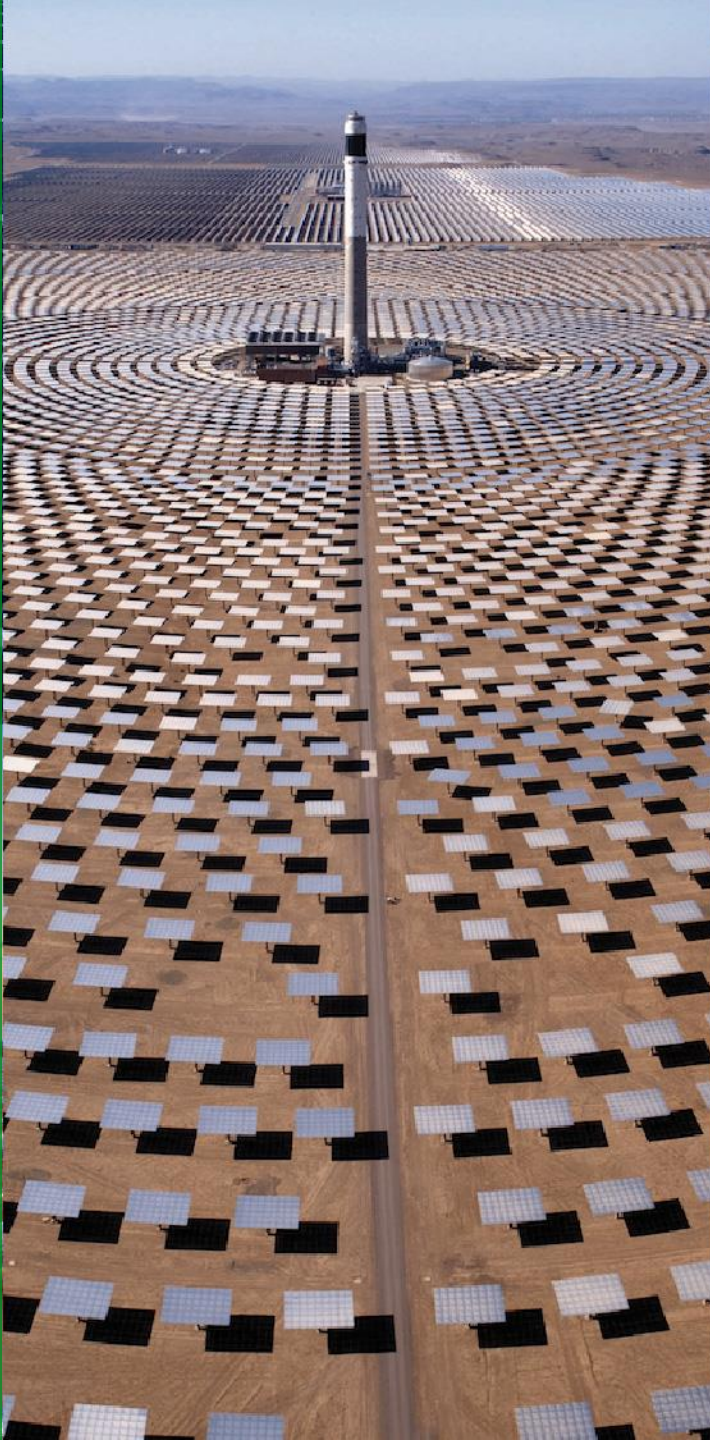


# Energy Transition and Tomorrow's Fuel - Green Hydrogen



Paddy Padmanathan  
Vice Chairman & CEO, ACWA Power



# Renewable Energy & Green Hydrogen are both now a compelling value proposition



In many parts of the world, electricity generated using solar & wind resources locally available:

- is cheaper than fossil fuel generated energy , for that amount of electricity we use when the resource is available
- Cost of that generated electricity is fixed over decades of time horizon
- Less of a drain on foreign currency
- And emits no carbon day in day out during operational life



But a huge Achilles heel of electricity;

- we are simply not yet able to store electrons at scale and for long duration,
- nor can electricity efficiently generate very high temperatures needed for many industrial processes
- nor can electricity be a catalyzer for some of the industrial processes.



