Green Hydrogen as an Option for Island Micro-Grids

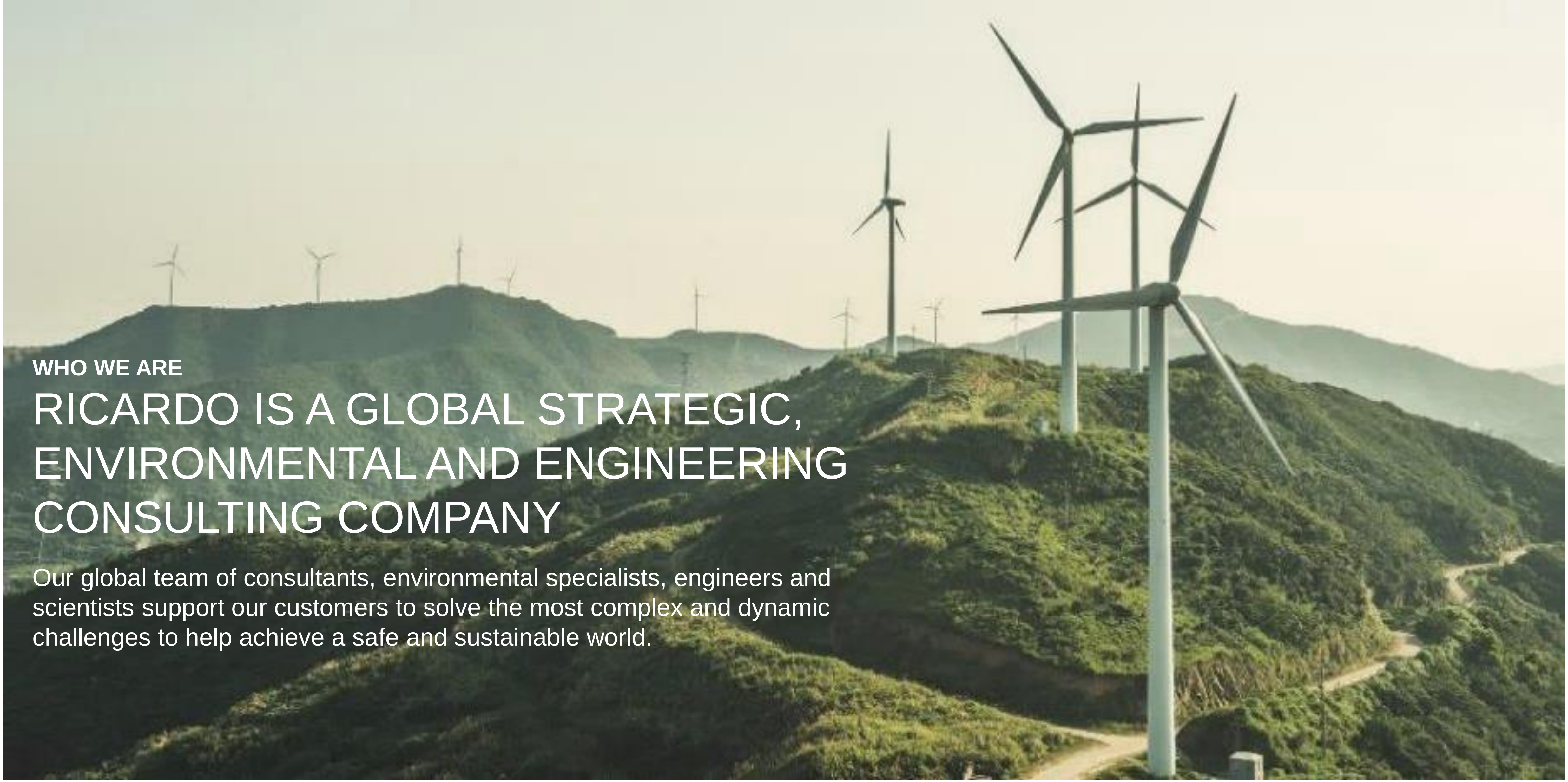
ACEF 2023 Spotlight Session

Green Hydrogen – its development, status and prospects

---

15 June 2023, 2:00-5:30 PM
Asian Development Bank, Philippines

Dr Romeo Pacudan
Technical Director
Ricardo Clean Energy & Environmental Solutions
United Kingdom



