘b’ and ‘c’; note there are options that limit GRN funding requirements). |
| **Case studies:** Chile, Australia | ▪ **Chile has created an attractive investment environment** (tax schemes, regulations, financing structures). Projects are designed & financed entirely by private developers. Government is providing or enabling support on multiple fronts including: financial support for pre-feasibility phases, development bank loans, favourable tax schemes (e.g., VAT refunds, increasing carbon tax).<br>▪ **Australia is similarly creating a supportive environment but also investing directly into projects** e.g., via government-owned Green Bank with $300 million hydrogen fund. Australia (as with Chile) is establishing international links that developers can leverage with importer countries and financing bodies (e.g., export credit agencies). |
| **Regulations & incentives** in context of limited budget | ▪ Amongst the many **policy & incentives options** countries are drawing upon, with Namibia focus on exports and limited budget there is a subset to focus on advancing, including; underpinning standards & guarantees of origin to enable projects & exports [no regrets to begin drafting]; concessional loans to improve economics; tax credits & fuel pricing to incentivise domestic sectors (i.e., mining trucks, freight trucks, rail)<br>▪ Though national budget is limited, for policies & support that require funding **Namibia can draw upon climate & development finance and export credit agencies** |

# ENGAGEMENT MODEL: NAMIBIA COULD SHIFT FROM INITIAL AUCTION TO TARGETED STRATEGIC PPPs, AS A MEANS TO ESTABLISH FOUNDATIONS OF THE INDUSTRY

***Increasing state involvement & control***

| **Model** | **"Hand over the keys" – single private contract** | **Private sector-led ecosystem** | **Public-private partnerships (PPPs)** - incl. versions that do <u>not</u> require much government funding & expertise | **Publicly SOE-led set of projects** |
|---|---|---|---|---|
| *Indicative example* | *Botswana mining with DeBeers* | *Chile hydrogen approach* | *Australia hydrogen approach* | *Controlling National Oil Companies (e.g., Aramco)* |
| **Description** | ▪ Contract with **single developer to exploit resource**<br>▪ Developer takes **full control** of all integrated projects across the country / a region.<br>▪ Government has oversight of land-use, **receives payments** from developer (terms vary). | ▪ Hydrogen projects are **100% private-sector led**<br>▪ Government & SOEs run **competitive tenders for land**<br>▪ **Public incentives** and occasional **support** (e.g., transport infra)<br>▪ **Government-backed risk mitigation:** guarantees on dev't bank loans | ▪ Government takes **'partnership' approach** to support developers on individual projects that deliver strategic advances[1]<br>▪ **Mix of options** on how this could be executed in terms of financing & ownership, risk & returns sharing, operating accountability. ***[see PPP deep-dive in section 6]*** | ▪ National Hydrogen Company **actively involved in project build & operation**, leveraging & learning from international developer expertise<br>▪ **Mix of options for financing projects,** some of which could rely heavily on private developers' finance (NHC equity linked to value of land use) |
| **Pros & Cons** | ⊕ **Fast scale-up** of infrastructure and production in the context of limited public budget available<br>⊖ Government holds **lower degree of control and upside sharing** | ⊖ **Works best in established ecosystem** (platform infrastructure; many engaged developers, off-takers – export & domestic; supply chains)<br>– attracts deep bidder pools for auctions<br>⊕ **Limited public funding** and risk support required<br>⊕ **Can design competitive tenders** to attain most competitive costs from contractors | ⊕ Helps **launch sector via strategic projects that leverage private capabilities** (e.g., industry expertise, financing) and **public resources** (e.g., land, international relationships)<br>⊕ Government **retains more control,** sees more revenue upside<br>⊖ **May not extract maximum value** from private sector without auction system, though **can create more total value** through partnership | ⊖ **Risk of unsuccessful industry scaling** if project execution suffers<br>⊕ **Maximises potential share of profit** captured by government [though per above, if profits could be diminished if industry does not scale]<br>⊕ **Highly centralised design** and approach to exploiting resource, ensures **high degree of synergies & alignment** in $H_2$ projects |

**Namibia's selected models:**

Namibia's first step with auction for part of resource, **awarded to single developer**

Namibia's next step may focus more on establishing a small set of **key strategic PPPs to establish foundations of hydrogen industry**

[1] strategic advances such as: **backbone shared infrastructure** ($H_2$ pipelines, power transmission lines, ports, ammonia storage); **secure first scale off-take agreements for given markets** (e.g., with international ammonia sales, power export to Eskom, domestic truck FCEV, synfuel production).

# CASE STUDY – CHILE: ATTRACTIVE TAX SCHEMES AND FINANCING STRUCTURES HAVE LED TO A LARGE MOBILISATION OF PRIVATE COMPANIES INVESTING IN GREEN $H_2$ PROJECTS, THOUGH NO CENTRAL PLAN

- Potentially delivering **globally leading low-cost green $H_2$** (<\$1.5/kg $H_2$, 2030) thanks to **incredible potential for wind and solar energy.**
- Have created **attractive investment environment bringing forward an ecosystem of players, who are then designing & launching projects.** Target industry and value chains seemingly not driven centrally.

**Financing projects & enabling infrastructure**

- Financing of the **40+ green $H_2$ projects in Chile** rely mostly on **corporate balance sheets.**
- Enabling infrastructure is case dependent:
  - Port infrastructure: **government investment,** has been consistently invested in as Chile has built up trade.
  - Electricity transmission infrastructure: 100% financed by **private companies**, and government regulated. Recently a consortium led by Iberdrola was chosen to build and operate 2 converter stations and a new 600kV of 1,400km HVDC line.
  - Renewables on grid: [note: relevant only for distributed, grid-connected electrolysers] – Chile has built up a supportive environment around renewables for many years, becoming a leader in the region & globally in attracting **private investment**

**Government support** *[beyond above]*

*Supports value-chain (supply & demand)*

- Via Chilean Development Agency 'CORFO' provide direct financial support in **pre-feasibility & engineering study phases**, and promotes innovation & research efforts. Example projects supported include:
  - E-fuels: Haru Oni project will supply >550m litres of e-fuels by 2026, to German oil company and to ENAP. Involves many players – Siemens Energy, Andes Mining & Energy (AME), ENAP & Enel. Received **substantial funding from German government** as well.
  - FCEVs in mining: Hydra project examining replacing the powertrain of mining vehicles with $H_2$ fuel cells. Run by Engie, and in **partnership with Australian research agency CSIRO, and major players in the mining sector.**
- Chilean government working to enable support to developers with **government-backed financial guarantees** or **bank financing** like concessions through the cooperation with international organisations, financial institutions, and development banks.
  - E.g., a **\$50 million credit loan from the Inter-American Development Bank** to support development of green $H_2$.

*Demand-focused*

- Facilitate high-demand markets with **development of favourable tax schemes** e.g., VAT refund to recoup costs on goods and services and zero-VAT for certain imported goods and services (e.g., fuel-cell electric vehicles)
- Potentially **increasing carbon tax rates** on use of fuels, **eliminating fossil fuel subsidies** to freight and transportation industries.[1]

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[1] ENAP is Chile's National Oil Company – Empresa Nacional del Petroleo

Sources: Ossa Daza, et al. (2021), *Chile aims to win green hydrogen Race;* Griffith-Jones (2018), *The Role of CORFO in Chile's Development;* Reuters Practical Law (2020), *Electricity regulation in Chile;* Transformer Technology (2021). *Iberdrola and partners chosen for Chilean HVDC power line tender;* Siemens (2021), *Haru Oni: a new age of discovery;* PV tech (2020), *Solar Century, EDF, Engie among winners as Chile unveils results of 2.6GW solar tender*

# CASE STUDY – AUSTRALIA: GOVERNMENT IS PARTICIPATING IN DIRECT PROJECT FINANCING, AND PROVIDING GRANTS VIA MULTIPLE FUNDS AT NATIONAL & REGIONAL LEVEL

- Potentially delivering **very competitive green $H_2$** (\$1.8/kg $H_2$, 2030) thanks to **incredible potential for wind and solar energy.**
- **Government partnering more actively in a number of projects** including through Green Bank; **working with international links to prepare attractive finance & export** opportunities that developers can then leverage.