**But Hydrogen molecule can serve all those needs**

and with lower cost renewable energy generated electricity (in certain geographies)  
**the electrolysis process can be used to generate hydrogen without emitting carbon**

# The Cost - Renewables and Green H<sub>2</sub> are good for the Economy and Energy Independence



**Renewables** – Predictable and fixed prices until end of the plant life. Tariffs refers to lowest tariffs in certain regions with good resource and financing conditions;

- Solar photovoltaic: in the range of **1.5 to 3.0 USDc/kWh**;
- Wind On-shore: in the range of **2.5 to 3.5 USDc/kWh**;
- Wind Off-shore: in the range of **6.5 – 7.5 USDc/kWh**;
- Dispatchable Solar (24/7): in the range of **6.0 – 7.0 USDc/kWh**;
- BESS (up to 4 hours): in the range of **5.0 to 6.5 USDc/kWh**



**Fossil fuel** – Subject to variable price of fuel (tariff below based on average gas and coal prices with cost of fuel included);

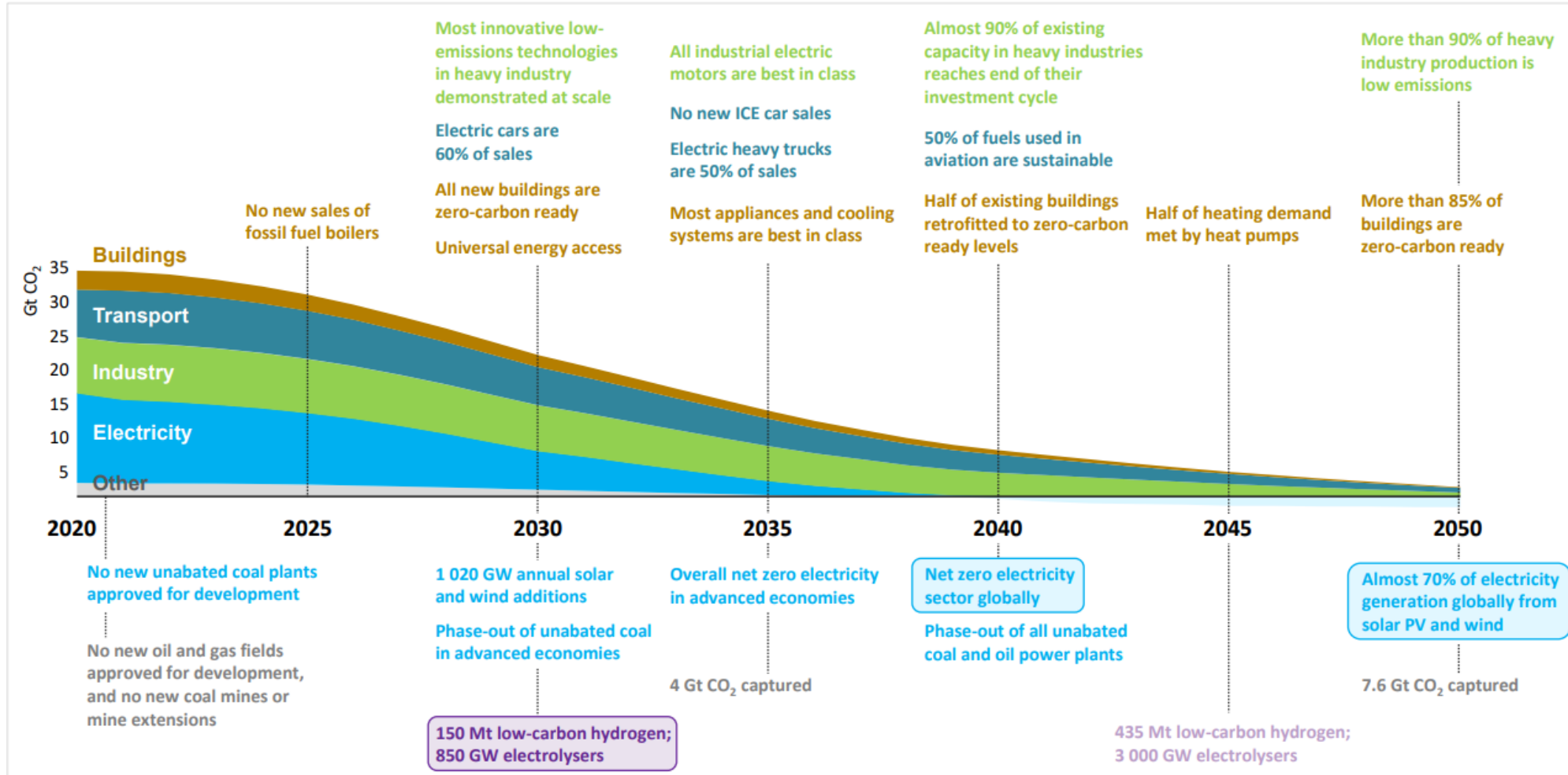
- CCGT: in the range of **7 to 11 USDc/kWh**;
- Coal: in the range of **3.5 to 6.0 USDc/kWh**;
- Oil fired: over **10 USDc/kWh**.

