

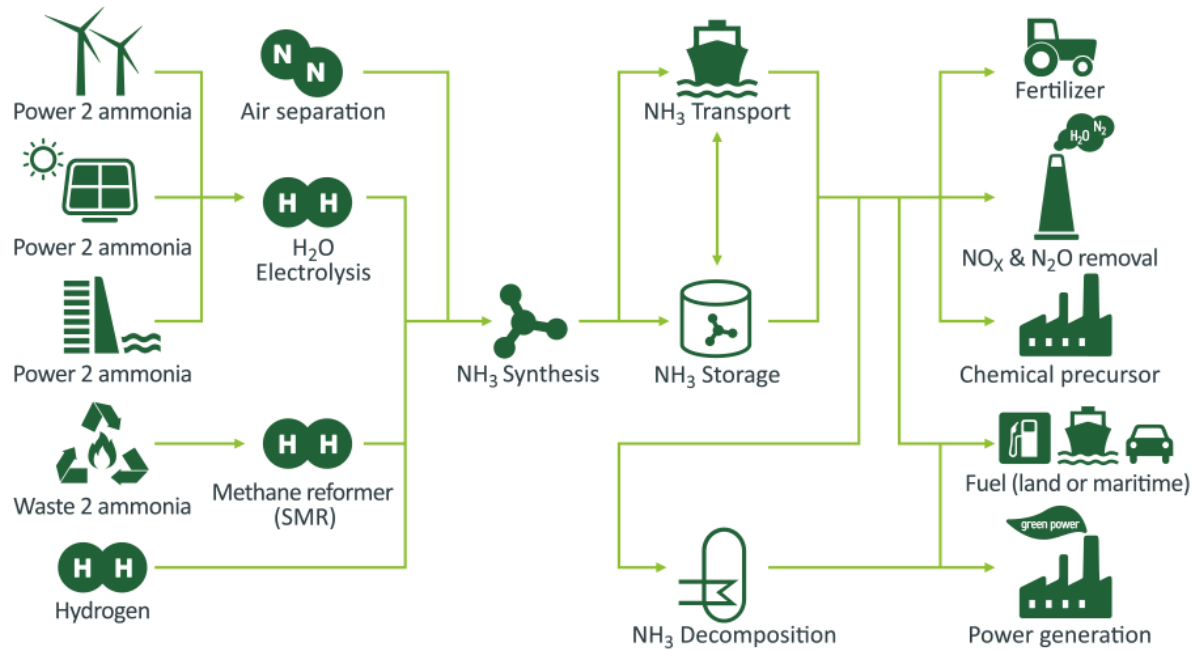


Solid Oxides

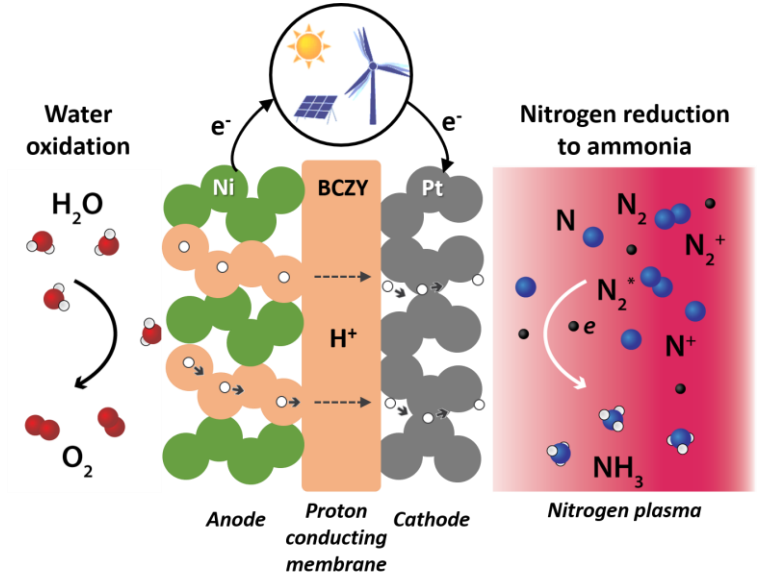
The Importance of a Resilient Supply Chain for Scaling Up SOEC and SOFC Technologies.