**Financing projects & enabling infrastructure**

- Hydrogen projects are **private sector-led** however **some debt and equity finance** provided by Clean Energy Finance Corporation (CEFC), a **government-owned Green Bank with a $300 million hydrogen fund** (has disbursed $62 million since 2012).
- **Regional governments will invest up to $118 million in seed-funding to hydrogen hubs** for shared infrastructure such as ammonia pipelines.
  - South Australia provided a $1 million grant to help project Neon (50MW) complete feasibility study, and would provide a further $4 million grant, then $20 million loan should the $600 million project go ahead.
- Enabling infrastructure: Electricity network: public and private ownership; Gas network: privately owned, led by APA group who recently received $0.3M grant to pilot transporting 100% hydrogen through pipes.

**Government support**

*Supply-side and export focused*

- **Financing of hydrogen feasibility studies and development projects** through corporate initiatives, as well as **public-private partnerships**, e.g.:
  - Australia Renewable Energy Agency (ARENA) plans to grant $79 million to three projects.
  - AUD$20 million agreement between Australia’s national science agency and Fortescue metals Group.
- **Establishing international links that developers can leverage for attractive export & financing opportunities:**
  - with countries: Germany, South Korea, Japan, UK – for future hydrogen export
  - with export credit agencies (ECAs): e.g., Japan Bank for International Cooperation, Export-Import Bank of China – to ensure larger commitments, longer tenors at **reduced funding costs to commercial lenders.**
- Supporting development and trials of **Guarantee of Origin** hydrogen emissions certification scheme with AUD$10 million.[7]
- **Making it easier to launch projects, and attain attractive project economics**, e.g.: [1] changing regulations & legislation to enable use of unutilised land or pastoral land; [2] allowing for compensation for grid firming; [3] R&D tax incentives; [4] favourable export tariffs.

*Domestic demand-focused*

- Stimulating off-take of FCEVs by **direct subsidies, taxation** (e.g., fuel excise) and registration discount.

Sources: Hydrogen Council (2021), *Hydrogen Insight Report 2021;* HyResource (2021), *A short report on Hydrogen Industry Policy Initiatives and the Status of Hydrogen Projects in Australia;* Offshore Energy (2021), *Governemnt grants $117.5 million for two Western Australian hydrogen hubs;* Energy Networks Australia (2019), *A guide Australia’s Energy Network;* CSIRO (2020), *Australian Hydrogen Centre;* CSIRO (2018), *National Hydrogen Roadmap: Australia.* A. Gilbert & Tobin (2021), *Australia’s plan to lead the green hydrogen industry.*

# REGULATIONS & INCENTIVES: A MYRIAD OF POLICY OPTIONS CAN SUPPORT THE DEVELOPMENT OF THE HYDROGEN ECONOMY

**Key** 🇳🇦 *Higher relevance for Namibia* 💲 *Requires financial support (Government or international) or has budget implications*

**Establishing targets & long-term signals**

- **National hydrogen roadmaps** 🇳🇦
- Economy-wide emission targets
- **National industrial strategy** 🇳🇦
- International agreements & commitments

**Support domestic demand creation**

- Portfolio standards
- $CO_2$ pricing[1], reduce fossil subsidies .
- Mandates & bans
- Performance standards
- **Electricity & gas market rules[2]** 🇳🇦
- **Tax credits[3]** 💲 🇳🇦
- Reverse auctions

**Mitigate investment risks**

- **Concessional loans[4], insurance, guarantees** 💲 🇳🇦 *via dev’t finance (e.g., MIGA)*
- **Export credits** 💲 🇳🇦 *via export credit agencies*
- **“Guarantee of origin” trading** 🇳🇦
- **Tax breaks** 💲 🇳🇦
- **Regulated returns** 🇳🇦
- Water resource and CCUS planning

**Promote R&D, pilots, knowledge sharing**

- **Direct project funding/cofunding** 🇳🇦 *e.g., via German Research Ministry*
- **Tax incentives** 💲 🇳🇦
- **Grants** 💲 🇳🇦 *via climate, development finance*
- Complex demonstration co-ordination
- Equity in start-ups 💲
- **Multilateral collaboration initiatives[5]** 🇳🇦
- Targeted communication campaigns
- Prizes

**Harmonise standards, remove barriers**

- **Safety standards** 🇳🇦
- Avoiding double taxation
- Distribution purity and pressure
- **International certification of $CO_2$ intensity, provenance of $H_2$ supplies** 🇳🇦
- Benchmarks for the incumbent processes hydrogen replaces

[1] e.g., carbon tax on transport fuels to promote use of domestic hydrogen over imported fossil fuels, thus helping trade balance; [2] E.g., permit hydrogen producers to use transmission grid at marginal costs & to be paid for balancing services; [3] E.g.: temporary royalties pause or reduction for mining companies to incentivize investment in FCEVs; subsidies for green fertilizer; [4] establish financing lines with DFIs & MDBs, e.g., for $H_2$ production, downstream plants (ammonia, fertiliser, synfuel); [5] E.g., work with China to have early use of Weichai FCEV mining trucks deployed in Namibia at Chinese owned mines.

Source: IEA, The future of Hydrogen (2019)

# REGULATIONS – STANDARDS: NO REGRETS MOVE TO BEGIN DRAFTING REGULATIONS UNDER WHICH HYDROGEN PROJECTS CAN OPERATE, TO CLARIFY AND REMOVE PROJECT RISKS

## Chile case study

- Current regulation only refers to hydrogen in **context of hazardous substances**, disparate set of regulations
- Chilean government to **build legal framework ground up** – **to address uncertainties that could create risk for $H_2$ projects**
- **Ministry of Energy & Mining retained GIZ** (German agency) to issue an $H_2$ regs proposal based on international standards
    - **Initial focus on key regs** for $H_2$ infra, transport, storage & use of $H_2$ in heavy duty vehicles (incl. freight, mining)
    - Comprehensive safety regulations, regs for broader applications, labour standards, to follow.
    - Timing: GIZ proposal issued April 2020; target for ME&M to issue key regs by 2024, broader set by 2028.
    - 'H2V Initiative' with ME&M and several committees (e.g., Science & Technology) focused on coordinating upcoming regulations.
- **In the interim,** Energy & Fuels Superintendency (with ME&M) is granting permits where projects apply **international standards**

## **Example regulations to progress** [not exhaustive]

*informed by Chile case study, some may not be relevant*

| | |
|---|---|
| Certification for **'Guarantee of Origin'** | *To ensure exports can be certified as green*<br>▪ Adopt **internationally recognized scheme**, or based on regulation of target importing countries<br>– E.g., 'CertifHy' – European focused though planning to launch scheme beyond EU-border; or GH2 standard<br>– **Complying with existing and upcoming EU regulation** can help to future-proof |
| **Commercial regulations** | *To provide commercial framework for $H_2$ use*<br>▪ Identifying & closing gaps in current regs, e.g.:<br>– Declare **green $H_2$ as a fuel**, not hazardous substance<br>– Regulations on **process for environmental permit** application in context of a hydrogen projects<br>– Clarity on **definition of freshwater produced** by seawater (national good vs. private ownership)<br>– **Rules for grid integration**, e.g., remuneration for grid stabilisation (e.g., electrolysers as balancing service) |
| **Safety regulations** | *To ensure safe production, transport, storage, use*<br>▪ Apply for **membership in ISO TC-197** (other members include Australia, Saudi Arabia, 15 EU)<br>▪ Apply **safety standards from ISO**, e.g.: ISO/TR 15916: Basic safety consideration of $H_2$ systems |

Sources: Ossa Daza, et al. (2021), *Chile aims to win green hydrogen Race*; World Bank (2021), *Deliverable 4: Advisory report on the development of a Green Hydrogen certification scheme in Chile*

# KEY QUESTIONS COVERED

The **'What'**

1. Export markets
2. Domestic markets
3. Namibia infrastructure design
4. Max. benefit to Nam. economy

The **'How'**

5. Regulations & incentives
6. **Financing**
7. Partnerships
8. Roadmap

- **Industry financing needs**
- **Engagement model** – PPPs, staple financing
- **Financing landscape** – source & uses
- Financing **early stage development**
- Using **blended financing** to unlock competitive cost of capital