What about **Green Hydrogen** ?

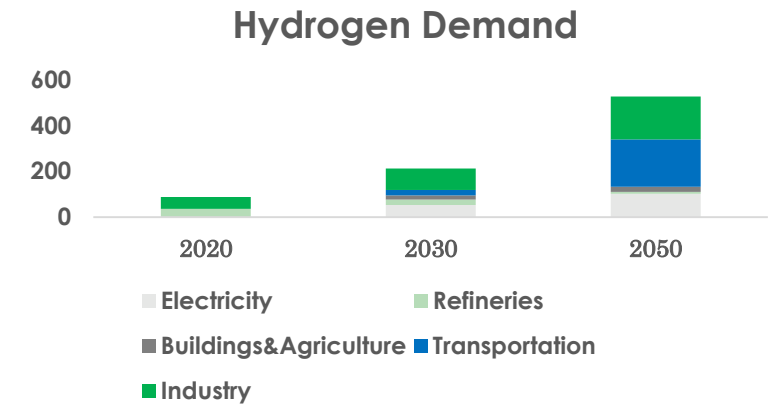
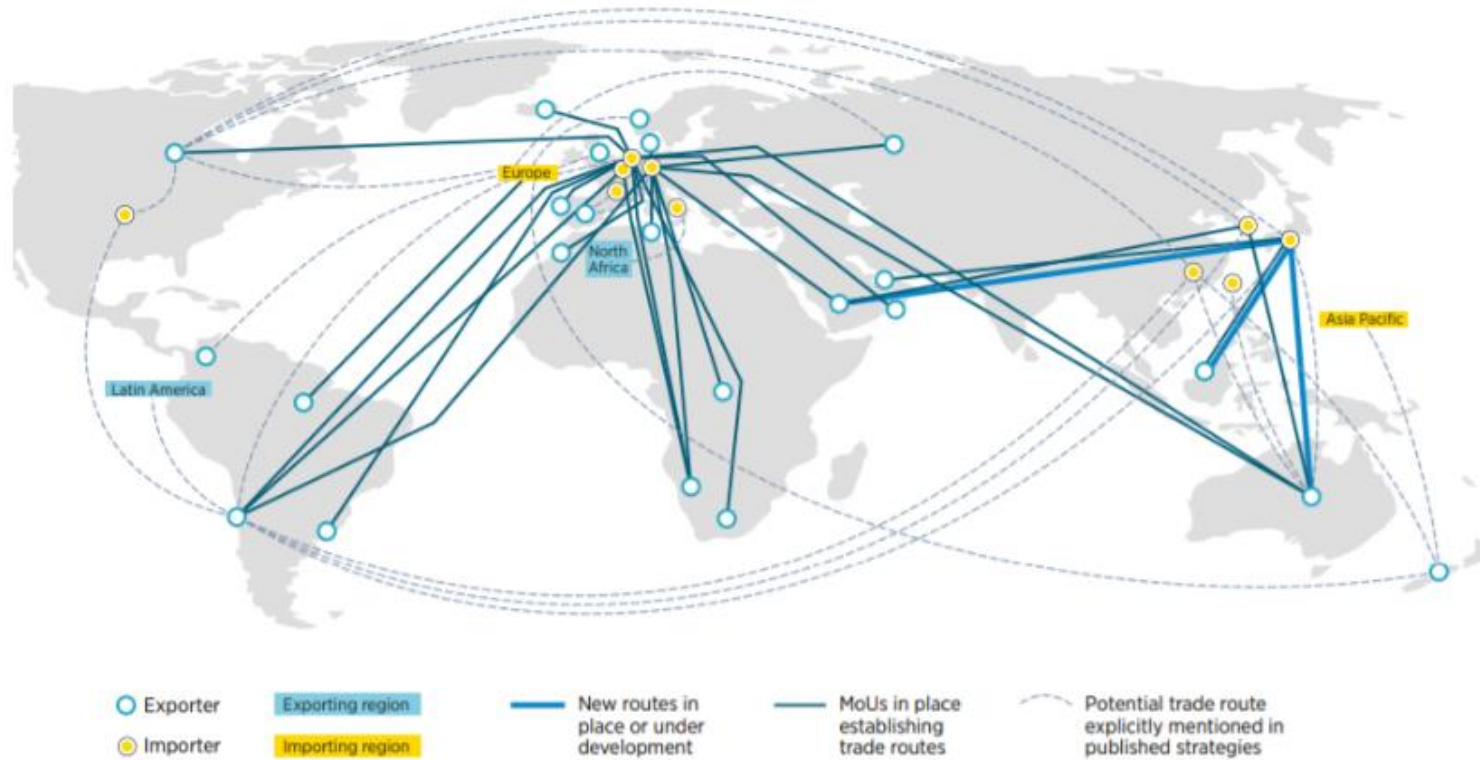