AEA Annual Conference - Atlanta - Nov 2023

Green Ammonia/Ammonia Cracking – Some Pathways



[Ammonia production - Proton Ventures](#)

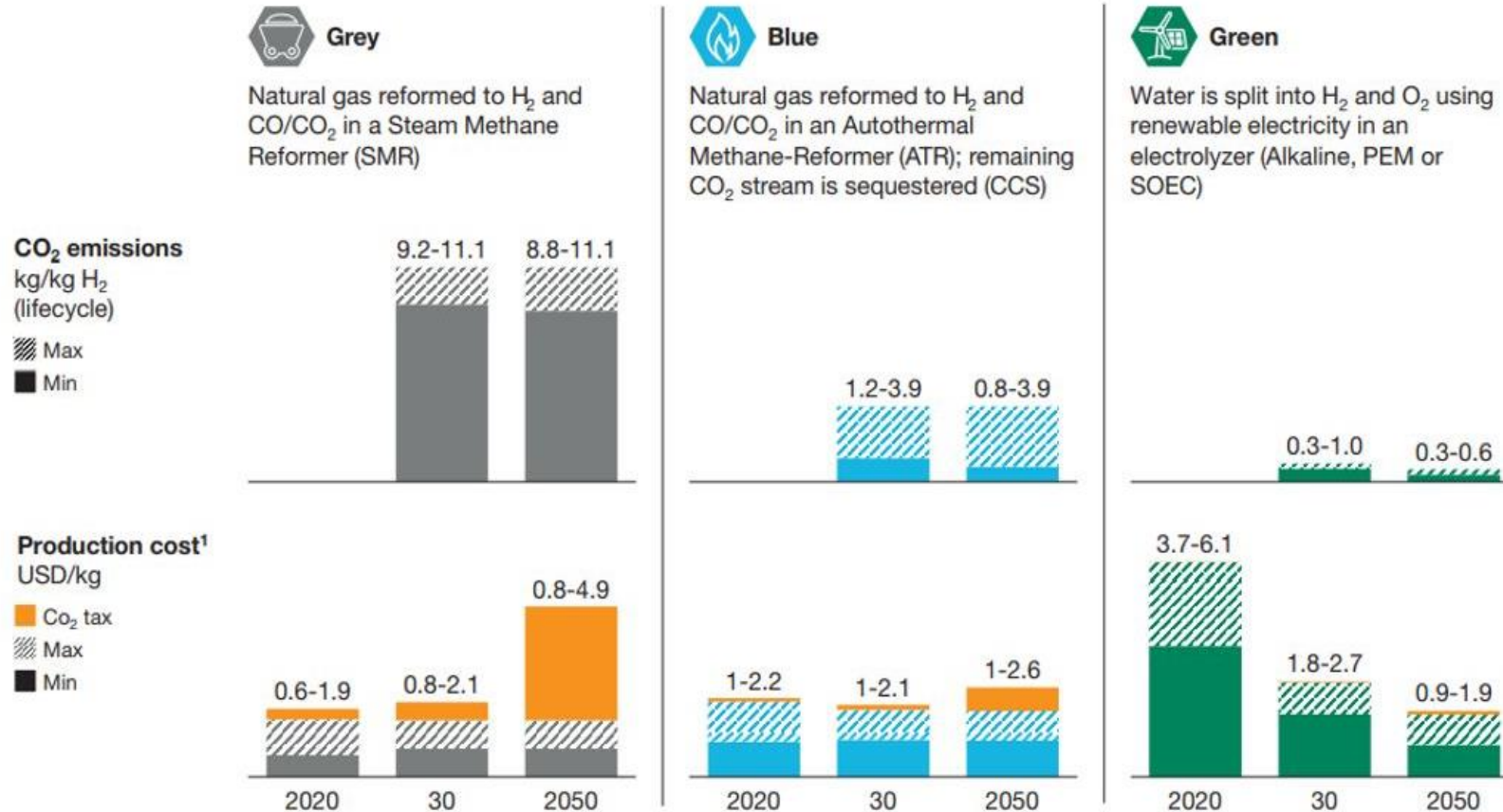


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BCZY is the abbreviation of BaCe_{0.2}Zr_{0.7}Y_{0.1}O_{3-δ}

Some Technologies in the Ammonia Value Chain based on Solid Oxide Materials and Components

