A perspective Energy Transition

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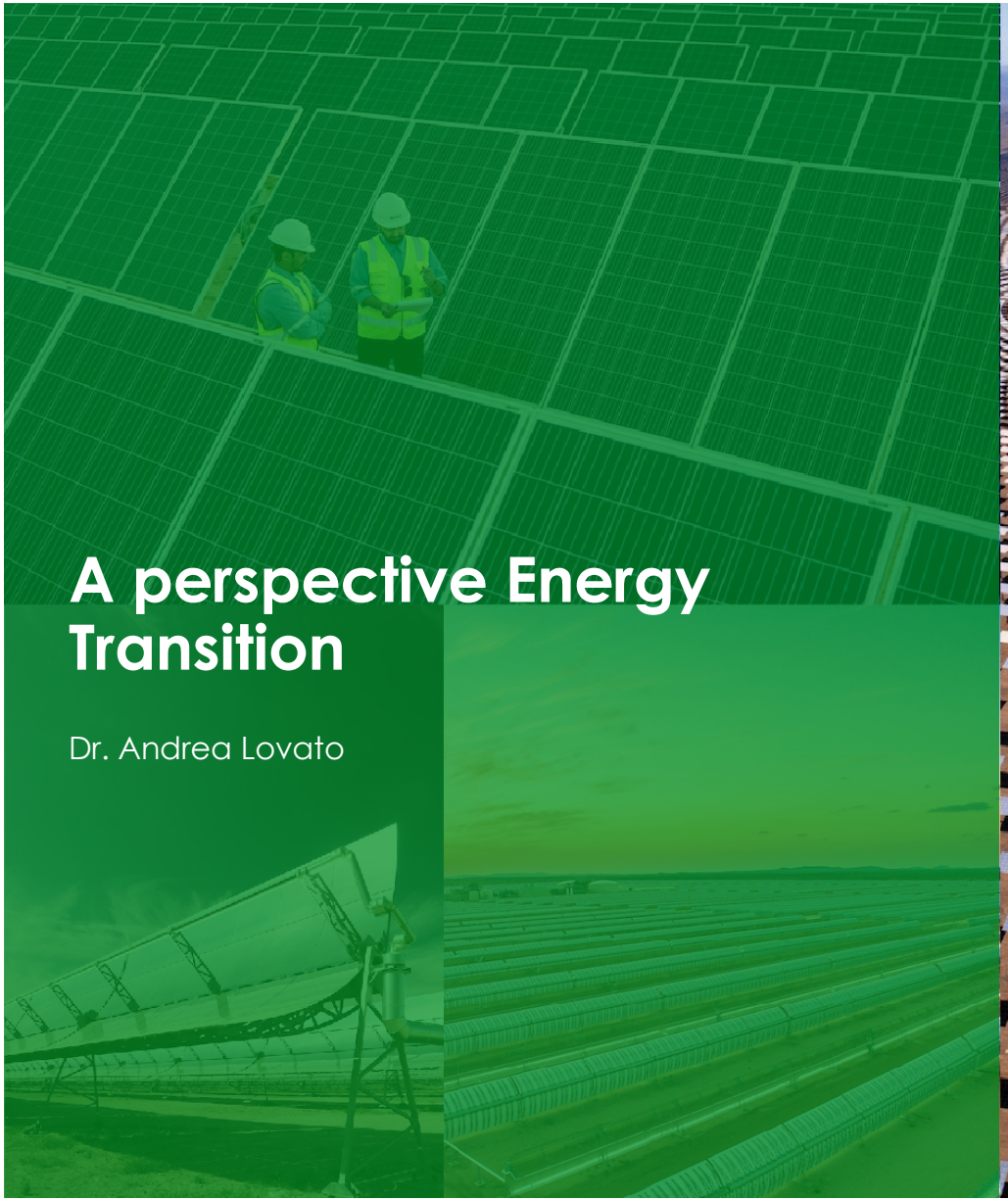
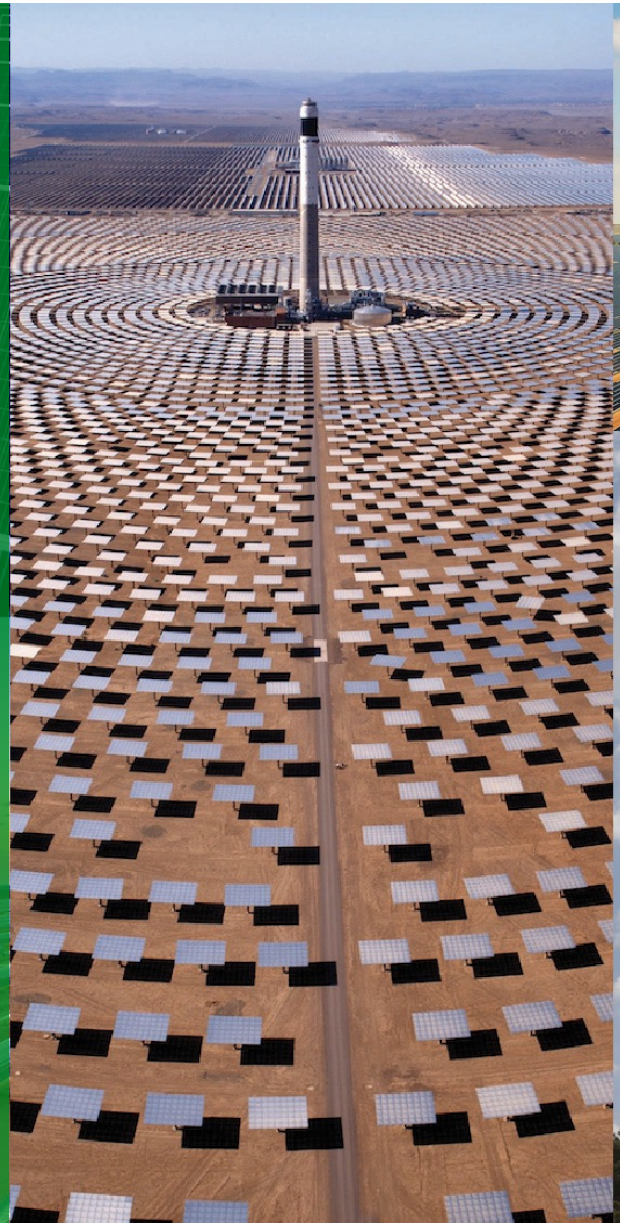