- 2000: more than 1,000 USD/MWh;
- 2015: approx, 800 USD/MWh;
- **2022: less than 100 USD/MWh**;
- **2030: 50 USD/MWh or approx. 2 USD/kg** (parity with Oil at average price)
- **2035: 25 USD/MWh or approx. 1 USD/kg** (parity with Gas at average price)

# Path to Net Zero



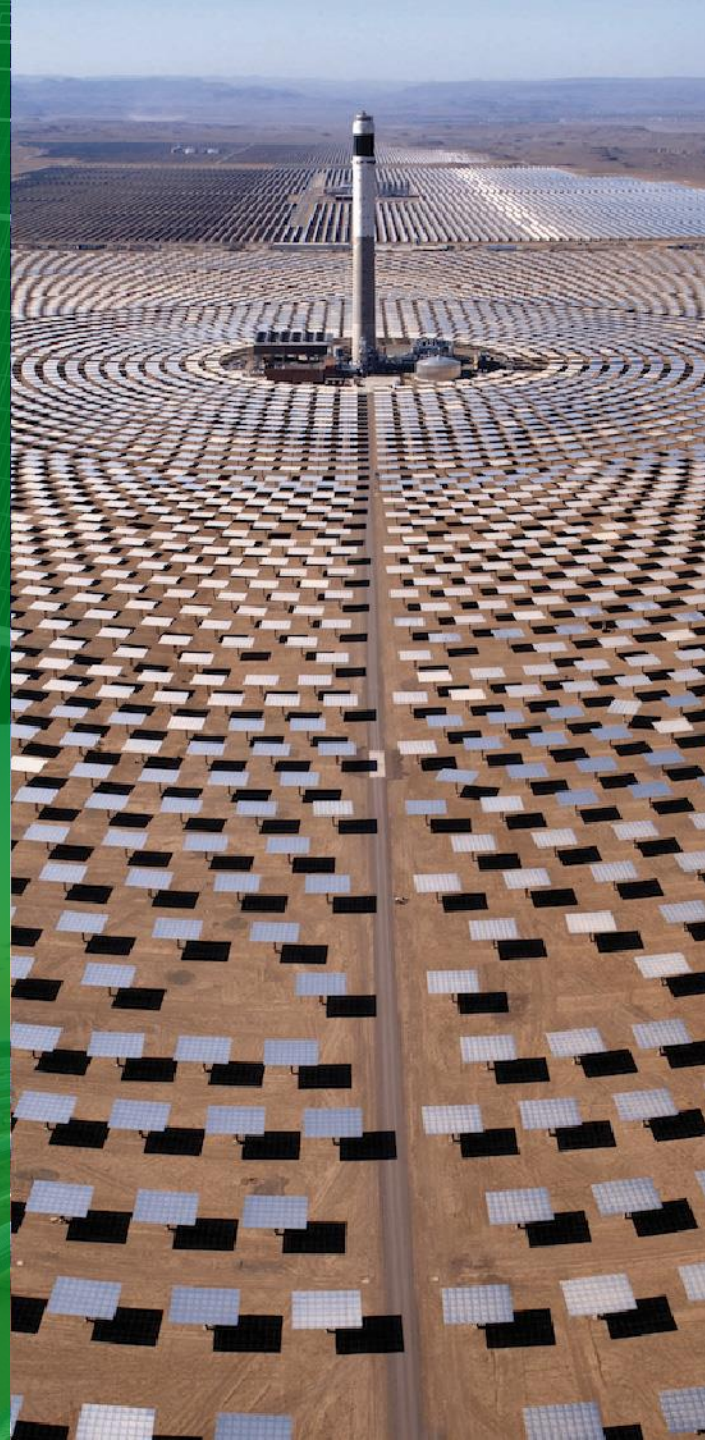
# Hydrogen has a clear market for the future with clear demand already in the present



