



# Pacific Hydrogen Roadmap

***32<sup>nd</sup> Pacific Power Association Conference***

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**Presented by Iain MacGill, based on the work of the UNSW team,  
and particularly Dr Rahman Daiyan and Dr M. Haider Ali Khan**



**GlobH2E**

ARC Industrial Transformation Training Centre  
for the Global Hydrogen Economy



**IRENA**  
International Renewable Energy Agency



**Pacific  
Community**  
Communauté  
du Pacifique



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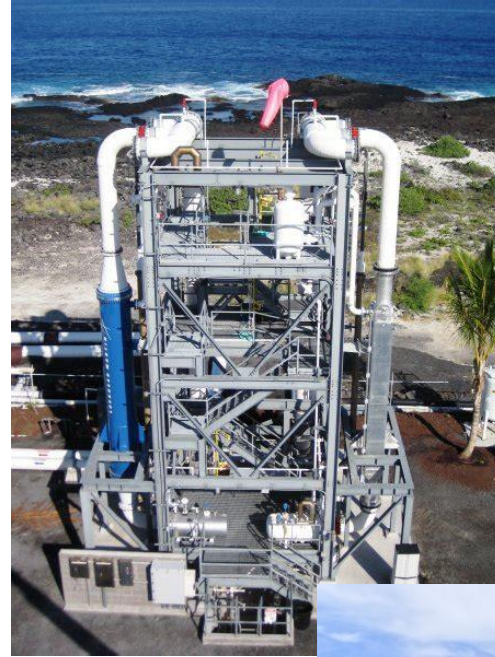




# A key planning, deployment and operational challenge

*assessing promising but still emerging energy technologies for the Pacific*

- Established technologies with expanded roles
  - High level PV integration into island grids
  - Battery Energy Storage Systems (BESS)
  - Off-shore wind
- New variations on existing technologies
  - Floating PV
  - Enhanced geothermal technologies
  - New biomass technologies
- Emerging technologies
  - Ocean Energy options
  - **Hydrogen and its derivatives**



# Deployment of emerging technologies in the Pacific

- Possible strategies to manage technology risks
  - Regionally relevant R&D and demonstration
  - Readiness assessments
  - Pilot projects
  - Ongoing Independent expert review and assistance for the region
  - **Tools that help us assess potential role of these technologies while minimizing risks and regret**
  - Technology roadmapping