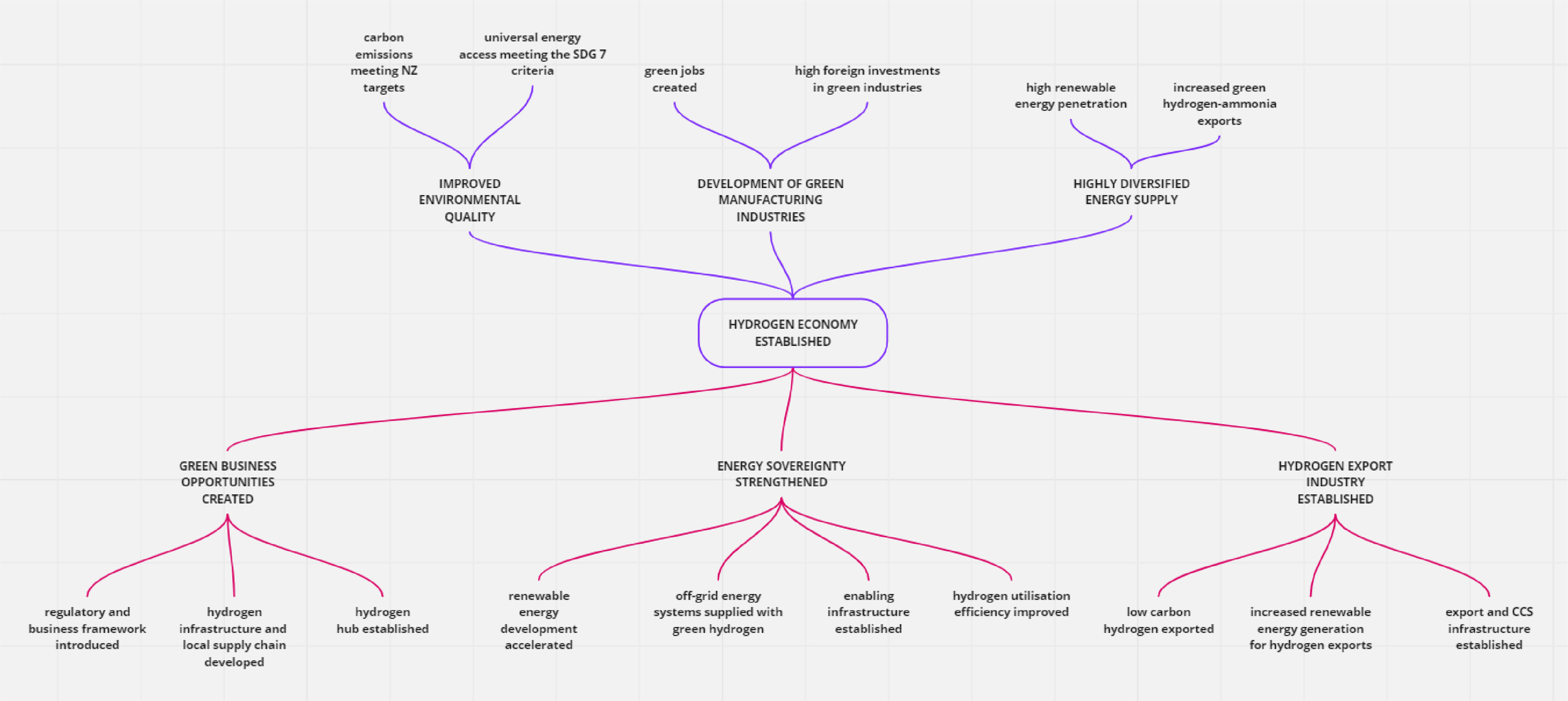
WHO WE ARE

RICARDO IS A GLOBAL STRATEGIC, ENVIRONMENTAL AND ENGINEERING CONSULTING COMPANY

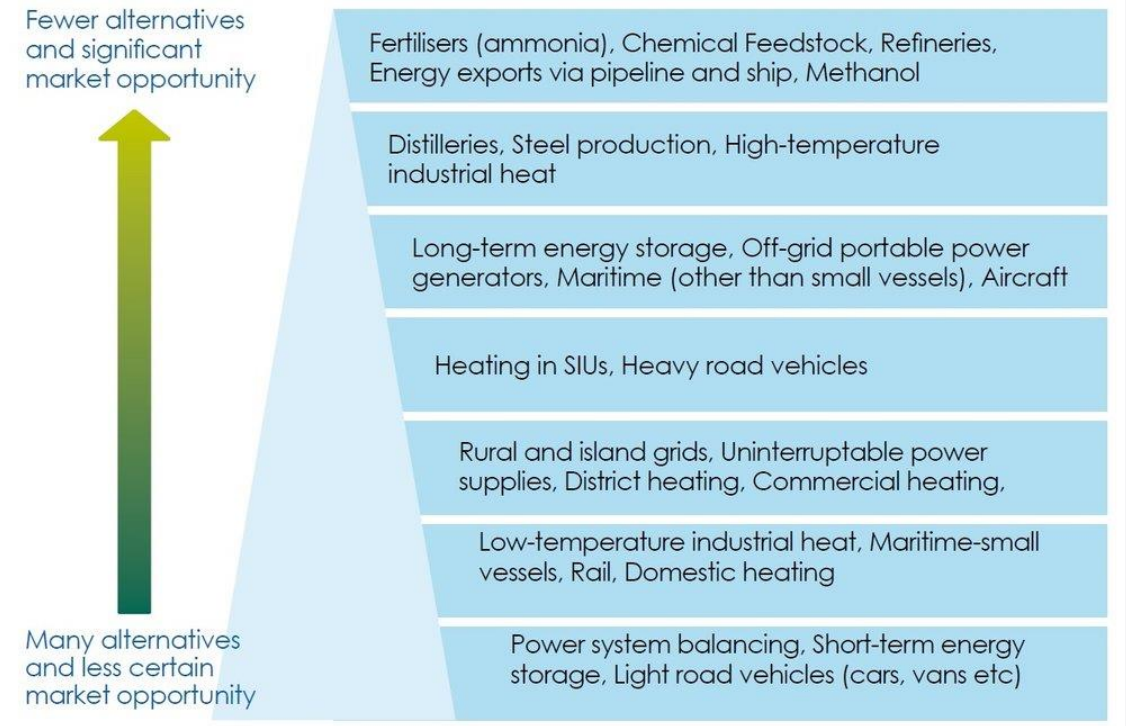
Our global team of consultants, environmental specialists, engineers and scientists support our customers to solve the most complex and dynamic challenges to help achieve a safe and sustainable world.

Supporting National Hydrogen Strategy Preparation in Asia: key insights

Key Hydrogen Insights



Hydrogen Hierarchy



Source: Scottish Hydrogen Action Plan, 2022

Need for molecules in addition to green electrons — Figure 7

Green molecules needed?	Industry	Transport	Power sector	Buildings
No-regret	· Reaction agents (DRI steel) · Feedstock (ammonia, chemicals)	· Long-haul aviation · Maritime shipping	· Renewable energy back-up depending on wind and solar share and seasonal demand structure	· Heating grids (residual heat load *)