Real Events !

- Glacier of Forni, Italian Alps (Valtellina)

- Mogens North in South Greenland

Where are we and where we will go ?

Targets:

- Long-term temperature goal keeping the rise in mean global temperature to **well below 2** °C (3.6 °F) above pre-industrial levels, and **preferably** limit the increase to +**1.5** °C (2.7 °F).
- Emissions should be reduced as soon as possible and **reach net-zero by 2050**.
- $CO_{2\ and\ Other\ greenhouse\ gases}$ Emissions: **30** Gtons/a 2020 → **21.1** Gtons/a 2030 (?) → **0.0 NetZero** Gtons/a 2050 (?)
- Total generation: **26,800** TWh (approx. 22% renewable) (2021)
- Hydrogen: **70** Mton/a (practically all gray)

What does this mean to sustain Net-zero (*EIA data*):	**2030**	**2050**
➢ Renewable: yearly additional Capacity (Wind / Solar)	≈15,000 TWh (50%)	≈ 45,000 TWh (90%)
➢ Investment:	≈ 260.- BUSD/a	≈ 800.- BUSD/a
➢ Green Hydrogen:	≈ 150 Mtons/a	≈ 470 Mtons/a
➢ New electrolyzers capacity	≈ 850 GW	≈ 2,600 GW
➢ Investment:	≈ 165 BUSD/a	≈ 800 BUSD/a
➢ H2 Co-firing in Power (% capacity):	up to 6% (2035)	*(?)*
➢ Low carbon shipping (% of capacity):	up to *50%* (2035)	*100% (?)*
➢ Low carbon aviation (% of capacity):	up to *50%* (2040)	*(?)*
➢ *Forestation*		
➢ *EV transportation*		
➢ *others means*		