# SUMMARY: MIX OF FINANCING SOLUTIONS NEEDED TO UNLOCK HYDROGEN INDUSTRY; GRN CAN PLAY ACTIVE ROLE IN ACHIEVING COMPETITIVE FINANCING & THUS COMPETITIVE LCOA

| | |
|---|---|
| Industry **financing needs** | ▪ **Catalysing the industry** through early-stage project development and building government capacity will require **tens of millions** though of course lead to construction of the industry in tens of billions<br>▪ **Financing needs** across stages and for different project components (e.g., shared infrastructure vs. individual developer / project) are **diverse and inter-connected**; no simple, single solution<br>– An attractive blend can create competitive advantage, given importance in low-WACC and ability for access to certain sources of financing to help launch the industry<br>– GRN has an important role to play in engaging some of the more catalytic sources of financing, e.g., development capital |
| **Engagement** model | ▪ **GRN can engage in PPPs without needing to input finance or expertise**, i.e., more 'concessional' PPPs. For certain shared infrastructure, GRN may prefer a more active role in the PPP (e.g., BOOT[1] model for Tx lines)<br>▪ **Staple financing** – where GRN pre-arranges attractive financing packages – may be a route to receive more competitive bids / terms from developers and unlock multi-project commitments from financiers.<br>▪ With a **focus on upskilling Namibian resources through PPPs today**, GRN may move to a more **active role in PPPs in the future** (as was seen with NOCs taking control in Saudi Arabia and Iran in the 1970s). |
| **Financing** landscape | ▪ It is important for GRN to understand financing across all stakeholders, to play its role in engaging competitive sources as a means of helping to drive down project WACCs and thus achieve the most competitive LCOA<br>▪ Multiple sources of funding to draw upon, e.g.: private capital as **scale investors**, public capital markets as means of **GRN raising funds**, development & philanthropic capital to **support industry inception, de-risk projects & lower WACC** |
| Early stage development & **blended finance** for project financing | ▪ **Funding early stage development** (incl. building government capacity) to launch the industry can draw upon a mix of funders to play different roles, e.g.: **philanthropic funders** for strategy & pre-feasibility, **DFIs** for (pre-) feasibility, **foreign government aid / ministries** for R&D, and **private companies** for R&D and pilot projects<br>▪ **Blended finance** can help mobilise private capital at scale and **de-risk projects** to achieve more competitive cost of capital (and thus more competitive LCOA). **GRN can play an active role** to help unlock blended financing. |

[1] BOOT: Build-own-operate-transfer

# INDUSTRY FINANCING NEEDS: MILLIONS REQUIRED TO ENABLE THE INDUSTRY (PROJECT DEVELOPMENT, GOVT CAPACITY), AND BILLIONS REQUIRED TO BUILD THE INDUSTRY

### Early-stage project development

- Grants for hydrogen **R&D**
- Project **pre-feasibility** and **feasibility** studies
- **Pilot and flagship projects**

**Millions**

### Infrastructure projects

- Wind & solar generation
- Electricity grid infrastructure
  - Hydrogen project-related
  - Curtailed power export
- Electrolyser plant
- Desalination plant
- Hydrogen pipeline & storage
- Ammonia plant
- Port

**Billions**

### Governmental capacity building

- **Government institutional capacity building –** recruitment & training, engagement with private sector
- **Advisory services** for establishing strategic partnerships, financing, designing/optimising regulations, etc.

**Millions**

### Commentary

- Attractive financing solutions are **critical to Namibia's global competitiveness**
- Critical for GRN to grasp financing across stakeholders, to **help engage competitive sources**
  - GRN own funding levels required depends on ownership structure
- **Financing needs** are large, diverse and inter-connected
- **No single source of funds**; requires different forms of capital to unlock industry

# ENGAGEMENT MODEL: NAMIBIA COULD SHIFT FROM INITIAL AUCTION TO TARGETED STRATEGIC PPPs (AND MUCH LONGER-TERM TOWARDS PUBLIC SOE CONTROL)

*Increasing state involvement & control* →

| Model | "Hand over the keys" – single private contract | Private sector-led ecosystem | Public-private partnerships (PPPs)<br>- incl. versions that do not require much government funding & expertise | Publicly SOE-led set of projects |
|---|---|---|---|---|
| *Indicative example* | *Botswana mining with DeBeers* | *Chile hydrogen approach* | *Australia hydrogen approach* | *Controlling National Oil Companies (e.g., Aramco)* |
| **Description** | ▪ Contract with **single developer to exploit resource**<br>▪ Developer takes **full control** of all integrated projects across the country / a region.<br>▪ Government has oversight of land-use, **receives payments** from developer (terms vary). | ▪ Hydrogen projects are **100% private-sector led**<br>▪ Government & SOEs run **competitive tenders for land**<br>▪ **Public incentives** and occasional **support** (e.g., transport infra)<br>▪ **Government-backed risk mitigation:** guarantees on dev't bank loans | ▪ Government takes **'partnership' approach** to support developers on individual projects that deliver strategic advances[1]<br>▪ **Mix of options** on how this could be executed in terms of financing & ownership, risk & returns sharing, operating accountability. ***[see PPP deep-dive next page]*** | ▪ National Hydrogen Company **actively involved in project build & operation**, leveraging & learning from international developer expertise<br>▪ **Mix of options for financing projects,** some of which could rely heavily on private developers' finance (NHC equity linked to value of land use) |
| **Pros & Cons** | ⊕ **Fast scale-up** of infrastructure and production in the context of limited public budget available<br>⊖ Government holds **lower degree of control and upside sharing** | ⊖ **Works best in established ecosystem** (platform infrastructure; many engaged developers, off-takers – export & domestic; supply chains)<br>– attracts deep bidder pools for auctions<br>⊕ **Limited public funding** and risk support required<br>⊕ **Can design competitive tenders** to attain most competitive costs from contractors | ⊕ Helps **launch sector via strategic projects that leverage private capabilities** (e.g., industry expertise, financing) and **public resources** (e.g., land, international relationships)<br>⊕ Government **retains more control,** sees more revenue upside<br>⊖ **May not extract maximum value** from private sector without auction system, though **can create more total value** through partnership | ⊖ **Risk of unsuccessful industry scaling** if project execution suffers<br>⊕ **Maximises potential share of profit** captured by government [though per above, if profits could be diminished if industry does not scale]<br>⊕ **Highly centralised design** and approach to exploiting resource, ensures **high degree of synergies & alignment** in $H_2$ projects |

**Namibia's selected models:**

Namibia's first step with auction for part of resource, **awarded to single developer**

Namibia's next step may focus more on establishing a small set of **key strategic PPPs to establish foundations of hydrogen industry**

Possible position **many years from now** (e.g., saw this with NOCs in Saudi, Iran in 1970s)

[1] strategic advances such as: **backbone shared infrastructure** ($H_2$ pipelines, power transmission lines, ports, ammonia storage); **secure first scale off-take agreements for given markets** (e.g., with international ammonia sales, power export to Eskom, domestic truck FCEV, synfuel production).

# ENGAGEMENT MODEL – PPP: MORE CONCESSIONAL PPP MODELS CAN LEVERAGE THE EXPERTISE & CAPITAL OF PRIVATE SECTOR PARTNERS, LIMIT GRN FINANCING REQUIREMENTS

| | Name* | Description | Financing source** | Required GRN expertise / capacity | |
|---|---|---|---|---|---|
| | **Contracting** | Private party designs and builds the asset which is then owned and operated by GRN; financed by GRN | GRN | High | |
| **Possible ownership model; more suitable once GRN has built up funds and capacity** | **Build-lease-transfer (BLT)**<br>**Build-transfer-operate (BTO)**<br>**Build-operate-transfer (BOT)/Build-own-operate-transfer (BOOT)** | Private party builds and operates the asset; financed by GRN. In a BLT arrangement, the asset is owned by GRN but leased to the private party before being transferred at the end of contract. BOT/BOOT are the same except the private party owns the asset during the contracted period prior to transfer. In a BTO contract, the asset is transferred to GRN once construction is complete, then the private party operates the asset until contract completion. | GRN | **Medium,** though **High** once asset operation is passed to GRN | BOOT for **Tx lines**? |
| Concessional: **Optimal ownership model given GRN's limited budget and existing expertise** | **Build-own-operate (BOO)** | Private party builds, owns, and operates the asset for duration of contract; no obligation to transfer ownership at end of contract | GRN or **private party** | **Low** - medium | |
| | **Design-build-finance-operate (DBFO)/Design-build-finance-operate-maintain (DBFOM)**<br>**Design-construct-manage-finance (DCMF)** | Private party designs, builds, finances, and operates the asset of which GRN retains ownership. The maintain function can be implied or included under 'manage' rather than explicitly stated, hence DBFO, DBFOM, and DCMF are effectively the same. | **Private party** | **Low** | DBFO for **Port, $H_2$ pipe**? |
| | **Concession** | Private party designs, builds, finances, and operates the asset subject to a contract with GRN regarding use of public land. | **Private party** | **Low** | For **RE → $H_2$ → $NH_3$** projects? |

*Different terminology is often applied to elements of these relationships. Most commonly, the design and build phase of a project is contained in an Engineering, Procurement, and Construction (EPC) contract, and the operation phase in an Operation & Management (O&M) contract.