**Best global locations for hydrogen production at scale for high volume export**

# ACWA Power

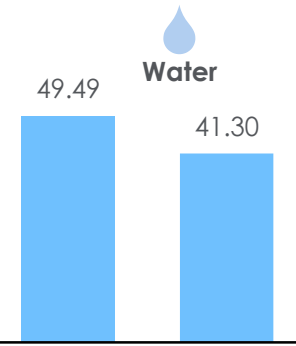
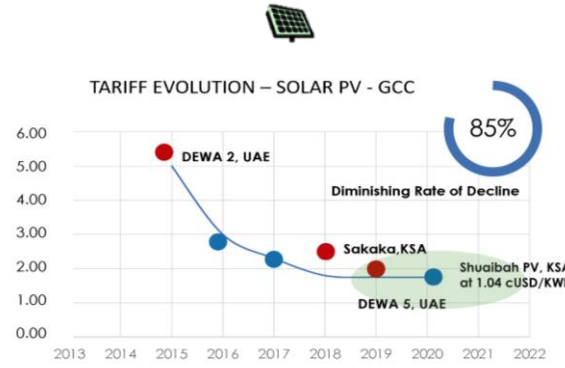
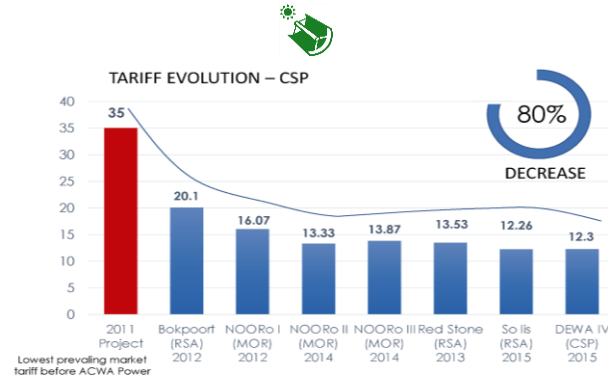
Based on our experience and value we have created in Renewable Energy we have ventured into producing Green Hydrogen at scale