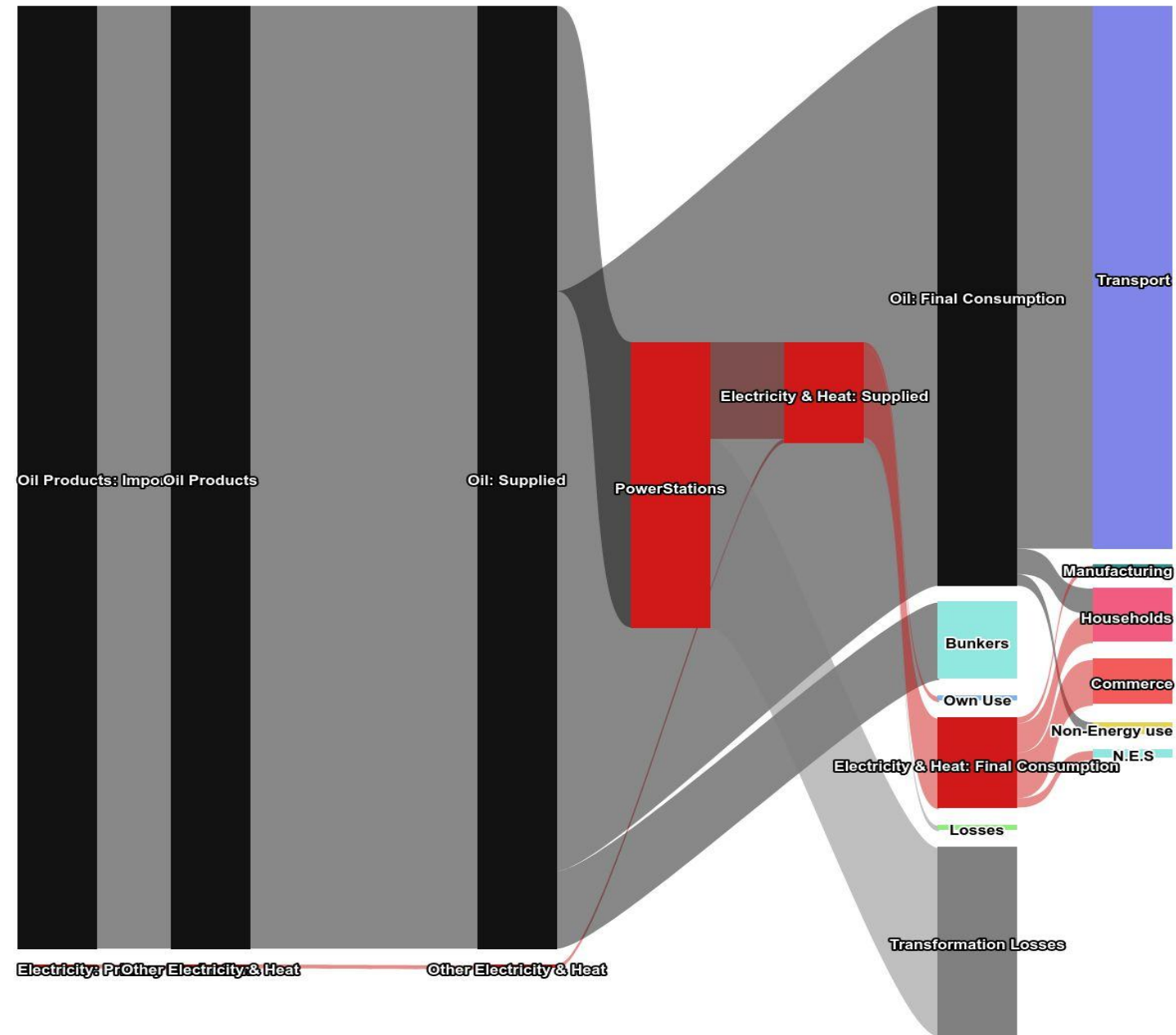
## Leading Edge vs. Bleeding Edge

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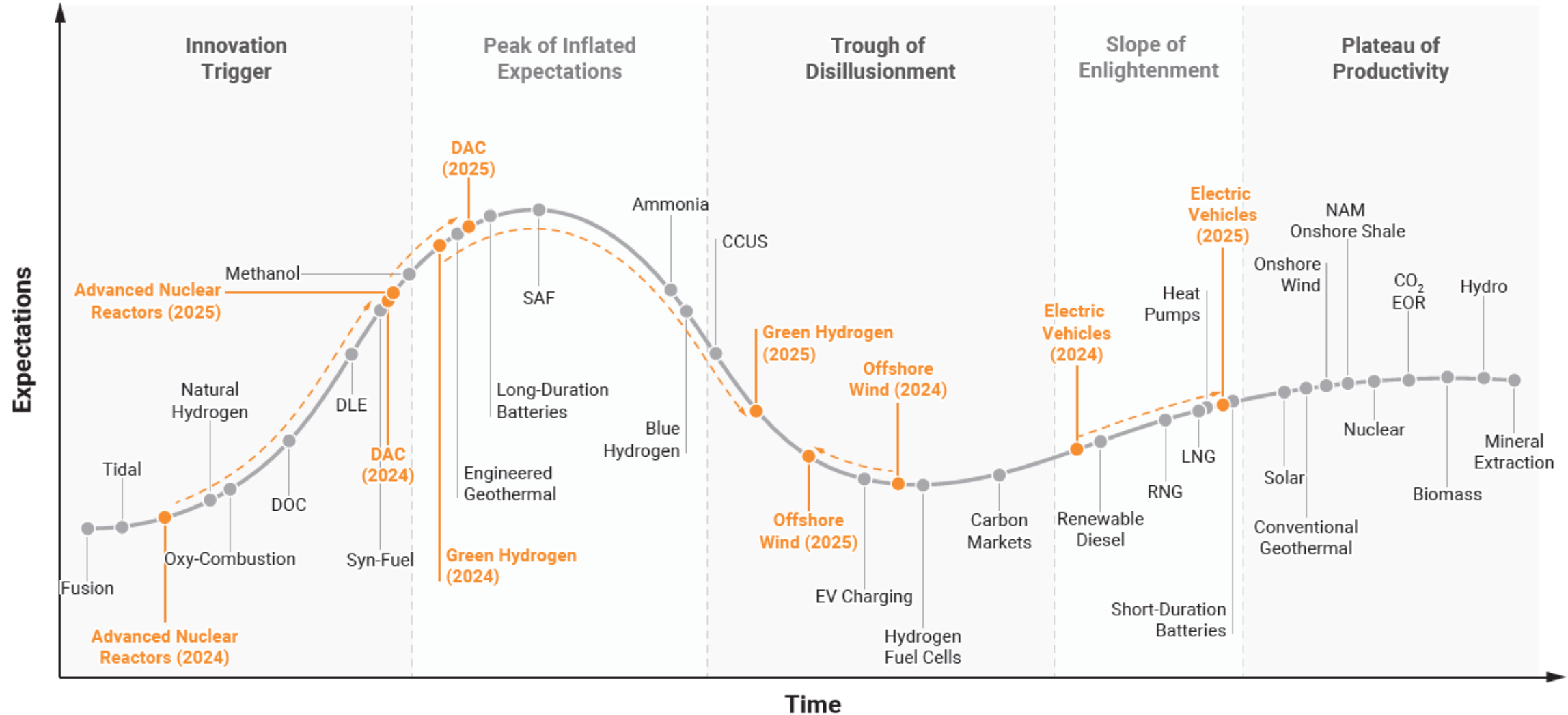
- Bleeding Edge: When failure occurs because an organization tries to be too far out on the technological leading edge

# Clean energy transition – isn't just cleaning up electricity

- Palua oil use dominated by transport
  - 30% road, 70% domestic navigation
- Bunkers consumption is for international aviation.
- Electrification might cover all/most road transport, some short haul domestic navigation, but what of other shipping, aviation**