Controversial	· High-temperature heat	· Trucks and buses ** · Short-haul aviation and shipping · Trains ***	· Absolute size of need given other flexibility and storage options	
Bad idea	· Low-temperature heat	· Cars · Light-duty vehicles		· Building-level heating

* After using renewable energy, ambient and waste heat as much as possible. Especially relevant for large existing district heating systems with high flow temperatures. Note that according to the UNFCCC Common Reporting Format, district heating is classified as being part of the power sector.

** Series production currently more advanced on electric than on hydrogen for heavy duty vehicles and buses. Hydrogen heavy duty to be deployed at this point in time only in locations with synergies (ports, industry clusters).

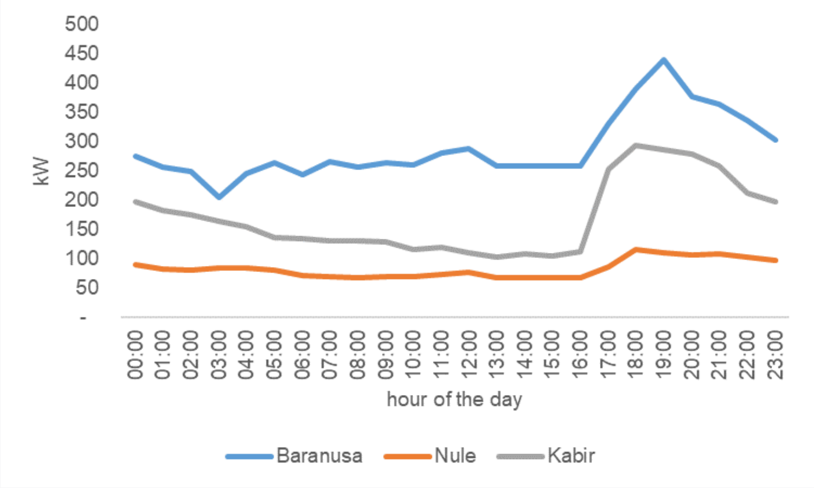
*** Depending on distance, frequency and energy supply options