Good News - Renewables and Green H_2 are good for the Economy and Energy Indipendece

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

- Solar photovoltaic: in the range of **1.1** to **2.1 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 USDc/KWH**;
- Dispatchable Solar (24/7): in the range of **7.1 USDc/KWH**;
- *BESS (up to 4 hours)*: in the range of **5** to **6 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**.

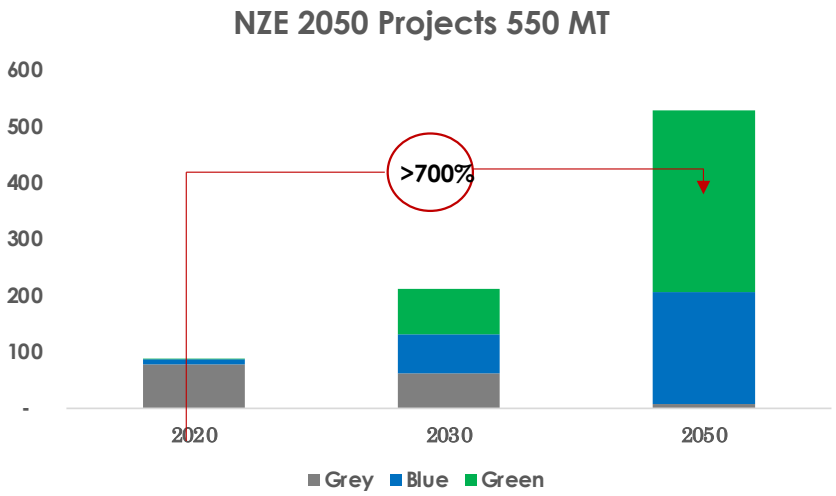
What about ***Green Hydrogen*** *?*

- 2000: 1,000 USD/MWH;
- 2015: 250 USD/MWH;
- **2021: 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)*

(*) @ best applicable conditions of resources, land availability and financing costs

Establishing balance between Demand and Supply for Green Hydrogen is Catch 22



850 GW of electrolyzers required by 2030 (IEA NZE-2030)

To date, the current pipeline of projects suggest that only 5-8 Mt of electrolytic hydrogen shall be met by 2030 Vs target of 80Mt.

- Uncertainty Factors:
  - Parity Price
    - Fossil fuels
    - Electrification
  - Readiness
    - Technology Readiness
    - Infrastructure Readiness
    - Policy and Regulation Readiness
    - Supply chain
  - Volumes
    - Supply &
    - Demand side

Where are we with Green Hydrogen ?