# The h2 hype bubble has burst – time to get to work





# H2 – the swiss army knife of energy, or a ladder?

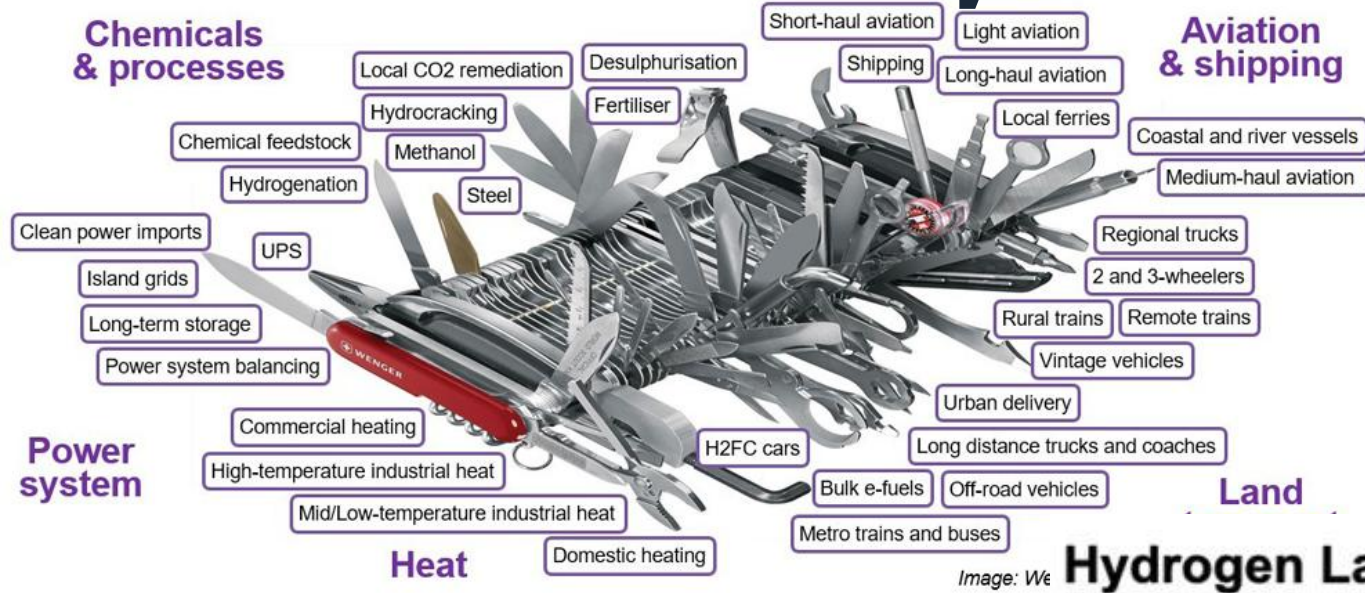
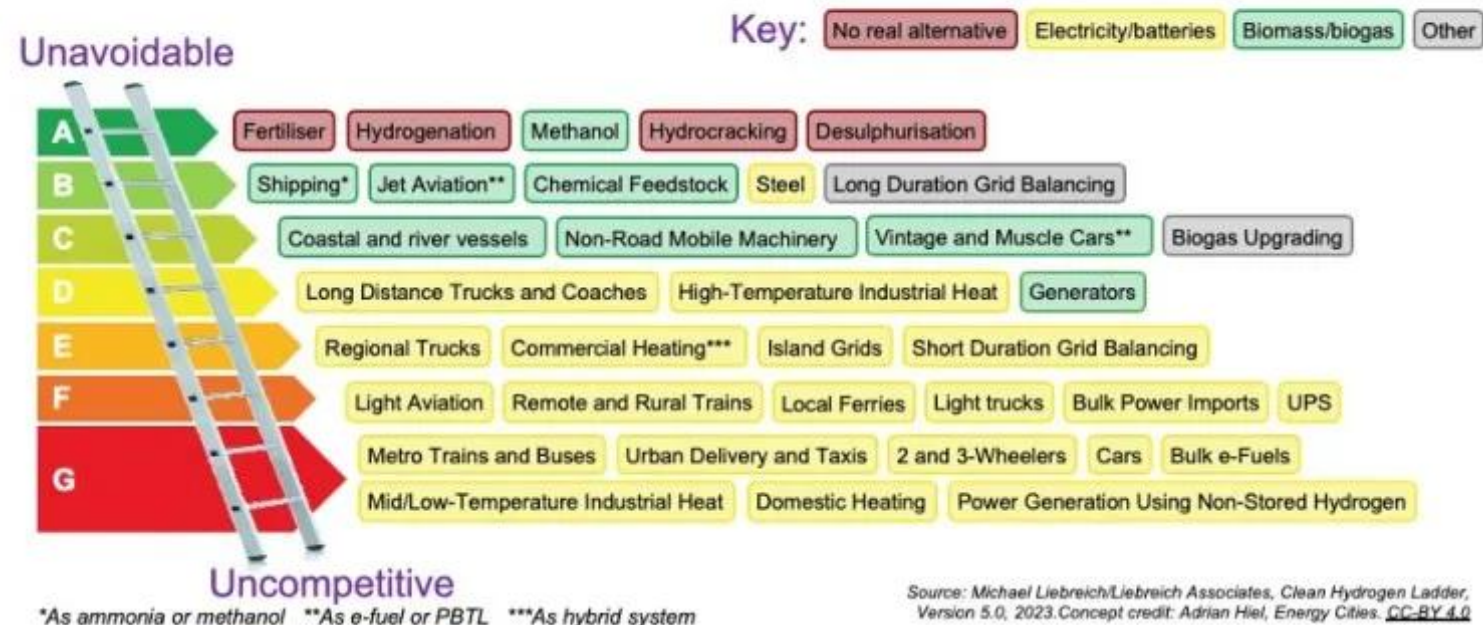


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## Hydrogen Ladder 5.0

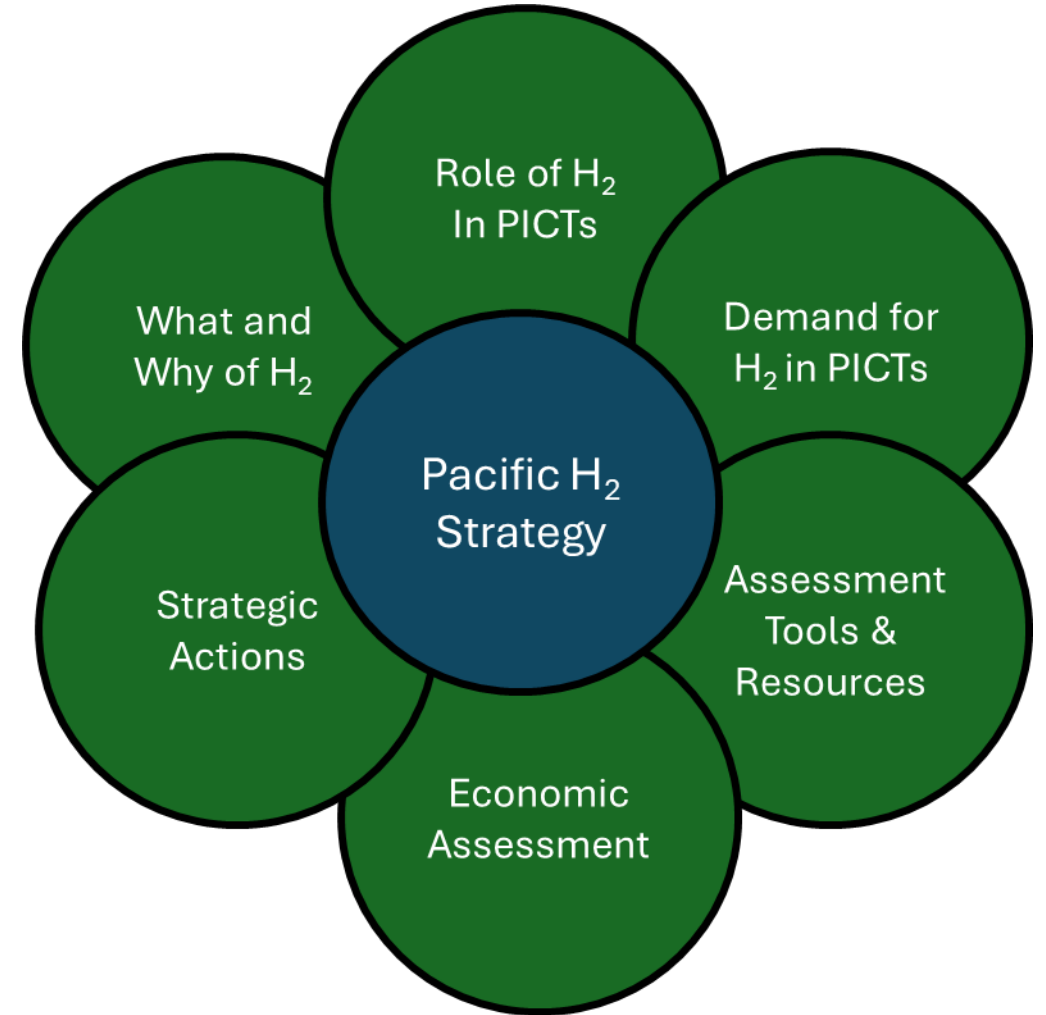
Liebreich Associates

- H2 can do just about anything – the Swiss army knife of energy, wonderfully flexible, but you often have a better tool
- The hydrogen ladder highlights that there is competition to h2 on many possible tasks
- A key issue for the pacific – likely restraints on local renewable generation means clean fuel imports likely required