# ACWA Power - History of challenging cost, reducing tariff in renewable energy and desalinated water production



**Tariff**  
(USDc/kWh for power assets and USDc per m<sup>3</sup> for water assets)

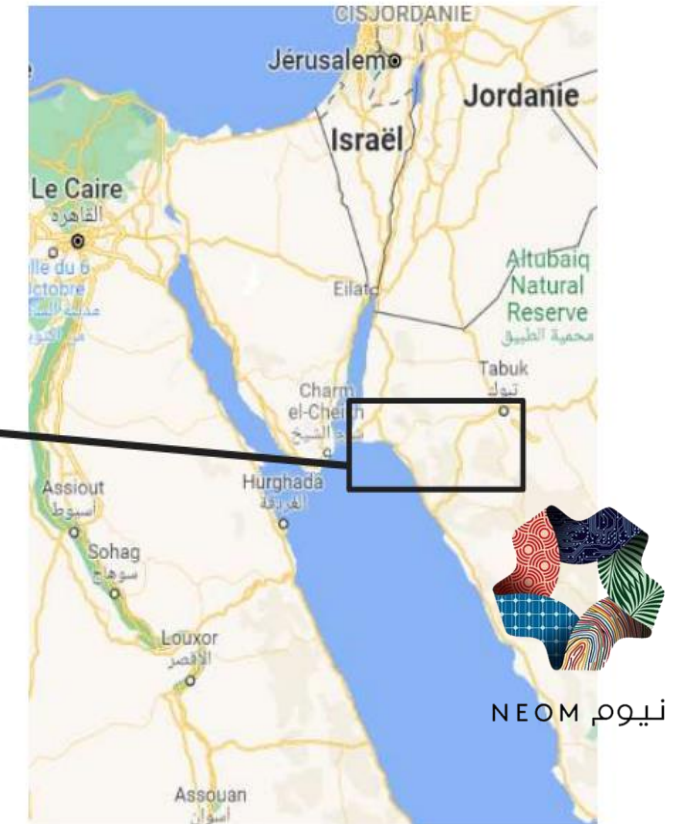


Bid Year	2012	2014	2014	2017	2015	2018	2019	2020	2018	2019
Asset	NOORo I CSP IPP	NOORo II CSP IPP	NOORo III CSP IPP	Noor Energy 1 IPP	Shuaa Energy PV IPP	Kom Ombo PV	DEWA V PV	Shuaibah Solar PV IPP	Taweelah IWP	Jubail 3A IWPP
Country										
Capacity	160MW	200MW	150MW	950MW <sup>(1)</sup>	200MW	200MW	900MW	600MW	909k m <sup>3</sup> / day	600k m <sup>3</sup> / day
Notable Achievement(s)	World's largest CSP operating complex			World's lowest CSP tariff World's CSP single site plant under development	Formerly the world's lowest solar PV tariff	Lowest solar tariff in the African continent	Achieved world's lowest power tariff at DEWA V PV (at the time)	World's lowest solar PV tariff	World's lowest water tariff at the time Partially solar powered	World's lowest water tariff at the time

Source: Company information. Note: (1) 950MW solar hybrid project (700MW CSP and 250 MW PV).

# NEOM Green Hydrogen Project Solar & Wind energy with Electrolyzers

Project locations three main sites (Wind / Solar / Green Hydrogen) for a total land allocation of close to 380 km<sup>2</sup>, connected via 210 km of rights of way for the overhead transmission lines