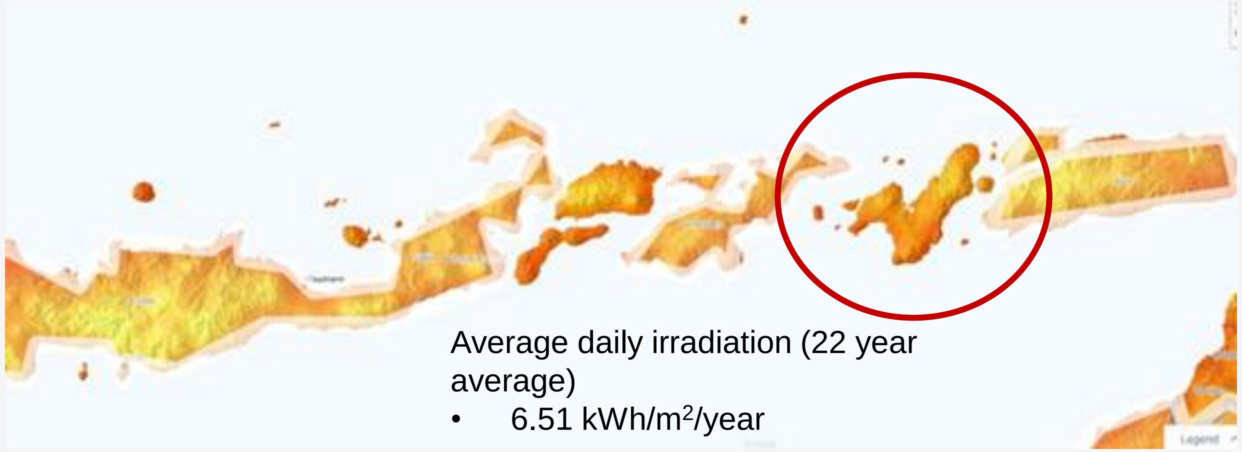
Agora Energiewende and Agora Industry (2021)

Source: Agora Energiewende and Agora Industry (2021)

Hydrogen as an Option for Island Micro-Grids

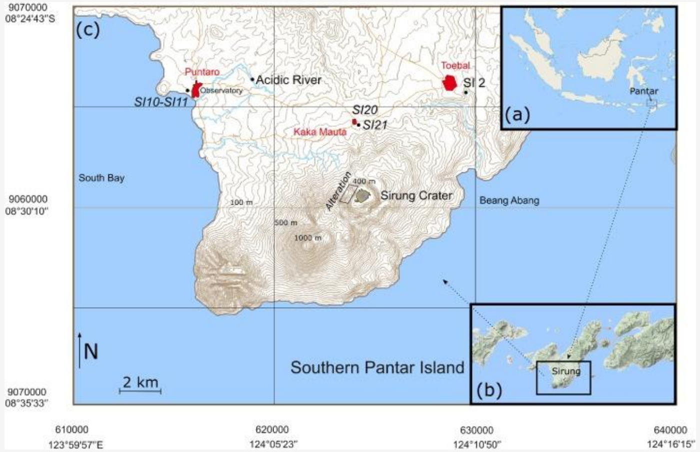
Case Sites mainly supplied with Diesel Generators





Average daily irradiation (22 year average)

- 6.51 kWh/m²/year



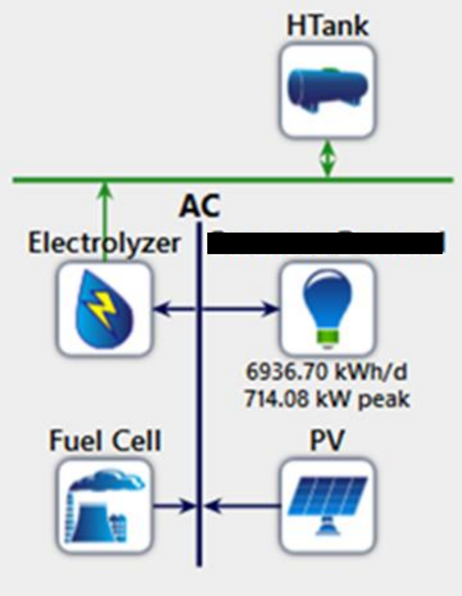
Geothermal Resource Potential:

- ~152 MW

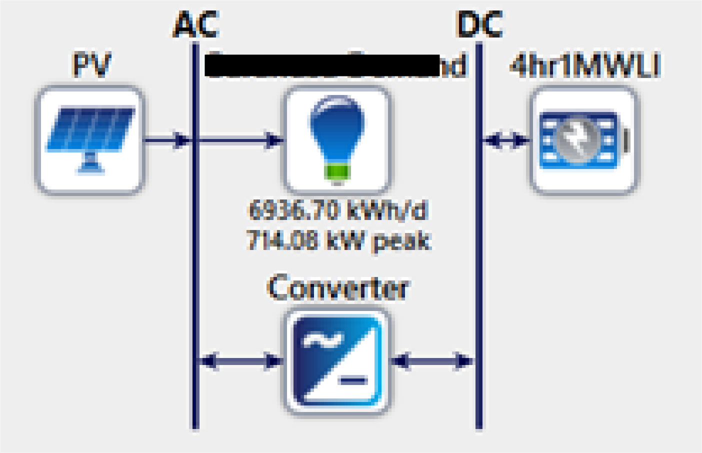
RICARDO

Alternatives for Diesel Replacement
Least-Cost Optimisation Analysis

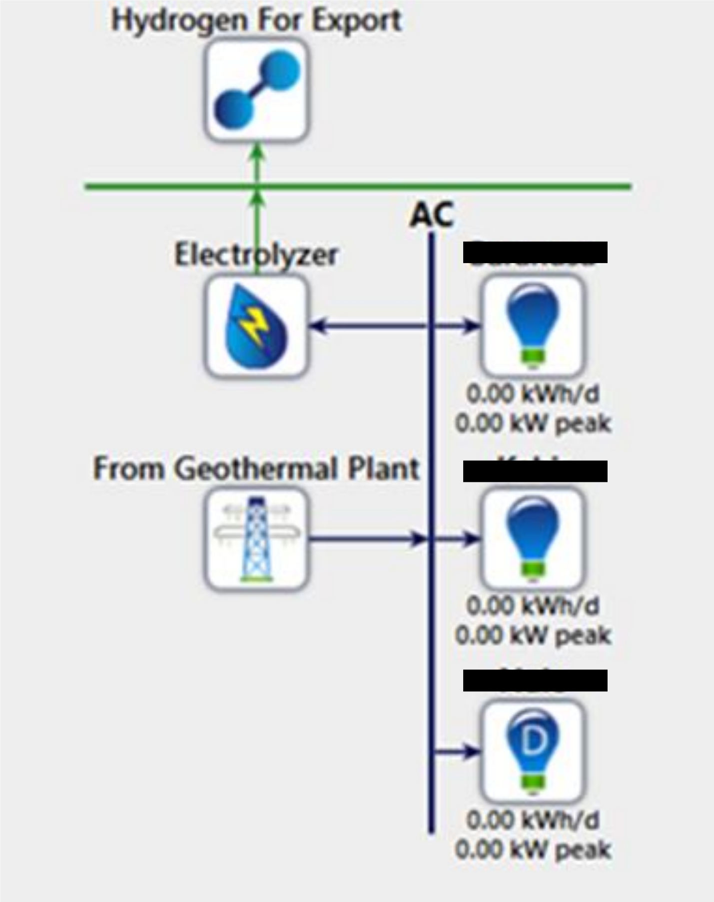
Optimal system configurations were determined using a least-cost optimisation model