# Project Overview

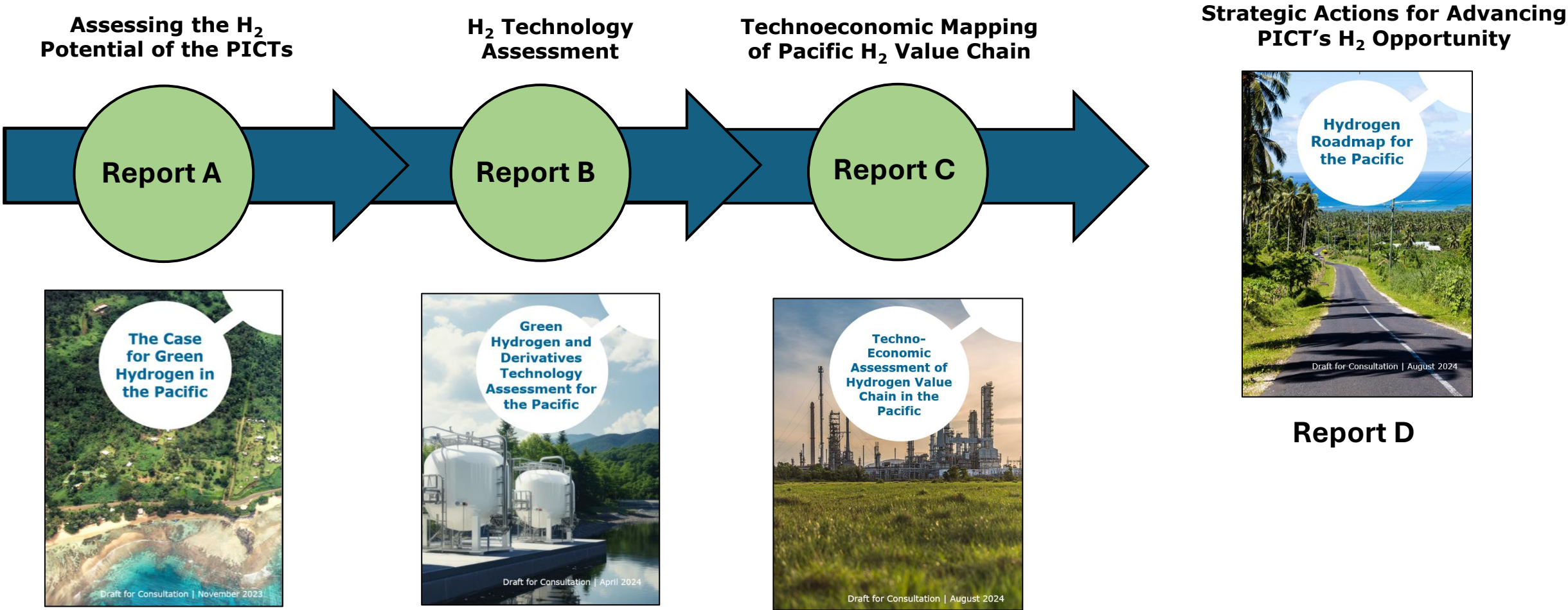
- The 2023 PRETMM Efate outcome statement recognises the need to consider the potential of green hydrogen and its derivatives in decarbonising the region. This included **endorsing the development of a timebound Pacific regional green hydrogen strategy.**
- Responding to this request, DCCEEW has funded UNSW Sydney consortia, supported by the International Renewable Energy Agency (IRENA) the Pacific Community (SPC), and the University of South Pacific (USP), to lead the development of a Pacific Hydrogen Strategy.





# Project Overview

## Reports



# Project Overview

## Resources

Levelised Cost of Ammonia (LCOA) Estimator			
Ammonia Facility Capacity			
Note: The section below provides a template for defining the overall system capacities			
Parameter	Value	Unit	Comment
Name Plate Capacity of Ammonia Facility	1.0	Mtpa of NH <sub>3</sub>	
	1,000,000	tpa of NH <sub>3</sub>	
Capacity Factor	100%	%	
Ammonia Produced	1,000,000	tpa of NH <sub>3</sub>	
Ammonia Facility Costing			
CAPEX	Hydrogen Fuel Cell vs Diesel Genset based Power Production Parity Calculator		
Note: This			
Parameter	Value	Unit	Comment
Reference	Fuel Cell Genset		
Note: The section below provides a template for defining the fuel cell performance			
Scale Index			
Scaled Am	Fuel Cell Operating Capacity		
Note: The section below provides a template for defining the overall system capacities			
Parameter	Value	Unit	Comment
Capacity of Fuel Cell	1	MW	
Peak Factor	100%	%	
Capacity Factor	12	hrs/day	
	300	days/year	
	41%	%	
Power Output	3,600	MWh/yr	
Fuel Cell Performance			
Note: The section below provides a template for defining the fuel cell performance parameters including efficiency and subsequent H <sub>2</sub> fuel req.			
Parameter	Value	Unit	Comment
Fuel Cell Efficiency	75%	% on HHV Basis	
H <sub>2</sub> Fuel Requirement	19.5	kg of H <sub>2</sub> /MWh	
	220	kg of H <sub>2</sub> /day	
	68,528	kg/yr	