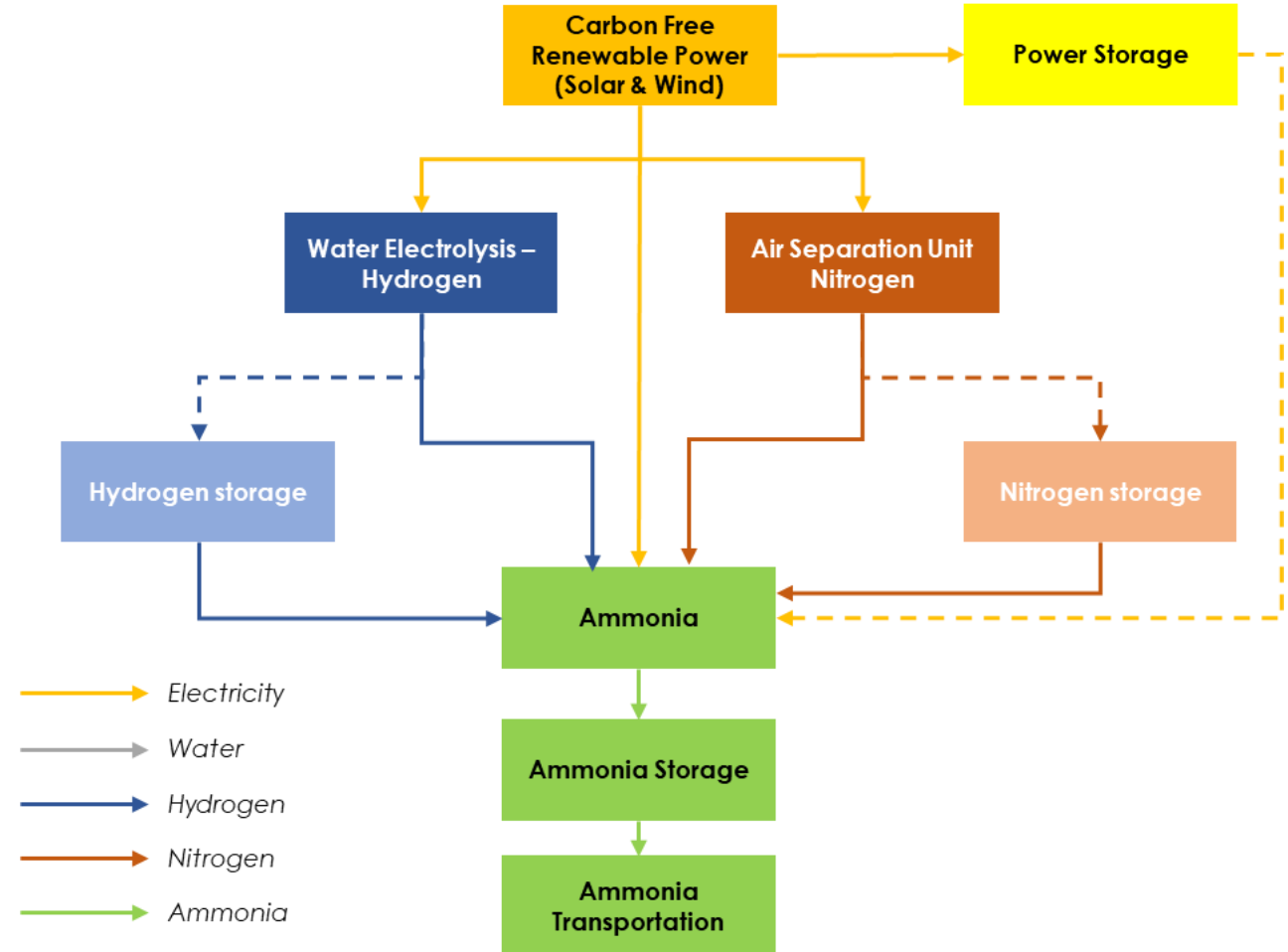




# NEOM Project Configuration – Large Utility Scale



Value chain step	Design Capacity & Outputs
<b>Average NH3 Capacity</b>	<b>Up to 1.2 Million tons/a (240,000 tons/year green Hydrogen)</b>
<b>Solar Capacity</b>	Over 2.5 GWac
<b>Wind Capacity</b>	Over 1.5 GW
<b>Energy storage</b>	300 MWh Battery storage
<b>Transmission system</b>	Internal grid Connection to main grid
<b>Hydrogen electrolysis</b>	Over 2 GW of TK Electrolyzers
<b>Hydrogen storage</b>	Pressurized storage capacity
<b>Air Separation (N<sub>2</sub>) + Ammonia Loop</b>	World class ammonia synthesis loop using Haber Bosch process