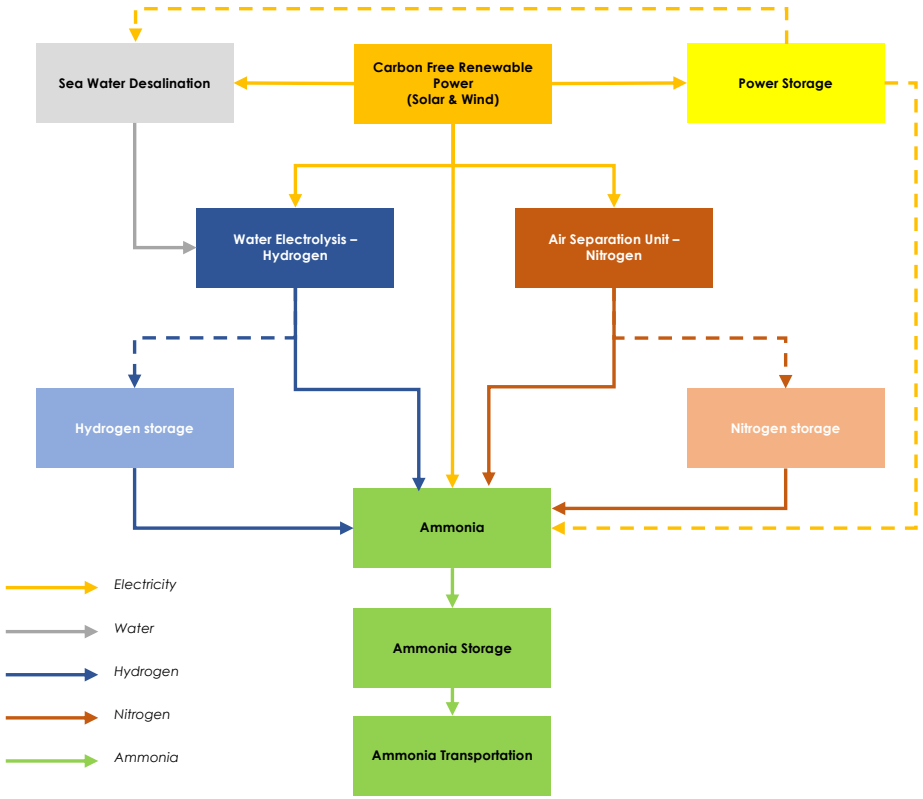
		Off-take potential in terms of volume, price, readiness	Price competitiveness	Readiness	Volume
Industry	Existing large market for hydrogen especially ammonia and methanol Limited decarbonization alternatives aside from green H2 and CCUS	Ammonia (Fertilizer)			
		Methanol (Chemicals)			
		Steel (DRI)			
Transport	Rapidly developing especially for heavy transpiration. Tough competition for Light vehicles from BEV. Infrastructure required for FCEV For shipping and aviation, limited options for decarbonizations.	Synthetic Fuels (Aviation)			
		Heavy Duty Vehicles			
		Shipping			
Heating and refining	Heating is an emerging market in EU targeting industries which require NG for heating at higher temperatures (glass). Refining sector – NG shall have major role, followed by blue and to limited extent green hydrogen	Heating (Blending in gas grid)			
		Refining (Green hydrogen is deemed limited up to 5MT by 2030)			