**In instances where GRN is the expected source of financing, the government can raise capital via the channels described on subsequent slides.

Sources: World bank; McKinsey; ADB; Thomson Reuters Practical Law; PPP Knowledge Hub

# ENGAGEMENT MODEL – STAPLE FINANCING: COULD HELP NAMIBIA SECURE ATTRACTIVE FINANCING SOURCES, AND RECEIVE MORE COMPETITIVE OFFERS FROM DEVELOPERS

## Staple financing: key features

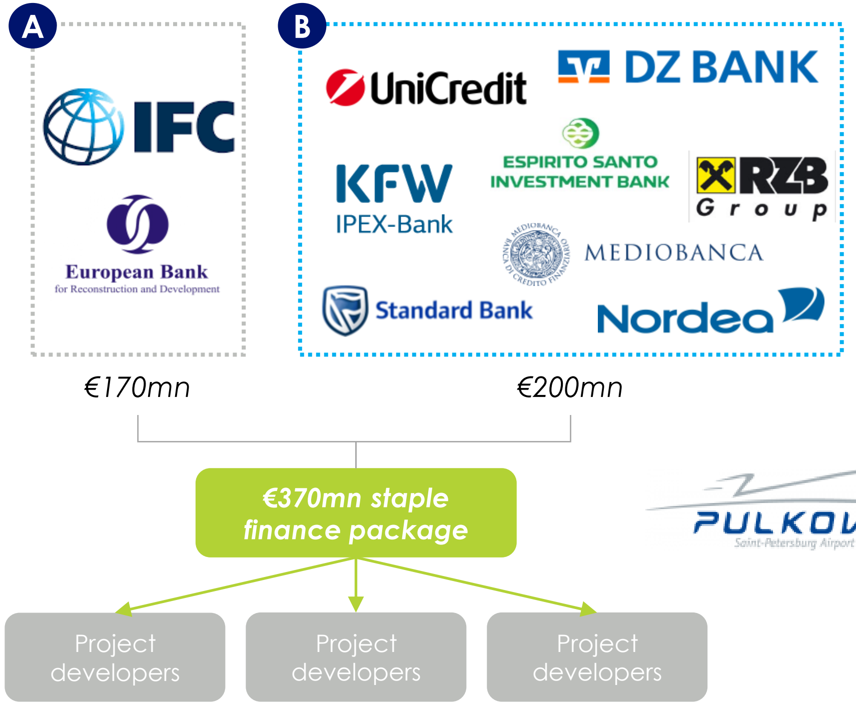
- **Pre-arranged financing package** offered to bidders
- **GRN do upfront leg work** – e.g., reach provisional agreements, assess investor interest
  - Range from **non-binding agreement** on principles to **detailed term sheets** included in tender
- The **winning bidder has the option**, but not the obligation, to use the financial package
- Can provide a **starting point for negotiation** between bidder & financier

## Staple financing: considerations

- Benefits include:
  - Can receive **more competitive bids or terms from developers** who can account for attractive financing within their project economic evaluations
  - Can unlock **multi-project or larger commitments from financiers**
  - **Improves transparency and reduces uncertainty** from early stage for potential financiers as project understanding (incl. risks) will have been socialized early
  - Can **shorten the time to financial close after awarding of contracts**, as financiers will already have conducted DD and considered financial structuring
- Costs & draw-backs include:
  - Requires GRN/NIPDB to engage financier up front, in-depth – **time & effort**
  - The more prescriptive the package, the **less opportunity for bidders to propose potentially innovative, alternative solutions**

## Case study: Pulkovo airport reconstruction & expansion

- IFC and EBRD arranged a **€370mn staple financing package**, which was **offered to project developers** as part of €1.2bn of commitments
- A/B loan structure where IFC (€70mn) and EBRD (€100mn) lent the A portion at a 15yr term, crowding in additional lenders via a €200mn syndicated B portion with a 12yr maturity



*€170mn*

*€200mn*

***€370mn staple finance package***

Project developers

Project developers

Project developers

Sources: pppknowledgelab.com; ifc.org

# ENGAGEMENT MODEL – CASE STUDIES: IN OIL, SAUDI ARABIA & IRAN STARTED WITH PPPs, ULTIMATELY PROGRESSED TO MORE GOVT. CONTROL VIA NOCs

Key: **Party/mechanism responsible for sourcing finance**

**Private company** ①

- **Concession agreement** between Saudi Arabian government and Standard Oil Company of California (SOCAL) – later Chevron – in 1933
  - Created California Arabian Standard Oil Company, or (CASOC)
- Included **article prioritising domestic employment:** ‘shall be directed and supervised by Americans who shall employ Saudi nationals as far as practicable…’
  - Opened schools for thousands of Saudis in next decades which included hybrid education/working days for students

**Government** ②

- Government purchased 25% of company in 1973 and took **full state ownership in 1980**
  - Catalysed by Arab-Israeli war – OPEC hiked oil prices for countries helping Israel (including the US); power shift from oil companies to producers
- In 2018, Aramco **revenue was 40% of total Saudi Arabia GDP;** entire economy has been driven by this enterprise which started as a PPP

**Public capital markets** ③

- **IPO in 2019 raised $29.4 billion for 1.5%** of the company’s shares ($1.87 trillion valuation)
- In 2017, the income tax paid by Saudi Aramco was reduced from c. 75-85% to 50%, bringing it in line with international benchmarks to make the company’s IPO more attractive to investors

**Private company** ①

- **Concession agreement** between Iranian government and a British businessman in 1901
  - Created Anglo-Iranian Oil Company (AIOC) – later British Petroleum (BP)
- Attempted nationalisation in 1951 as National Iranian Oil Company (NIOC); led to international agreement

**Government** ②

- New government in **1979 nationalised** oil industry (and others) to reduce dependence on foreign investment

**Private company + Government (fees)** ③

- In 2016, approved a new **Iran Petroleum Contract (IPC)**, which outlines model for PPPs, in bid to draw in $200 billion of foreign investment in next 5yrs
  - Foreign companies have up to **20yrs of production rights** from start of development until NIOC takes ownership (**BOT model**)
  - During this time NIOC pays a **fee per unit of fuel to producers**
  - Requirements and incentives for **transfer of technology and expertise** and participation of Iranian entities during all project phases
- This model has succeeded in attracting foreign investment e.g., Total took on 50.1% interest in 20yrs phase 11 of South Pars gas field (2017) – an initial investment of around $1 billion
- CNPC took 30%; Petropars **(NIOC subsidiary) will hold 19.9%**

**Private company + Government (incentives)** ①

- Mauritanian ministry of Petroleum, Mines & Energy is planning creation of an exporting hydrogen economy
- Doing so by launching hydrogen projects with private sector partners, and constructing a sector roadmap which will include:
  - i. An **incentive legal and regulatory framework** to attract foreign investment
  - ii. A national **skills development** plan
- E.g., partnering with CWP Global in ‘Aman’ project to develop **30GW of wind & solar** power which will be used to make green hydrogen and its derivatives
  - Mauritania will export these products, generating **billions of dollars for the national economy**
- E.g., granted Chariot Ltd. the exclusive right to carry out pre-feasibility and feasibility studies for <**10GW** green hydrogen project, ‘Nour’, (which Chariot would then develop)

① **Growth journeys often start with higher private ownership…**

② **…but can progress to higher government ownership**

③ **In more proven markets, with built-up local capabilities, govt’s have more options for their involvement**

Sources: Aramco; FT; Reuters; Statista; Herbert Smith Freehills; Total Energies; energyvoice.com