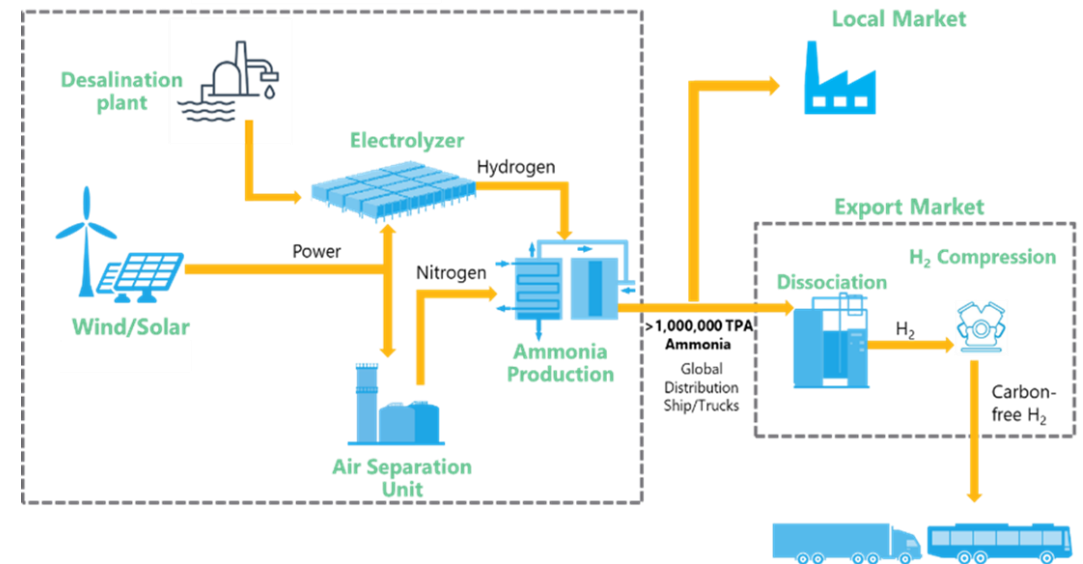


# Oman Green Hydrogen Project Dhofar Governate

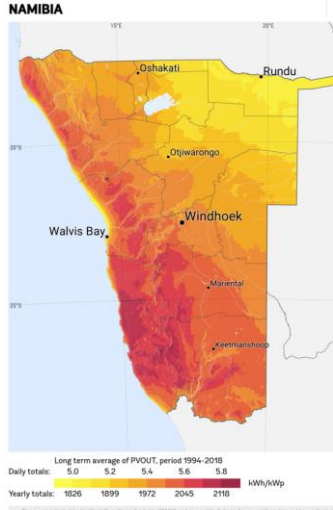


<b>Project Stage</b>	<b>Design</b>
<b>Production levels</b>	<b>Green Ammonia: 1.0 Million tons/a</b>
<b>Commercial Operation</b>	Y-2028
<b>Solar &amp; Wind Capacity</b>	3.5 GW scale combined profile (1.5GW Wind; 2 GW solar)
<b>Energy storage</b>	Battery storage to manage the intermittency on base load processes
<b>Transmission system</b>	Internal grid / Connection to main grid
<b>Seawater desalination</b>	Commercial scale SWRO 100% powered by renewables
<b>Hydrogen electrolysis</b>	For H2 production powered 100% by renewables
<b>Air Separation (N2) + Ammonia Loop</b>	Production of Ammonia from H2 to bypass limitations of transport and storage

**Investors: ACWA Power; Air Products; OQ**  
**Off-take: Air Products + OQ**



# Namibia Value Proposition to deliver GH2 at scale



- Competitive renewable electricity is a key ingredient to produce competitive green hydrogen (electricity represents 65-70% of the total cost of production)
- Excellent Solar and wind resources
- Land in abundance
- Stable governance and an unblemished track record of honoring contracts
- While Namibia itself is a small market, the region based on mining, minerals and metals and industrial capacity of South Africa, is a significant market
- With a long coast on the Atlantic Ocean, good access to a major emerging market for green hydrogen; Europe.
- Reasonably good construction and industrial capacity in the neighborhood.
- Opportunity for Namibia is to
- Accelerate to implement a green economy in country
- Become a production center to export energy to the region and further afield
- Grow industrial capacity to become a green goods manufacturer utilizing Namibia's other mineral and natural resources.



Je vous remercie Danke obrigado  
Дякую  
Asante **рақмет сізге**  
Teşekkürler **شكراً**  
謝謝 நன்றி  
rahmat təşəkkürlər mihi koe  
धन्यवाद **Thank you**  
Terima kasih Ngiyabonga Tak  
Спасибо