Projection on cost of Hydrogen based on CO₂ intensity* * The Hydrogen Council



¹ Costs for hydrogen produced in new installations; Assuming CO₂ tax of USD 28/ton in 2020, USD 48/ton in 2030, USD 300/ton in 2050, excluding vectorization/transport
Source: LBST; Hydrogen Council – Path to Cost Competitiveness; McKinsey

Green Hydrogen Production Will Require Efficient, Reliable, Scalable and Low-Cost Technology

Electrolysers Demand (Net Zero Scenario)

* IEA 2023

Milestones	2022	2030	2035	2050
Low-emissions hydrogen production (Mt H ₂)	1	70	150	420
From low-emissions electricity	0	51	116	327
From fossil fuels with CCUS	1	18	34	89
Cumulative installed electrolysis capacity (GW electric input)	1	590	1 340	3 300

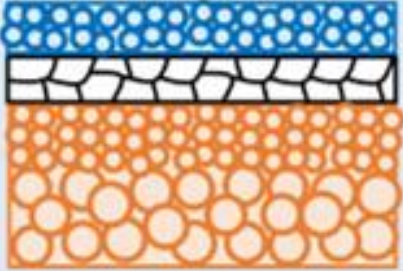
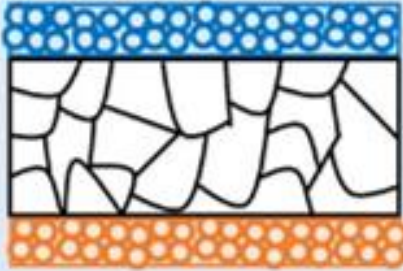
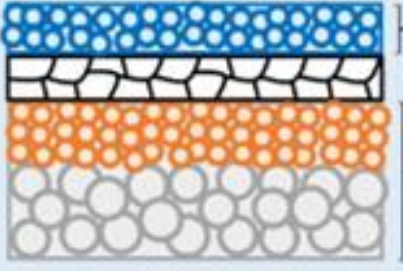
- **SOEC catching up very quickly with PEM and alkaline, overtaking beyond 2030:**
 - **Highest Efficiency**
 - **Scalable,**
 - **Robust/ Resilient/Reliable**
 - **Competitive**
 - **Most compatible with Decarbonizing Energy Intensive Industries (e.g. Ammonia...)**
 - **Integrates (Waste) Heat**

Year	Alkaline (MW)	PEM (MW)	Other/unknown (MW)	Total (MW)
2019	164	80	13	257
2020	197	108	14	319
2021	354	147	58	559
2022	404	217	66	687
2023e	1152	921	811	2884

Predominantly
SOEC

Fuel and Electrolysis Cells – Solid Oxide Make Up

Source: Carlos Bernuy-Lopez

SOLID OXIDE FUEL AND ELECTROLYSIS CELLS (SOFC/SOEC)					
Operation temperature		650-800 °C	750-850 °C	550-700 °C	
Ceramic cell types		Fuel electrode supported	Electrolyte supported	Metal supported	
	O ₂ -electrode Electrolyte Fuel electrode Support				10-20 μm 10-20 μm 80-200 μm
Raw materials	O ₂ -electrode	(La,Sr)(Co,Fe)O _{3-δ} LaCoO _{3-δ} (La,Sr)MnO _{3-δ} (La,Sr)(Cr,Mn)O _{3-δ}			
	Electrolyte	ScY-ZrO ₂	Y-ZrO ₂	Gd-CeO ₂	
	Fuel electrode	Ni-YSZ, Ni-CGO (La,Ca)(Ni,Ti)O _{3-δ} Sr ₂ MgMoO _{6-δ}			
	Interconnect	Coated ferritic stainless steel			

Rare Earths (Ce, La, Gd...) and Zr based Mixed oxides + Transition Metals (Co, Ni, etc..)