# FINANCING LANDSCAPE (SUMMARY): WELL-TARGETED SOURCES OF FINANCE CAN DEPLOY, GUARANTEE, OR UNLOCK BILLIONS

## Private capital

### Infra funds $

**Example investors:** Emerging Africa Infrastructure Fund, actis, Allianz, TPG Rise Climate

Typical ticket size: <$5bn

### Merchant & Investment banks & AMs $

**Example investors:** MUFG, Standard Chartered, BNP Paribas, ING, Ninety One, Macquarie

Typical ticket size: >$1bn

## Public capital (sovereign)

### Debt capital markets $

**Example issuers:**

Typical ticket size: <$5bn

### Equity capital markets $

**Example issuers:** أرامكو السعودية saudi aramco, هيئة كهرباء ومياه دبي Dubai Electricity & Water Authority

Typical ticket size: <$30bn

## Catalytic capital (development finance institutions, multilateral development banks, donors & philanthropy)

### Bilateral DFIs 🟡🔵

**Example funders:** CDC Investment works, KFW, PIDG Private Infrastructure Development Group

Typical ticket size: <$500mn

### MDBs, climate funds 🟡🔵

**Example funders:** IBRD, Green Climate Fund

Typical ticket size: <$500mn

### Donor agencies 🟡

**Example funders:** Federal Ministry for Economic Affairs and Energy, Netherlands Enterprise Agency

Typical ticket size: <$40mn

### Philanthropic funders 🟡🔵

**Example funders:** The African Climate Foundation, The Rockefeller Foundation

Typical ticket size: <$200mn

## Value chain partners

### Export Credit Agencies (ECAs) $

**Example funders:** EKF, ekn

Typical ticket size: <$5bn

### Vendor finance

**Example funders:** ABB, Siemens

Typical ticket size: <$50mn

### Off-taker support

**Example funders:** Yara, Airbus

Typical ticket size: <$100mn

**Deploy/guarantee billions**

$ = ability to deploy/guarantee billions

**Unlock billions**

🟡 = potential for **concessional rates**

🔵 = potential for **grant capital**

# FINANCING LANDSCAPE – DETAIL (1/3): PRIVATE CAPITAL & PUBLIC CAPITAL MARKET PROVIDE THE QUANTUM REQUIRED TO BUILD A MULTI-BILLION HYDROGEN INDUSTRY

| | Private capital | | Public capital markets (sovereign) | |
|---|---|---|---|---|
| | **Funds** | **Merchant & investment banks & AMs** | **Debt capital markets (DCM)** | **Equity capital markets (ECM)** |
| **Mandate/ description** | **Deployment of capital into a range of investments for the generation of returns for investors.** Types include Private Equity, Sovereign Wealth, Pension, etc. | **Provide financial services to corporates around the world to generate returns for shareholders.** | **Raise debt capital via issuance of government bonds or treasury bills. Can be used to support any government spending plan. Can appeal to more investors by issuing in \$ or €, and tying to green/sustainability targets.** | **Raise equity capital by listing some (or all) of a 100% government-owned entity on a stock exchange. Can be used to support any government spending plan. Higher annual dividends will attract more investors.** |
| **Products** | ▪ **Equity** (e.g., PE, hedge funds); either private or via equity capital markets<br>▪ **Senior, secured debt** (e.g., pension funds); often buy stakes from merchant banks via these banks' distribution desk, or public debt instruments via debt capital markets | ▪ **Senior, secured debt** (often syndicated using an originate & distribute model e.g., for large-scale project finance)<br>▪ **Subordinated debt**<br>▪ **Trade finance products** (e.g., working capital finance)<br>▪ Access to **DCM and ECM** | ▪ Issuance of **GRN bond** would create a pool of capital available for spending on any $H_2$-related infrastructure | ▪ **IPO of a GRN-owned entity** would create a pool of capital available for spending on any $H_2$-related infrastructure |
| **Typical financing terms** | ▪ **Quantum**: **<\$5bn**<br>▪ **Tenor**: <25 years<br>▪ **Cost of capital**: medium – high (PE will seek double digit returns, while pension fund debt is less; Namibia viewed as a higher risk country) | ▪ **Quantum**: **<\$1bn**<br>▪ **Tenor**: <25 years<br>▪ **Cost of capital**: low – medium (higher if subordinated/unsecured debt; Namibia viewed as a higher risk country) | ▪ **Quantum**: **<\$5bn**<br>▪ **Tenor**: <30 years<br>▪ **Cost of capital**: medium – high (Namibia is Ba3 rated by Moody's with negative outlook; viewed as risky market; would be cheaper if issued in foreign currency on overseas stock exchange) | ▪ **Quantum**: **<\$30bn+**<br>▪ **Tenor**: n/a<br>▪ **Cost of capital**: medium – high (dependent on demand for equity and returns requirements/dividend size) |
| **Example funders** | GLOBAL INFRASTRUCTURE PARTNERS<br>Allianz<br>NORGES BANK INVESTMENT MANAGEMENT<br>AXA Investment Managers<br>actis<br>LEAPFROG INVESTMENTS<br>Legal & General<br>Nordea | standard chartered<br>Ninety One<br>ING<br>HSBC<br>MACQUARIE<br>BNP PARIBAS<br>MUFG<br>ICBC<br>中国银行 BANK OF CHINA | **Example issuance:**<br>▪ Senegal €775mn Eurobonds issuance (June 2021)<br>▪ 5.375% yield maturing in 16 years<br>▪ Partly issued to finance participation in large-scale energy projects | **Example issuance:**<br>▪ Saudi Aramco IPO (Dec. 2019)<br>▪ \$29bn raised for 1.5% of company's shares<br>▪ Proceeds to help finance diversification away from oil<br>أرامكو السعودية saudi aramco |

Sources: Allianz; Leapfrog; JP Morgan; infrastructureinvestor.com; Refinitiv; Reuters; Saudi Aramco; FT

# FINANCING LANDSCAPE – DETAIL (2/3): DFIs, FOREIGN GOVERNMENTS ARE CRITICAL FOR PRODUCTS TO DE-RISK PROJECTS, AND THUS MOBILISE PRIVATE CAPITAL AT LOWER RATES

## Catalytic capital (development finance institutions, multilateral development banks, donors & philanthropy)

| | Bilateral DFIs | MDBs, climate funds | Donor agencies, vehicles | Philanthropic funders/donors |
|---|---|---|---|---|
| **Mandate/ description** | **Established by one sovereign, implementing that government's foreign development agenda (often aligned with SDGs); for-profit. Focus on infrastructure, energy, education, and sustainability. Particularly interested if project uses a supplier from underlying sovereign.** | **Established by multiple sovereigns, deploying capital for development (e.g., the SDGs), including in areas of 'high' political risk; for-profit. Focus on infrastructure, energy, education, and sustainability.** | **Deploying capital for feasibility studies for pilot projects, R&D, for capacity building for skilled professionals** | **Deploy capital into projects with the aim of achieving societal and/or environmental impact; most have specific goals within this.** |
| **Products** | ▪ **Low-interest debt** (e.g., A/B syndicated)<br>▪ **Guarantees**<br>▪ **Risk insurance** (e.g., FX, payments)<br>▪ Equity<br>▪ Limited grants | ▪ **Low-interest debt** (e.g., A/B syndicated)<br>▪ **Guarantees**<br>▪ **Risk insurance** (e.g., FX, payments)<br>▪ **Technical assistance**<br>▪ Equity<br>▪ Grants | ▪ **Grants**<br>▪ **Purchase guarantees** | ▪ **Grants**<br>▪ Capacity building<br>▪ Technical assistance<br>▪ Risk/first-loss capital (limited)<br>▪ Guarantees (limited) |
| **Typical financing terms** | ▪ **Quantum: <$500mn**<br>▪ **Tenor:** 25+ years<br>▪ **Cost of capital:** low (due to underlying credit quality of the sovereign guaranteeing the financial institution) | ▪ **Quantum: <$500mn**<br>▪ **Tenor:** 25+ years<br>▪ **Cost of capital:** low (due to underlying credit quality of the sovereigns guaranteeing the financial institution) | ▪ **Quantum: <$40mn**<br>▪ **Tenor:** <5 years<br>▪ **Cost of capital**: low | ▪ **Quantum: <$200mn**<br>▪ **Tenor:** n/a (often no return date)<br>▪ **Cost of capital:** zero – very low |
| **Example funders** | KFW<br>DFC<br>CDC Investment works<br>PIDG Private Infrastructure Development Group | African Development Bank<br>African Development Fund<br>Green Climate Fund<br>MIGA Multilateral Investment Guarantee Agency<br>IBRD<br>IFC | **Example:**<br>Federal Ministry for Economic Affairs and Energy ▪ $350mn to support international hydrogen projects for feasibility studies and research projects<br>H2Global ▪ H2 Global designed to cover gaps between lowest sales price offered by exporters and highest purchase prices offered by off-takers | The African Climate Foundation<br>Quadrature Climate Foundation<br>CIFF Children's Investment Fund Foundation<br>The Rockefeller Foundation<br>Bezos Earth Fund |