a) Green Hydrogen



b) Battery Storage



c) Geothermal Energy

Least-cost Optimisation Results

System Sizes	[redacted]			[redacted]			[redacted]		
	2024	2030 (M)	2030 (L)	2024	2030 (M)	2030 (L)	2024	2030 (M)	2030 (L)
Green Hydrogen Option									
Capital investment cost (US$ million)	9.26	4.85	4.26	6.11	3.19	2.80	2.73	1.42	1.25
System LCOE (US$/kWh)	**0.57**	**0.29**	**0.26**	**0.66**	**0.33**	**0.29**	**0.59**	**0.29**	**0.26**
System LCOH (US$/kg)	10.28	5.37	4.77	9.99	5.19	4.61	10.16	5.45	4.78
System LCOH (US$/kWh)	404.81	211.36	187.78	393.48	204.33	181.78	400.12	214.87	188.10
BESS Option									
Capital investment cost (US$ million)	6.19	4.48	3.96	3.47	2.43	2.14	1.78	1.27	1.10
System LCOE (US$/kWh)	**0.31**	**0.23**	**0.20**	**0.30**	**0.21**	**0.19**	**0.34**	**0.24**	**0.21**
System LCOS (US$/kWh)	0.29	0.22	0.19	0.21	0.16	0.14	0.25	0.19	0.17
Geothermal Option									
Capital investment cost (US$ million) for 5 MW	45.22	38.89	38.89	45.22	38.89	38.89	45.22	38.89	38.89
System LCOE (US$/kWh)	**0.11**	**0.06**	**0.06**	**0.11**	**0.06**	**0.06**	**0.11**	**0.06**	**0.06**
System LCOH (US$/kg)	6.68	3.08	3.03	6.68	3.08	3.03	6.68	3.08	3.03
System LCOH (US$/kWh)	262.95	121.39	119.42	262.95	121.39	119.42	262.95	121.39	119.42

(M) – moderate; (L) – low

- The **least-cost option** is through a **centralised geothermal power generation**, but the **initial capital cost** required however **is relatively high**.
- **Between the 2 decentralised options** considered in the study, the **battery energy storage system (BESS) is the least-cost option** compared with the green hydrogen system.
- The **green hydrogen system remains the most expensive option**. The **LCOEs** in the 3 sites of this option will **however converge to those of BESS options in 2030s.**
- If the development of **geothermal energy resources is pursued**, the **production of hydrogen for export** from geothermal power plant **could also be considered**.

Economic Analysis Results

The economic analysis supports the results of the optimisation analysis.

- Geothermal energy has the highest EIRR, followed by BESS then Green Hydrogen.
  - The optimisation analysis ranks projects based on least-cost solutions.
  - The economic analysis ranks projects based on maximum rate of benefits.

The economic analysis however shows that the green hydrogen option, despite having the highest LCOE and lower EIRR, will be economically viable by 2030.

The results indicate that green hydrogen is a viable option for island micro-grids towards the end of this decade and forms part of the national technology mix to decarbonise the economy.

	unit	2024	2030 (moderate)	2030 (low)
[redacted]				
Green Hydrogen Option	ENPV ($ million)	-4.18	1.41	2.00
	EIRR (%)	0.4%	**13.7%**	**16.5%**
Battery Energy Storage System Option	ENPV ($ million)	0.73	2.60	3.07
	EIRR (%)	11.0%	18.2%	21.1%
[redacted] Geothermal Energy Option	ENPV ($ million)	54.15	60.44	
	EIRR (%)	19.5%	21.9%	
[redacted]				
Green Hydrogen Option	ENPV ($ million)	-3.00	0.82	1.23
	EIRR (%)	**-0.6%**	**13.2%**	**16.1%**
Battery Energy Storage System Option	ENPV ($ million)	1.01	2.14	2.40
	EIRR (%)	13.7%	22.5%	26.0%
[redacted] Geothermal Energy Option	ENPV ($ million)	54.15	60.44	
	EIRR (%)	19.5%	21.9%	
[redacted]				
Green Hydrogen Option	ENPV ($ million)	-1.21	0.43	0.60
	EIRR (%)	**0.5%**	**13.9%**	**16.6%**
Battery Energy Storage System Option	ENPV ($ million)	0.24	0.79	0.94
	EIRR (%)	11.2%	18.8%	22.2%
[redacted] Geothermal Energy Option	ENPV ($ million)	54.15	60.44	
	EIRR (%)	19.5%	21.9%	

Presentation Quote and Key Takeaways

Quote

'Green hydrogen, with its projected technological learning, will become an economically viable option for island micro-grids towards the end of this decade and will form part of the national technology mix to decarbonise the economy'.