Tools

PICT Comparison and Overall Data						
	Purpose	Fiji	Samoa	Vanuatu	Solomon Islands	PHG
USD	GDP per capita	5926.82	4105.33	3010.29	2236.73	3019.93
%	GDP spend on fossil fuels	5.66	6.91	3.80	4.19	5.75
kg CO2	CO2 emissions per capita	1589.86	1322.41	535.16	438.96	839.03
%	Percent of energy use as electricity	23.83	20.55	20.84	13.72	28.38
Calculations				Key		
Conversion of Energy Input in (TWh of Diesel Equivalent) to Fuel Demand:				Electricity Generation		
$\text{Fuel Demand (Mt)} = \text{Energy Required (TWh)} \times \frac{\text{Diesel Conversion Efficiency (\%)}}{\text{Fuel Conversion Efficiency (\%)}} \times \frac{1}{\text{Fuel Energy Density (TWh/t)}} \times \frac{1 \text{ Mt}}{1 \times 10^6 \text{ kg}}$				Land Transport		
				Maritime Transport		
				Aviation Transport		
Conversion of Fuel Demand (Mtpa) to Fuel Demand (Gtpa)						
Renewable Energy Generation Profiles of Cook Islands						
Cook Islands Renewable Energy Generation Profiles	Time	Solar	Wind		Solar Stats	Wind Stats
	2010-01-01	0.828	0.083	Average CF%	0.21891815	0.359121
	2010-01-01 01:00:00	0.781	0.103	Min CF%	0	0
	2010-01-01 02:00:00	0.668	0.111	Max CF%	0.882	0.986
	2010-01-01 03:00:00	0.397	0.118			
	2010-01-01 04:00:00	0.148	0.125			
	2010-01-01 05:00:00	0	0.127			
	2010-01-01 06:00:00	0	0.128			
	2010-01-01 07:00:00	0	0.131			
	2010-01-01 08:00:00	0	0.136			
	2010-01-01 09:00:00	0	0.139			
	2010-01-01 10:00:00	0	0.144			
	2010-01-01 11:00:00	0	0.153			
	2010-01-01 12:00:00	0	0.168			
	2010-01-01 13:00:00	0	0.179			
2010-01-01 14:00:00	0	0.195				

Database

Renewable Hydrogen for the Pacific
Lecture 1: Intro to Hydrogen and Hydrogen Production Methods
Renewable Hydrogen for the Pacific
Lecture 2: Hydrogen Storage, Transportation and Utilisation
Renewable Hydrogen for the Pacific
Lecture 3: Hydrogen Safety and Economics

Masterclasses

# Report A: Overview

Purpose	Key Findings
<ul style="list-style-type: none"><li>▪ PICT-specific analysis of energy outlook, fossil fuel consumption, electricity mix, CO<sub>2</sub> emissions.</li><li>▪ PICT-specific assessment of sectors that face decarbonisation challenges using electrification.</li><li>▪ Indicative potential for hydrogen and derivatives in key sectors.</li></ul>	<ul style="list-style-type: none"><li>▪ <b>Over 6% of the combined GDP</b> of the PICTs is spent on imported fossil fuels, making up <b>~70%</b> of regional energy supply and resulting in <b>10 million tonnes</b> of CO<sub>2</sub> emissions.</li><li>▪ <b>1.1 Mtpa of H<sub>2</sub></b> and derivatives could play a complementary role to direct electrification in key sectors, including for electricity generation and mobility applications including the maritime and aviation industries.</li><li>▪ A <b>regional collaborated trade market</b> could entail the generation of bulk amounts of green fuels, that can be transported to the more remote and resource deficient regions across the Pacific to yield mutual benefits.</li></ul>

## Status:

- Report A - Draft for Consultation is available on the Project Website (<https://pacifich2strategy.com/publications>).

# Report A: Country Specific Assessment

- Country-specific assessments were undertaken to develop a state of play of the region (energy demand/supply, infrastructural resources and emission outlook).
- These assessments were carried out for Fiji, Samoa, Vanuatu, Solomon Islands, Papua New Guinea, New Caledonia, Kiribati, Federated States of Micronesia, Tonga, Cook Islands, Republic of the Marshall Islands, Tuvalu, and Nauru.
- The state of play was then used to develop a **case for H<sub>2</sub> and derivatives in the region (and identify potential end uses)**