Sources: EIB; OECD; EBRD; ODI; IFU; CDC Group; Climateworks

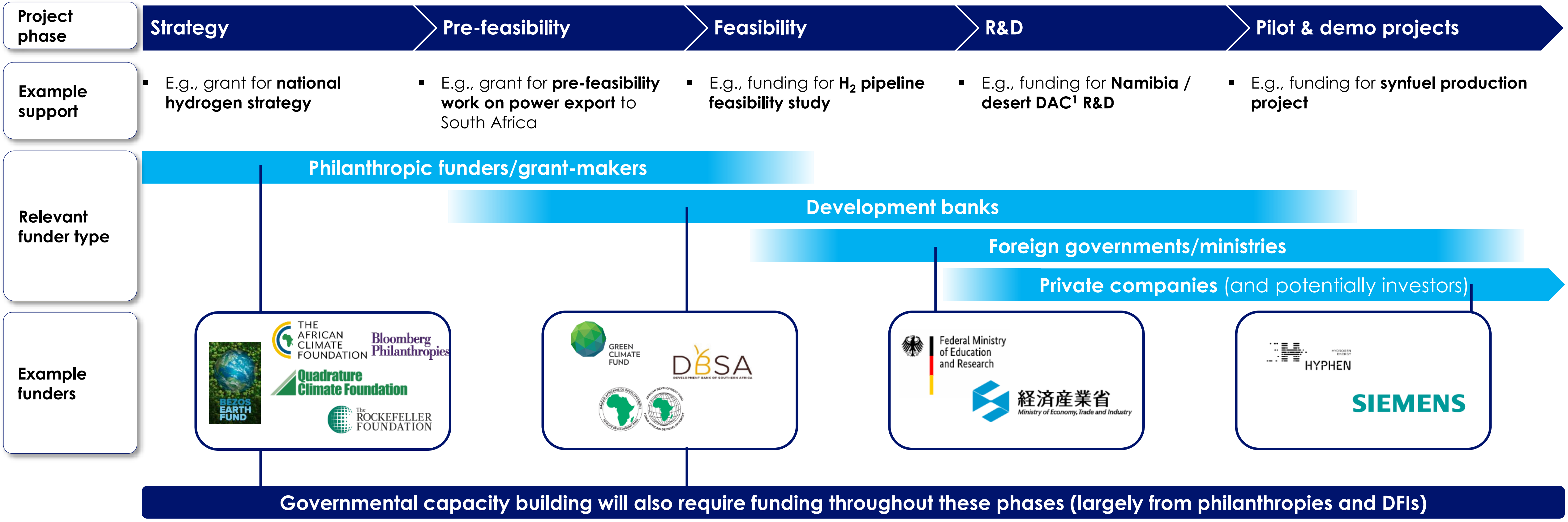
# FINANCING LANDSCAPE – DETAIL (3/3): EXPORT CREDIT AGENCIES IN PARTICULAR CAN PROVIDE SCALE LEVELS OF FINANCING, MAY INFLUENCE SELECTION OF OEM SUPPLIERS

## Value chain partners

| | Export credit agencies (ECAs) | Off-taker support | Vendor finance |
|---|---|---|---|
| **Mandate/ description** | **Supports domestic companies to export goods (typically large-scale) to higher-risk countries. Highly regulated by OECD.** | **Financial support from the principle off-taker(s) to the project sponsor, developer, or operator, which enables faster scaling of project outputs.** | **Financial support from a vendor which enablers the borrower to buy the vendor's product.** |
| **Products** | ▪ **Guarantees**<br>▪ **Risk insurance**<br>▪ **Debt** (senior or subordinated)<br>▪ **Trade finance products** (e.g., working capital finance)<br>▪ Way to support export and/or offtake of the export | ▪ **Guarantees**<br>▪ **Debt** (senior or subordinated)<br>▪ **Equity**<br>▪ Take-or-pay contracts (if also credit-wrapped with insurance, can be securitised and sold to investors)<br>▪ Can offer favourable payment terms to reduce working capital needs | ▪ **Debt** (senior or subordinated) |
| **Typical financing terms** | ▪ **Quantum: <$5bn**<br>▪ **Tenor:** <25 years<br>▪ **Cost of capital:** low – medium (growing desire to guarantee close to 100% of 'green' exports from many countries) | ▪ **Quantum: <$100mn**<br>▪ **Tenor:** <25 years<br>▪ **Cost of capital:** medium | ▪ **Quantum: <$50mn**<br>▪ **Tenor:** <20 years<br>▪ **Cost of capital:** medium to higher (unknown credit risks) |
| **Example funders** | EKF<br>ekn<br>JAPAN BANK FOR INTERNATIONAL COOPERATION<br>中国进出口银行 THE EXPORT-IMPORT BANK OF CHINA<br>Korea Eximbank THE EXPORT-IMPORT BANK OF KOREA | YARA<br>MAERSK<br>HÖEGH AUTOLINERS<br>Eskom<br>AIRBUS | SIEMENS<br>thyssenkrupp<br>nel<br>ABB<br>Vestas |

Sources: eca-watch.org; SEK; EKF; Thomson Reuters Practical Law; Hogan Lovells; Iwoca; Siemens

# FINANCING LANDSCAPE – EARLY STAGE DEVELOPMENT: MIX OF FUNDERS CAN BE ENGAGED IN DIFFERENT STAGES TO LAUNCH INDUSTRY THROUGH EARLY STAGES, BUILD GRN CAPACITY



| **Project phase** | **Strategy** | **Pre-feasibility** | **Feasibility** | **R&D** | **Pilot & demo projects** |
|---|---|---|---|---|---|
| **Example support** | E.g., grant for **national hydrogen strategy** | E.g., grant for **pre-feasibility work on power export** to South Africa | E.g., funding for **$H_2$ pipeline feasibility study** | E.g., funding for **Namibia / desert DAC[1] R&D** | E.g., funding for **synfuel production project** |

**Relevant funder type**

- **Philanthropic funders/grant-makers**
- **Development banks**
- **Foreign governments/ministries**
- **Private companies** (and potentially investors)

**Example funders**

- Bezos Earth Fund; The African Climate Foundation; Bloomberg Philanthropies; Quadrature Climate Foundation; The Rockefeller Foundation
- Green Climate Fund; DBSA Development Bank of Southern Africa; African Development Bank; African Development Fund
- Federal Ministry of Education and Research; 経済産業省 Ministry of Economy, Trade and Industry
- Hyphen Hydrogen Energy; Siemens

**Governmental capacity building will also require funding throughout these phases (largely from philanthropies and DFIs)**