Less favourable — More favourable

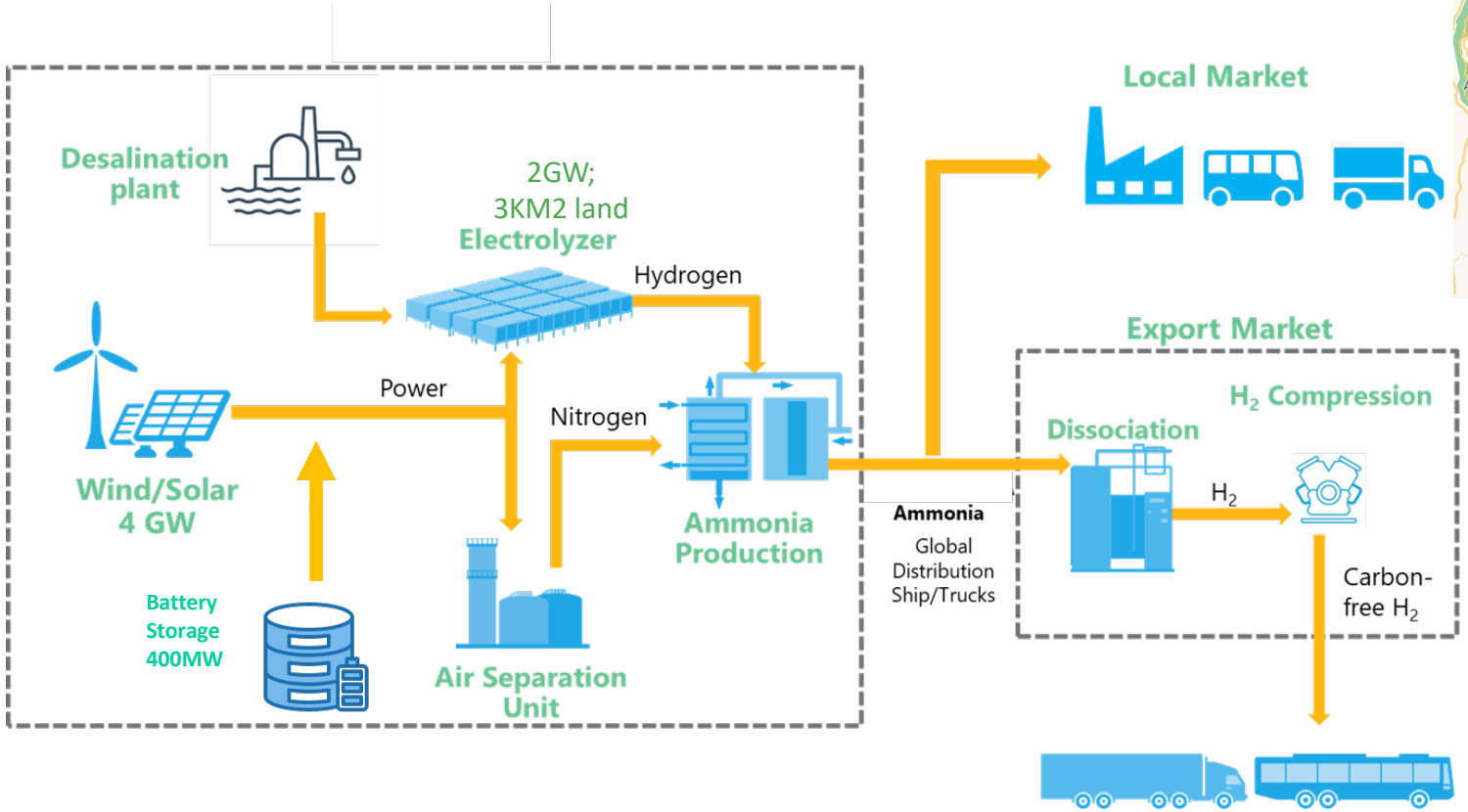
GW Scale Green Ammonia Production – NEOM Green Hydrogen Project

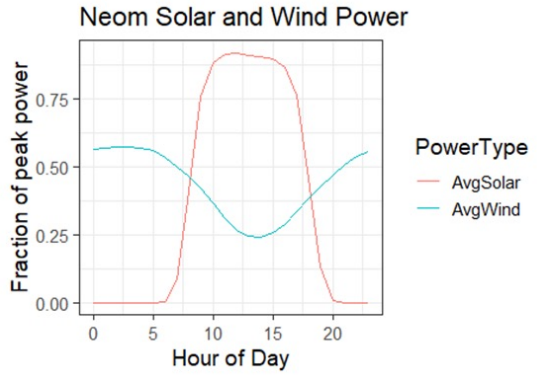
ACWA Power, in cooperation with partners, has studied the possibility to produce green ammonia at commercial scale, exclusively from renewable energy sources, in a pristine location for combined wind and solar.

Value chain step	Design Capacity & Outputs
Solar & Wind Capacity	Approx. 4 GW
Energy storage	Battery storage to manage the intermittency on base load processes
Transmission system	Internal grid / Connection to main grid
Seawater desalination	Commercial scale plant powered by renewables
Hydrogen storage	Couple of hours of pressurized storage capacity in underground pipelines
Air Separation (N_2) + Ammonia Loop	1.25 Mtpa



NEOM Green Hydrogen Project – Block Diagram snapshot





Project area: ~650 km^2


Je vous remercie
Danke
Дякую
Asante
рақмет сізге
Teşekkürler
謝謝
நன்றி
شكراً
ありがとうございました
감사합니다
obrigado
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Спасибо
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Thank you
Terima kasih
Ngiyabonga
Tak
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