Key Takeaways:

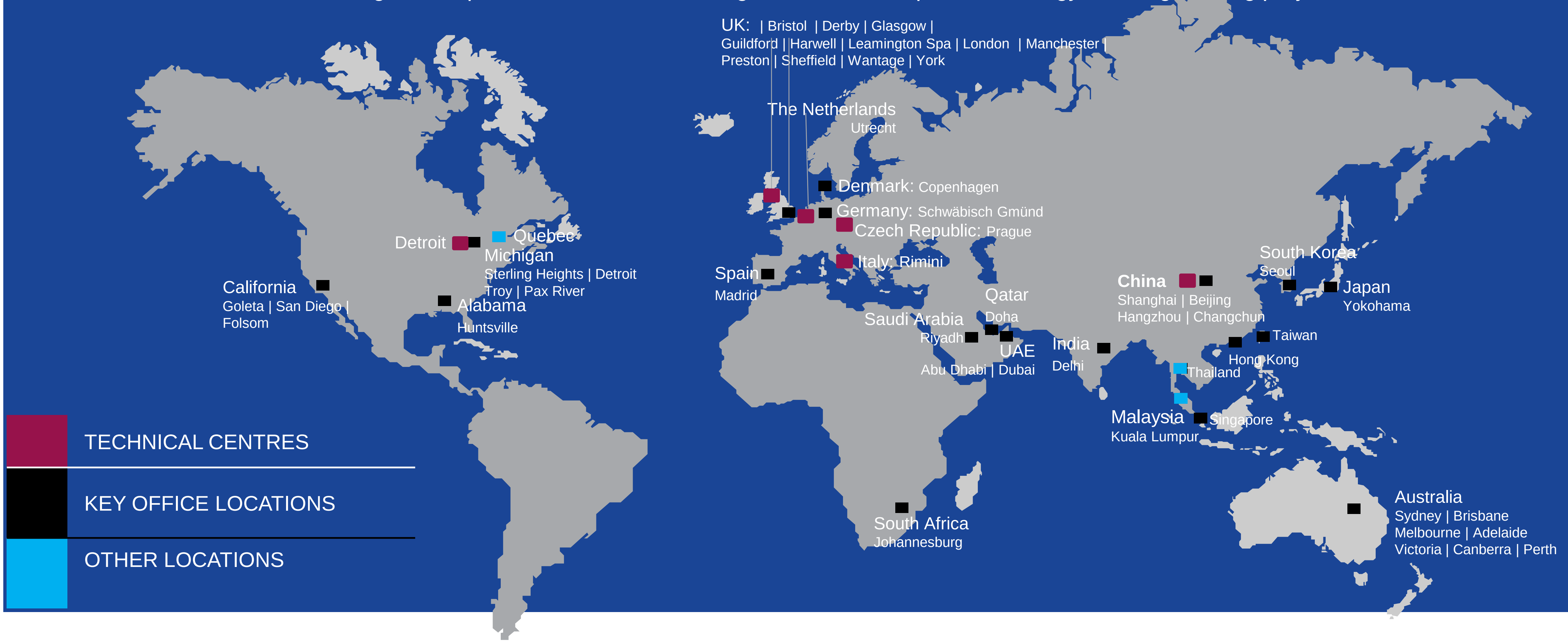
- Ricardo's approach to preparing national hydrogen economy strategies and developing a country's hydrogen insight is to deep-dive into the country's NZE strategies, NDC commitments, energy sector road maps and development plans, and using tools such as problem tree analysis and SWOT analysis while taking hydrogen hierarchy as the baseline concept.
- The least-cost system analysis for island micro-grids supports the concept that **green molecules** are **add-on** to **green electrons**.
- Green hydrogen is an attractive option for islands with limited renewable energy resources.

THANK YOU

www.ricardo.com

OUR GLOBAL PRESENCE

We blend our global expertise with local knowledge to deliver complex technology and engineering projects



RICARDO GROUP OPERATES THROUGH ITS 5 BUSINESS UNITS

AUTOMOTIVE &INDUSTRIAL

Trusted specialists in clean, efficient, integrated propulsion and energy solutions

PERFORMANCE PRODUCTS

Engineering specialists in niche-volume manufacturing and software development

ENERGY& ENVIRONMENT

A leader in sustainability consultancy, solving complex environmental challenges

RAIL& TRANSIT

Expert in solving complex rail systems through the delivery of independent assurance and consultancy services

DEFENSE

Trusted expertise in delivering wide-ranging engineering programmes to drive efficiencies while optimising safety