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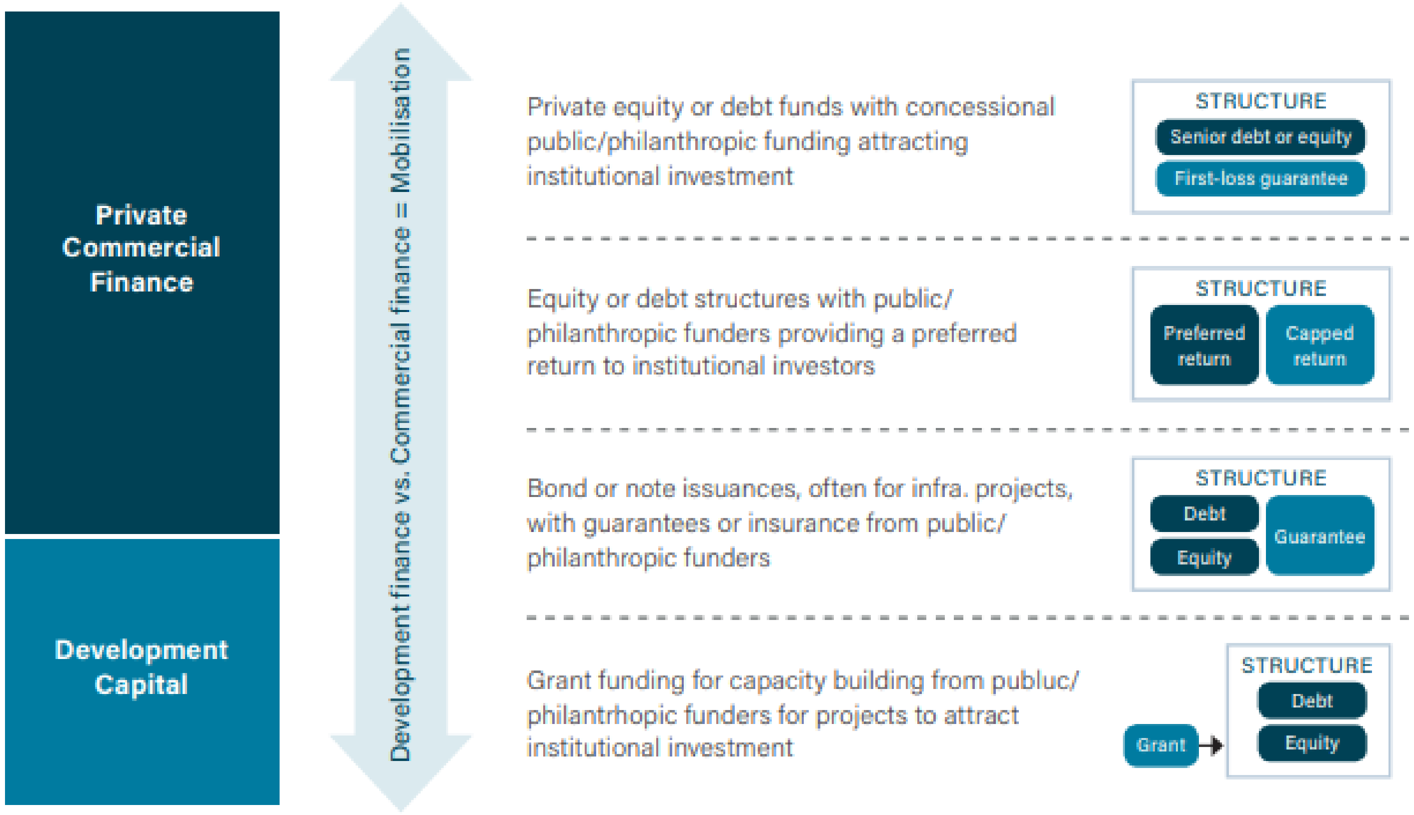
[1] Direct Air Capture – not yet proven in sandy environments (sand clogs up the filters)

# BLENDED FINANCE: GRN CAN ENGAGE DEVELOPMENT CAPITAL PROVIDERS TO DEPLOY MORE CATALYTICALLY TO DE-RISK PROJECTS &LOWER COST OF CAPITAL FROM PRIVATE FINANCE

## Blended finance key points

- Blended finance brings **development capital[1] to de-risk projects** and thus mobilise investment from private capital
- This can help **achieve lower cost of capital** – e.g., lower cost of debt, equity from lower risk investors
- **De-risking mechanisms** include (amongst others):
  - First-loss guarantee
  - Capped return
  - Guarantee or insurance
  - Grant funding (e.g., technical assistance to advance projects)
- **GRN can play an active role, working with lead sponsor (developer) to lock in de-risking & support mechanisms**
  - E.g.: concessional finance, insurance commitments, funding for incentives from DFIs and foreign govts.
  - GRN approaching development capital providers alongside project sponsor adds credibility, can bring weight of Govt-Govt relations to help spur support (e.g., from DFIs)

## Blended finance example structures



Private equity or debt funds with concessional public/philanthropic funding attracting institutional investment

Equity or debt structures with public/ philanthropic funders providing a preferred return to institutional investors

Bond or note issuances, often for infra. projects, with guarantees or insurance from public/ philanthropic funders

Grant funding for capacity building from publuc/ philantrhopic funders for projects to attract institutional investment

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[1] could also include philanthropic capital

Source: Blended Finance Taskforce (2019), *‘Better Finance, Better World’*

# BLENDED FINANCE – EXAMPLES: STRUCTURES BRING TOGETHER MULTIPLE FINANCING PARTIES, EACH PLAYING A ROLE IN DEPLOYING FINANCE AT SCALE WITH COMPETITIVE RATES

October 2020:

- 370MW solar park in Angola
- Developer: **Sun Africa** (USA)
- Construction: **MCA Group** (Portugal) & smaller **Swedish suppliers**
- €560mn debt tranche (18yrs)
  - Lenders: **ING** & **SEK**
  - 100% guaranteed by **EKN**
- €80mn debt tranche (12yrs)
  - Fully funded and covered by Development Bank of Southern Africa (**DBSA**)

February 2021:

- Follow-on financing of same amount, using same financing partners to fund solar build-out

September 2021:

- MoF signed MoU with **Sun Africa** and **AfricaGlobal Schaffer** (USA) for $1.5bn mini-grid project to supply solar electricity and drinking water to southern Angola
  - Funding from **US EximBank**

August 2018:

- 158MW onshore wind farm in Senegal
- Sponsor: **Lekela** (Netherlands)
- EPC: **Vestas** (Denmark) – incl. 20yrs maintenance
- Senegal National Electricity Company (**SENELEC**) has signed a PPA to offtake 100% of generated electricity for 20yrs
- Financing:
  - €140m export loan facility for Vestas from **EKF**
  - US Overseas Private Investment Corporation (**OPIC**) committed $250mn in financing and $70mn in reinsurance
  - Political risk insurer: **MIGA**
  - **USAid** provided grants for early development phase
- $20mn to be invested in the Taiba N'Diaye community through the lifetime of the windfarm

October 2018:

- Dedicated **blended finance** platform to fund projects in Indonesia which will help achieve SDGs
- Over $3bn committed by **32 partners** across public sector, philanthropy, commercial and development banks, funds etc.
- Platform provides four types of finance facilities:
  1. **Development** e.g., grant, TA, research
  2. **De-risking** e.g., concessional loan, first-loss, guarantees, cost-overrun insurance
  3. **Financing** e.g., senior or subordinated loan (fully commercial)
  4. **Equity** (fully commercial)
- Managed by PT SMI – largest infrastructure financing company in Indonesia

Sources: nsenergybusiness.com; txfnews.com; SEK; energycapitalpower.com; renewafrica.biz

# KEY QUESTIONS COVERED

The
**'What'**

1. Export markets
2. Domestic markets
3. Namibia infrastructure design
4. Max. benefit to Nam. economy

The
**'How'**

5. Regulations & incentives
6. Financing
7. **Partnerships**
8. Roadmap

- **Partnership discussions to advance**, across:
  - Off-takers
  - Financing
  - Tech providers
  - Developers