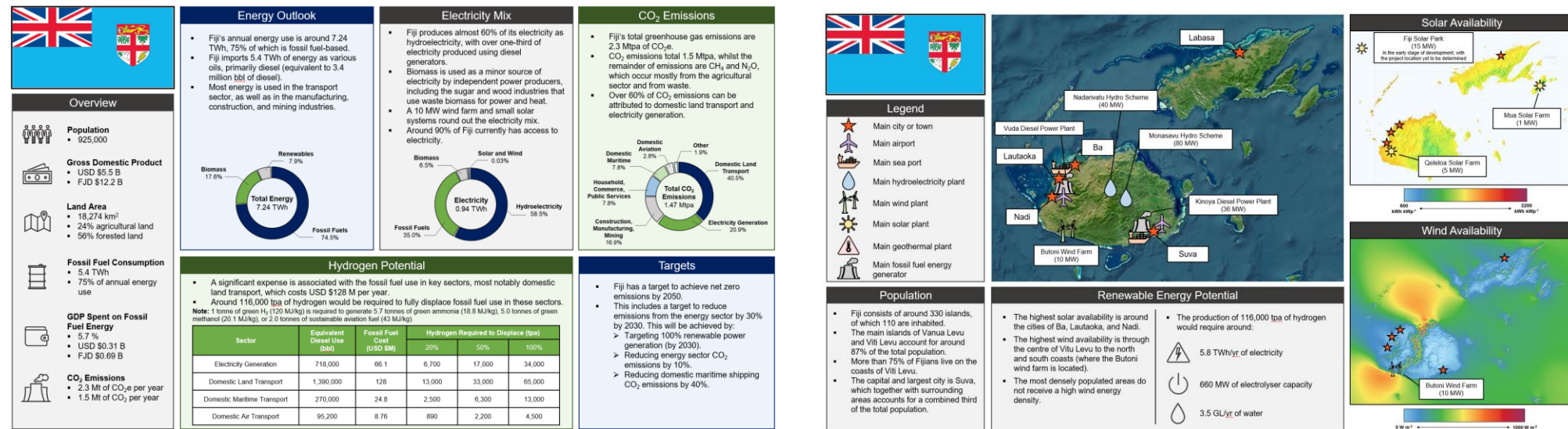


FIGURE: EXAMPLE OF COUNTRY SPECIFIC ASSESSEMENT

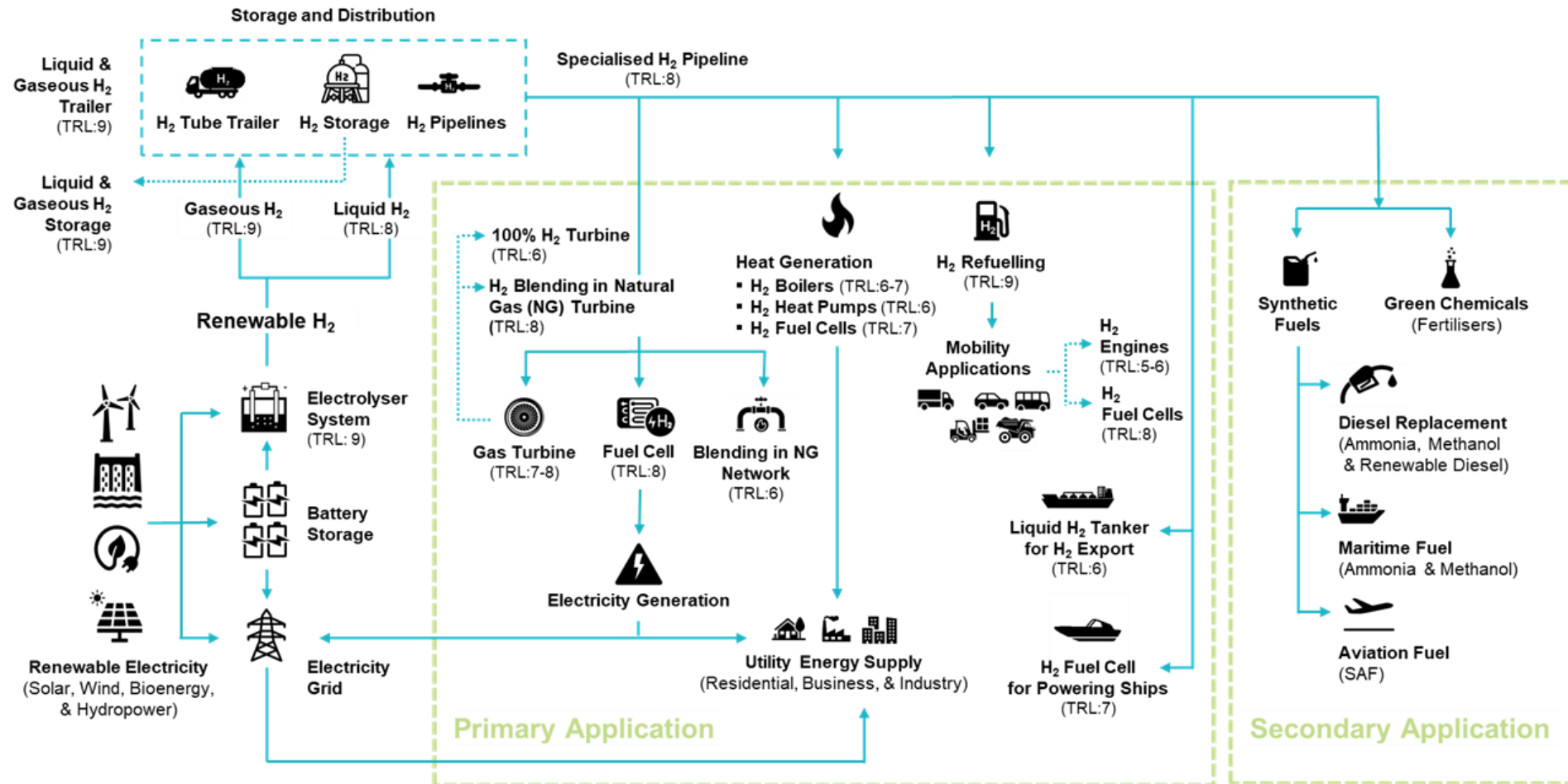


# Report B: Technology Assessment Across Value Chain

*An in-depth assessment identifying H<sub>2</sub> and derivatives technology for generation, storage & distributing and eventual end use were identified and assessed for maturity.*

The assessment considered and elaborates on:

- Background and description of each technology.
- Status of the technology and global market size.
- Technology suppliers.
- Current projects and decentralised facilities.
- Economics.
- Issues, challenges, opportunities for implementation within a Pacific context.



**FIGURE: THE HYDROGEN VALUE CHAIN AND TRL OF RELEVANT TECHNOLOGIES.**

# Report B: Conclusion

- Based on the MCA result the end-use opportunities in the PICTs were reviewed. *More targeted application for each fuel considering the economics, challenges, opportunities in a PICTs context.*

Application	Hydrogen	Methanol	Ammonia	Renewable Diesel	SAF
Seasonal power storage	✓			✓	
Power Generation	✓			✓	
Land mobility fuel	✓	✓		✓	
Maritime fuel		✓	✓	✓	
Aviation fuel					✓

FIGURE: REVISED EARLY MARKET OPPORTUNITIES FOR HYDROGEN TECHNOLOGIES IN THE PACIFIC REGION.

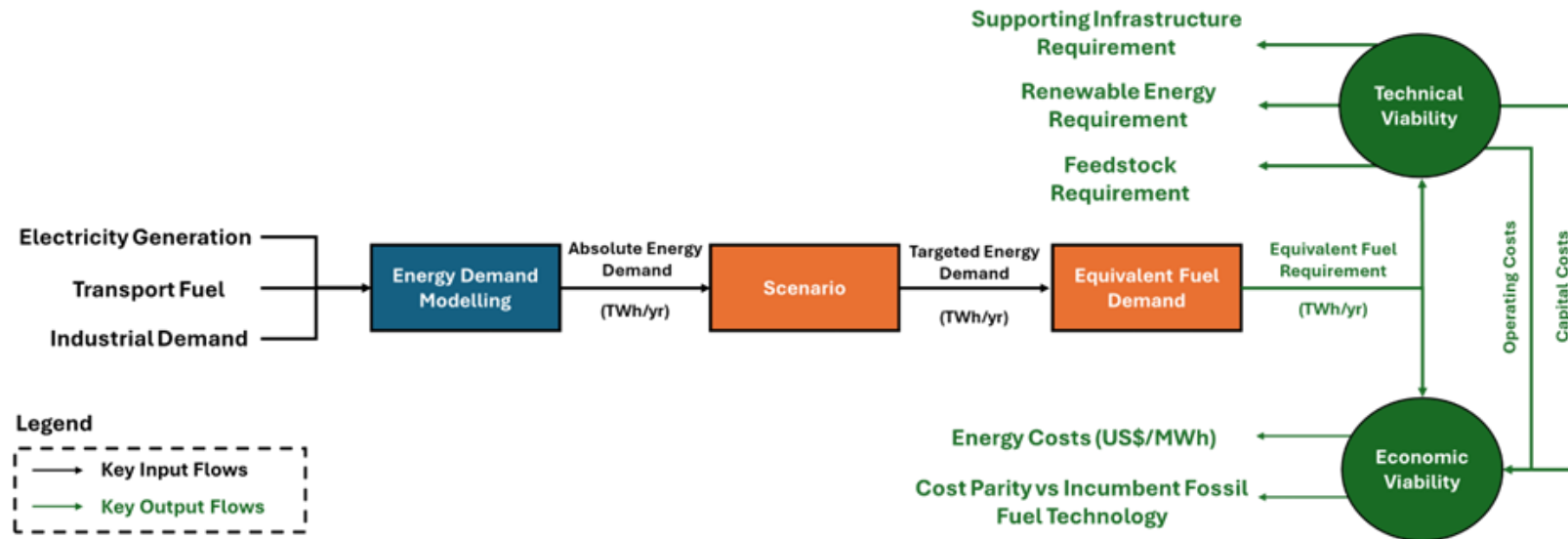
- A **near-term opportunity in the PICTs is the generation of biogenic fuels** like methanol, SAF, and renewable diesel using regional biomass resources, which can be produced at competitive costs and used as **drop-in replacements for fossil fuels through existing infrastructures.**
- While e-fuels might initially be more suited for niche applications** like on demand power generation in remote areas using fuel cells powered with hydrogen. However, **widespread P2X technology distribution is hindered** by a lack of infrastructure and economics. Yet, **over the long-term**, the PICTs have the potential to become a green shipping corridor, supplying **maritime fuels like methanol and ammonia are key demands** due to lack of alternative solutions.