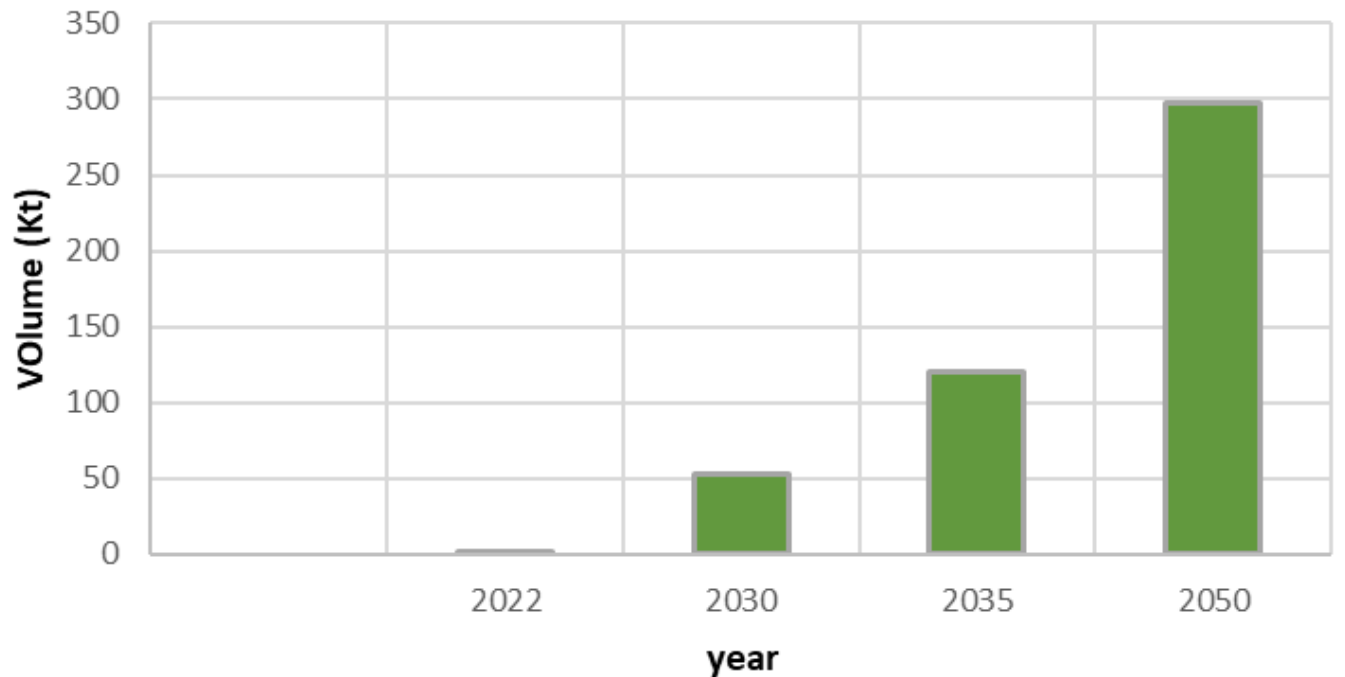
Solid Oxides - Potential Demand (Net Zero Scenario)

Milestones <small>* IEA 2023</small>	2022	2030	2035	2050
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Assumptions :

- ~30% of Green H2 Production via SOEC
- ~ 300 kg Solid Oxides/MW SOEC installed

Potential Cumulative Demand in Solid Oxide



Solid Oxide - Road Map to Commercialisation

Considerations

- Raw Material
- Refining – Expertise/Capacity
- Solid Oxides Production
- Recycling

Challenges

- Sourcing
- Diversity
- Expertise
- Scalability
- Capacity
- Silos

Opportunity

Create a smart Solid Oxides Supply Chain, Resilient and Sustainable

- Partners data exchange
- Collaboration in Innovation
- Forecasting
- Procurement and Inventory planning
- End-to-end supply chain visibility
- Transparency and Orchestration

Lynas and Relevance to Solid Oxide Roadmap to Commercialisation

- An Australian company listed on the ASX
- Operating in both Australia and Malaysia for over 10 years
- Ethical and environmentally responsible producer of rare earth materials
- World's only significant producer of separated rare earth materials outside of China



- Expertise in Solid Oxide Formulation, Synthesis and Characterization (Rare Earths and Zr based materials)
- **Unique Capability to produce a variety of Solid Oxides, from Mining to End Products**
- Deep understanding of relevant raw material markets
- Expanding Refining and Manufacturing Capabilities
- Ability to respond to fast moving situations
- **Willingness to Collaborate with the Industry To establish a Diverse, Sustainable and Resilient Supply Chain**

Questions ?