BLENDED FINANCE TASKFORCE

SYSTEMIQ

# PARTNERSHIPS: NAMIBIA SHOULD FOCUS ON PROGRESSING CONVERSATIONS WITH POTENTIAL PARTNERS THROUGH WELL-INFORMED DISCUSSIONS THAT CAN LEAD TO MOBILISING ACTION

| **Group** | **Sub-group** | **Potential Partners** (e.g.) | **Key points to discuss, to move towards action** | |
|---|---|---|---|---|
| **Off-takers** | International ammonia importers | Fertiliser: **Yara, Mosaic, BASF**<br>Shipping: **Maersk, Hoegh Autoliners** | ▪ Namibia as supplier of **globally low-cost green ammonia** (<$400/t NH$_3$) | |
| | Domestic hydrogen | Trucks (mining, haulage): **CGNPC & CNUC[1], Anglo-American**<br>Rail: *Nicholas Holdings' portfolio company* | ▪ Value case of hydrogen solution, e.g., **TCO on trucks**<br>▪ Any **government actions** (e.g., VAT break) that might help instigate switch to hydrogen | |
| | Regional power | **Eskom, SAPP** | ▪ **Scale power export terms:** price, profile (firmness / variability)<br>▪ **Transmission investment** to enable – financing approach | |
| | Regional hydrogen | **Sasol** | ▪ Competitiveness of **Namibia H$_2$ production & transport to SA** for synfuel N. Cape; potential synfuel production in Namibia | |
| **Financing** | Philanthropic capital | **African Climate Foundation, GEAPP[2]** | ▪ Support **early-stage development, blended financing** | |
| | Foreign Governments | **BMZ, H2 Global** (Germany), **DFiD** (UK) | ▪ **Grants & CfDs** to advance Namibia's H$_2$ industry | |
| | Development banks | **KfW** (Germany), **AfDB, DBSA, GCF, WB, CIF** | ▪ Invest into **feasibility stage** & **blended finance** | Potentially as **staple financing** |
| | ECAs | **EKF** (e.g., if Vestas turbines used) | ▪ Attractive terms on project finance | |
| **Tech providers** | Electrolysers | **ThyssenKrupp, Siemens, Nel, McPhy, Bloom Energy, ITM power** | ▪ Possible **multi-year consistent order of electrolysers** (across multiple projects, phases) – to negotiate **very large discount** | |
| | Domestic H$_2$ end-sectors | Mining trucks: **Weichai, Caterpillar** | ▪ Launching **pilots in Namibia** to demonstrate tech with low-cost H$_2$ | |
| **Developers** | RE, H$_2$ & NH$_3$ production | H$_2$: **HYPHEN, Fortescue, H1 Energy**, etc.<br>RE: **Orsted** (off-shore wind), **Enel GP**, etc. | ▪ Potential **strategic PPPs** that build core Namibia H$_2$ industry | |
| | Future downstream value chain | Steel: **Arcelor Mittal, H$_2$ Green Steel** ,etc.<br>Synfuel: **Airbus, SunFire** (German) | ▪ Locating **downstream process** (steel, synfuel production) **in Namibia** – key considerations (e.g., source for iron ore, CO$_2$), potential timelines | |

[1] CGNPC = China General Nuclear Power Company; CNUC = China National Uranium Corporation; [2] GEAPP is the Global Energy Alliance for People and Planet, launched by Rockefeller, IKEA Foundation, Bezos Earth Fund.

# KEY QUESTIONS COVERED

The **'What'**

1. Export markets
2. Domestic markets
3. Namibia infrastructure design
4. Max. benefit to Nam. economy

The **'How'**

5. Regulations & incentives
6. Financing
7. Partnerships
8. **Roadmap**

- **Strategy-on-a-page**
- **Roadmap** through 2020s and into 2030s

# STRATEGY-ON-A-PAGE [INITIAL]: A SET OF CRITICAL INITIATIVES CAN TURN NAMIBIA'S FOUNDATIONAL STRENGTHS INTO TRANSFORMATIONAL ECONOMIC DEVELOPMENT

**Target**

**Namibia as globally leading $H_2$ exporter:**
Lowest-cost green ammonia + other $H_2$-products

| GDP growth | Employment | Energy independence | Trade balance |
|---|---|---|---|
| c.$20bn/yr boost by 2040 | 100,000+ jobs before 2040 | Achieved before 2040 | $6-8bn impact by 2040[2] |

**Critical initiatives**

### Attract **export demand**
- **Long-term off-takes with intent to scale**
- **Ammonia** (to start)
- Eventually, also steel or **H.B.I.**[1], **methanol, synfuels**

### Establish **regional value**
- **Power exports to Eskom / SA** as first priority
- **Hydrogen value chains** (e.g., with Sasol) as secondary priority

### Enable **lowest cost prod'n**
- **Coordinated procurement** for lowest cost electrolysers
- **Blended finance** to help lower WACC

### Attract **investments**
*e.g.:*
- **Secure & stable regulations** (see right)
- **DFI / MDB** support with guarantees (example)

### Drive **R&D pipeline**
- **e.g. ,synfuels production** (incl. biogenic carbon source)
- International & industry **partnerships**

### Kick-start **domestic $H_2$**
*i.e.:*
- **Long-haul trucks** with HRS (mine ←→ port routes)
- **Mining trucks**
- **Rail**
- **Fertiliser**

### Build **skills & capacity**
*e.g.:*
- NGHRI
- Apprenticeships in JVs
- Partnerships with overseas educational programmes

### Implement **enabling regs.**
*e.g.,*
- Guarantee of origin
- Safety standards
- Electricity market rules
- Tax incentives

**Foundational strengths**

Secondary strengths: **investment environment –** stable & improving; **geographic position** for exports & regional synergies with S. Africa

Primary strengths: Globally leading **solar & wind resource**; available **land near water**

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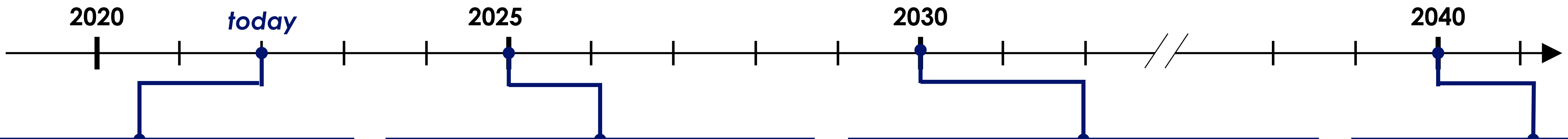
[1] HBI = Hot Briquetted Iron, a form of semi-refined iron ore that uses hydrogen as a reducing agent in the production process. Does not require nearly the extent of expertise as is required for steel manufacturing. [2] Coarse estimate of incremental impact on Namibia's annual balance of accounts for ammonia and power export revenues less imports/foreign expenditures (CapEx, OpEx, financing costs).

# ROADMAP: ESTABLISH AS RELEVANT PLAYER IN 2020s, TO DE-RISK SCALE-UP IN 2030s



- Global market: pilots, **early instances of commercial scale**
- Namibia production: first large-scale **project progressed into feasibility & negotiation** with selected bidder (HYPHEN)
- Namibia strategic partnerships: establish further partnerships, **scope agreements & begin work,** e.g., suppliers, regional value chain, off-takers, financing.
- Namibia capacity: entities & working groups established and **begin implementing to set foundations of $H_2$ industry**, e.g.:
  - E.g.: enabling regulations, financing solutions, Masterplan for Tsau // Khaeb National Park, R&D roadmap

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- Global market: beginning to establish with **2+ Mt $H_2$** [1]
- Namibia production: 1+ project(s) **in-construction**, and **further projects** (1+) under evaluation pre-FID.
- Namibia strategic partnerships: **active contractual engagements underway** with partners across the ecosystem.
- Namibia capacity: **$H_2$ industry foundations set**, increasingly skilled & knowledgeable **workforce established, being deployed and scaling up**
  - Further, institutional capacity built up
  - **R&D and pilot projects** well underway (e.g., synfuels, HBI[3])

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- Global market: in midst of scaling up at pace, with **c.30+ Mt $H_2$** [1]
- Namibia production: **0.5 – 1+ Mt $H_2$,** achieving **c.$400/t $NH_3$** Delivered by **2+ scale projects in operation**, further pre-FID.
  - **Regional links** operating, notably power export to S.A.
  - **Backbone infrastructure** for industry scale-up in place.
  - First scale projects in operation for **other products,** e.g.: synfuels, HBI[3]
  - **Domestic market** also being served across 2+ sectors[2].
- Namibia strategic partnerships: **implementing scale-up** with select key partners, building **new partnerships** as industry matures.
- Namibia capacity: **high-skilled workforce**; mature institutions

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- Global market: fully mature, at **c.250Mt $H_2$**[1], steady growth
- Namibia production: **4+ Mt $H_2$**, achieving **<$350/t $NH_3$**; as many as **10+ large-scale projects** across Namibia
  - **10+ GW power export** to region, mostly to S. Africa
  - **Regional $H_2$ links** incl. pipeline to S. Africa
  - Multiple end-products at scale, e.g.: **synfuels, HBI[3]**
  - **Namibia energy independence**
- Namibia strategic partnerships: at scale, thriving, expanding to **new industries**
- Namibia capacity: capable **National $H_2$ Co.** [TBD]

[1] in target sectors: green ammonia & methanol, e-fuels for shipping & aviation, green steel; [2] e.g., long-haul trucking and mining trucks;
[3] HBI: Hot Briquetted iron

# Thank you