# Report C: Assessment Framework

An assessment framework was developed to conduct the value chain modelling and costing

The framework has the following functionalities:

- **Demand Modelling:** Revise H<sub>2</sub>/derivative demand based on energy scenario
- **Technical Viability:** Evaluate the technical viability based on feedstock and infrastructure requirement
- **Economic Viability:** Cost the value chain and provide a cost parity vs incumbent fossil fuel use.



**FIGURE:** ASSESSMENT FRAMEWORK

# Report C: Overview

Purpose	Key Findings
<ul style="list-style-type: none"><li>▪ Model the demand for hydrogen and derivatives towards target end-use applications.</li><li>▪ Map the energy resources, land availability, infrastructure, and other feedstocks that would be required to establish a hydrogen economy in the PICTs.</li><li>▪ Investigate the economics of developing a hydrogen economy in the PICTs.</li></ul>	<ul style="list-style-type: none"><li>▪ In progress.</li><li>▪ Initial findings suggest:<ul style="list-style-type: none"><li>a) The demand for H<sub>2</sub> could significantly exceed over the 1 Mtpa initially estimated. For context accounting for the energy content of H<sub>2</sub> and the efficiency of conversion technology, over <b>2 Mtpa of H<sub>2</sub></b> for electricity generation, <b>3.5 Mtpa of renewable diesel</b> for land transport, <b>2 Mtpa of ammonia</b> for maritime and <b>1 Mtpa of SAF</b> would be needed to displace 100% of the fossil fuel demand by 2050.</li><li>b) <b>Production cost of electrolytic fuels would exceed global estimates</b> mainly due to lack of infrastructure and cost of project development in the region; therefore, would require funding support to become viable.</li><li>c) <b>Biogenic pathways in comparison would be more cost competitive.</b></li><li>d) <b>Replacing fossil fuels for on demand power generation using H<sub>2</sub> could potentially be viable against diesel generators, renewable diesel can potentially be competitive for land transport and power generation. Shifting to 100% SAF, methanol and ammonia would entail significant premiums.</b></li></ul></li></ul>

**Status:** Report C - Draft for Consultation is currently in the works, with a draft expected this month.



# Report D: Roadmap and Stakeholder Engagement Framework

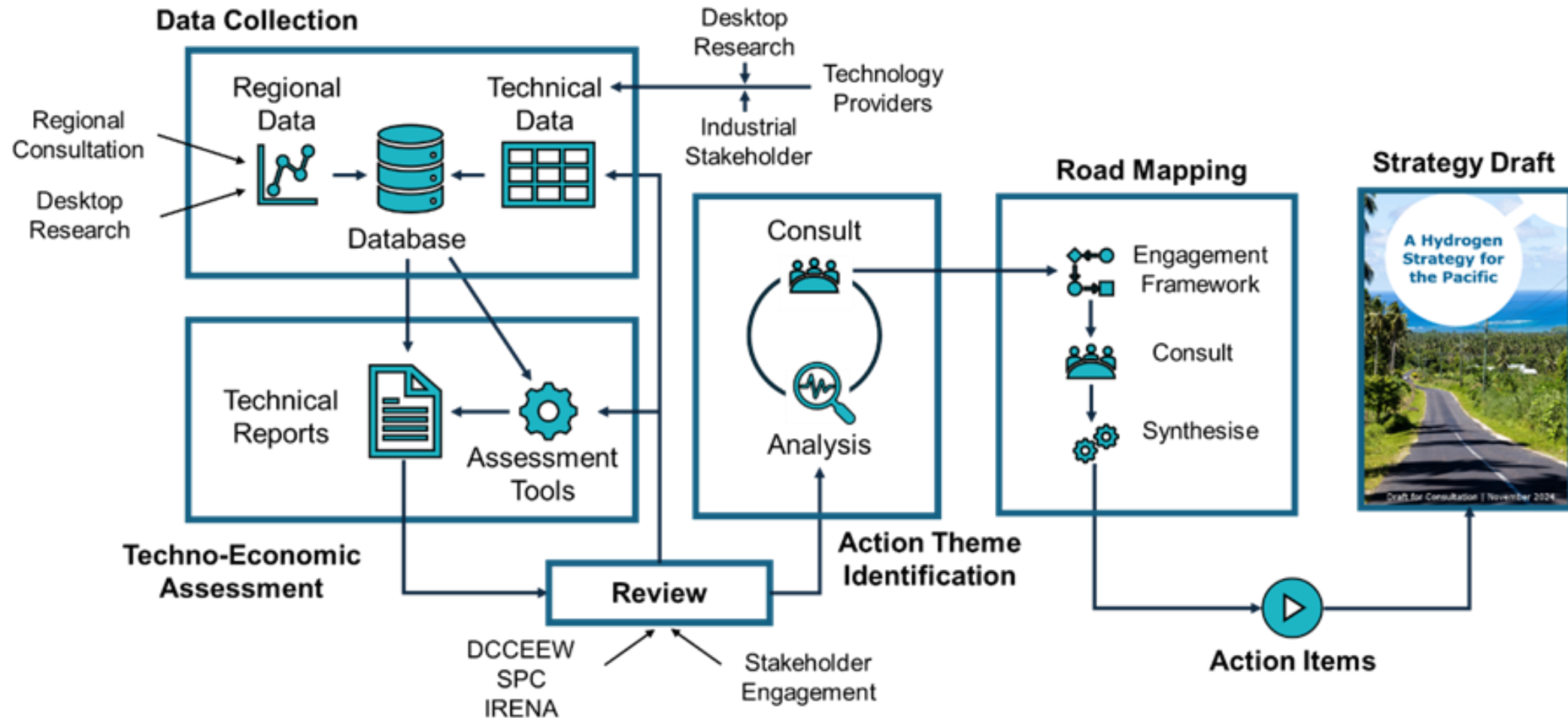


FIGURE: FRAMEWORK FOR ROADMAP DEVELOPEMENT

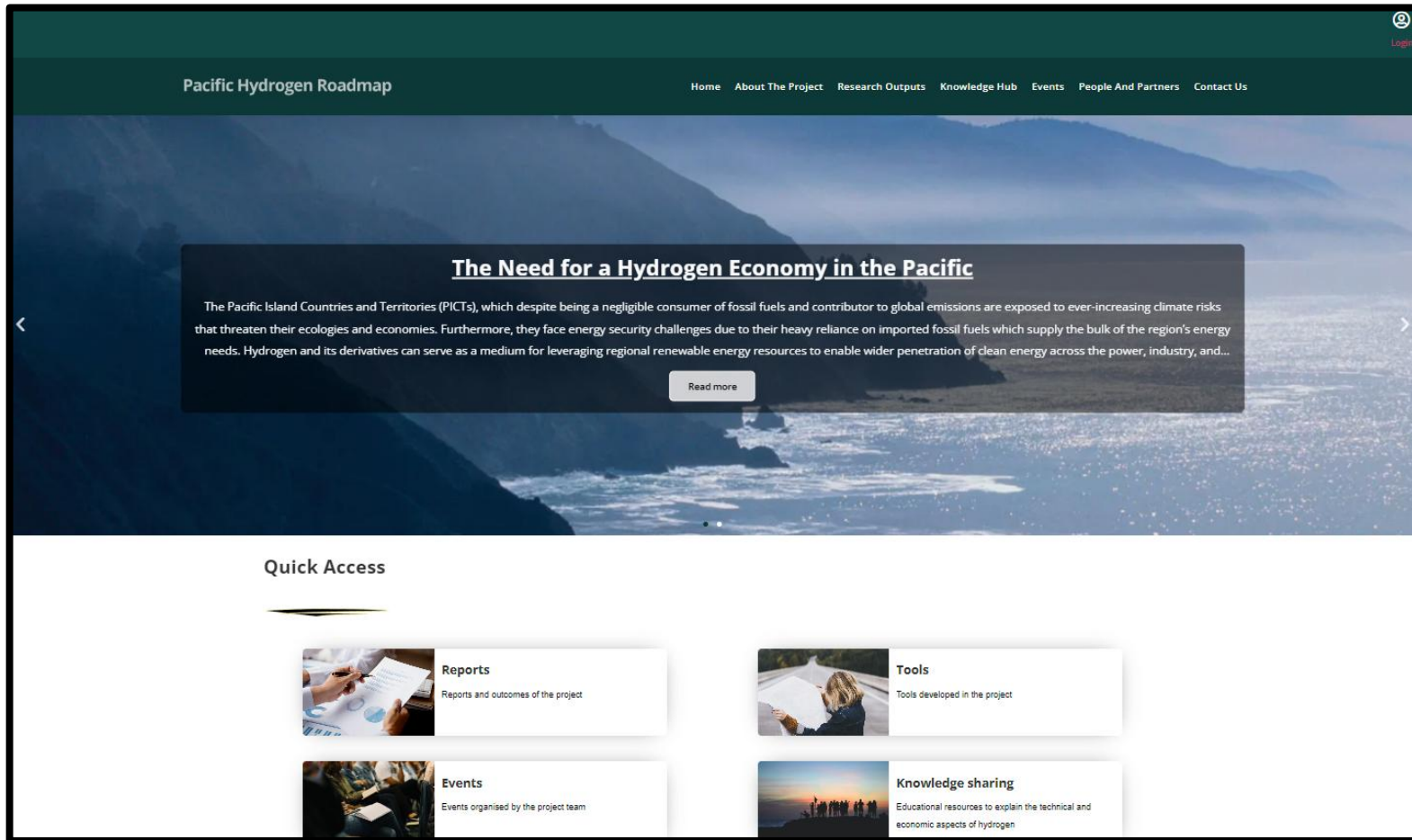
# Stakeholder Engagement: Challenges Identified

- **General Understanding of H<sub>2</sub> and Derivatives:** Lack of greater understanding on role of H<sub>2</sub> and derivatives. There is a lot of hype but little practical movement to date.
- **Realistic Target setting, Feedstock Availability, and Allocation:** A need to understand and promote that H<sub>2</sub> and derivatives are not the only solution and will compete with other options for both feedstock (water, renewables and biomass), economics (capital investment) and land
- **Economics:** All these processes are capital intensive – e.g., a 1 MW electrolyser (500 kg a day of H<sub>2</sub>) would cost between USD 500k to 1.8 million. In addition, the turnaround times of these facilities (ammonia, methanol and biofuels) at scale are 3 to 4 years so that's capital locked in for a significant time (that can be used in other places).
- **Infrastructure Readiness:** Biofuels have a significant opportunity to be used in as drop in replacement fuels – but why has there been little progress across the Pacific to implement these. Is it a production and distribution problem or an end use problem (social acceptance ?).
- **Risks:** Technical risks in terms of safety and compliance. SAF and RD are synthetic replacements and can leverage existing understanding and capabilities. Hydrogen, ammonia and methanol on the other hand will require infrastructural changes and new skills in the region.

# Key Takeaway Messages

- Clean H<sub>2</sub> and derivatives will have a facilitatory role to play in decarbonising the PICTs. Especially complementing and not taking away focus from renewable based electrification.
- Aviation, maritime and drop-in fuel replacement opportunities are likely key markets for clean H<sub>2</sub> and derivatives for the region.
- Clean H<sub>2</sub> and derivatives may provide the region the opportunity to achieve a regionally self-sufficient and integrated energy future. It also provides the region an opportunity to take active ownership and leadership role in driving their regional H<sub>2</sub> strategy.
- Some jurisdictions in the Pacific have limited renewable energy opportunities and clean H<sub>2</sub> derivatives imports provides an opportunity to pursue ambitious climate goals.
- Altogether these reports and resources provides insights, knowledge and tools to enable the region to develop its own H<sub>2</sub> strategy, based on energy ambitions as well as social and economic priorities.

# Project Website



Hub for information  
hosting and sharing  
for this project

Link: <https://pacifich2strategy.com/>



# Project Partners



Australian Government

Department of Climate Change, Energy,  
the Environment and Water



**UNSW**  
SYDNEY



**IRENA**  
International Renewable Energy Agency



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