The challenges of energy planning with emerging technologies the example of hydrogen

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GlobH2E

Collaboration on Energy and Environmental Markets

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International Renewable Energy Agency

Pacific Community
Communauté du Pacifique

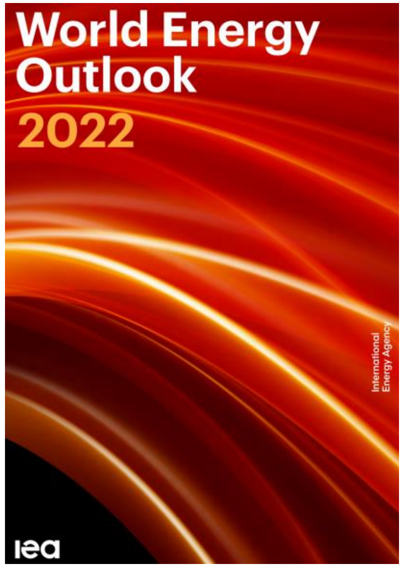
USP
THE UNIVERSITY OF THE SOUTH PACIFIC

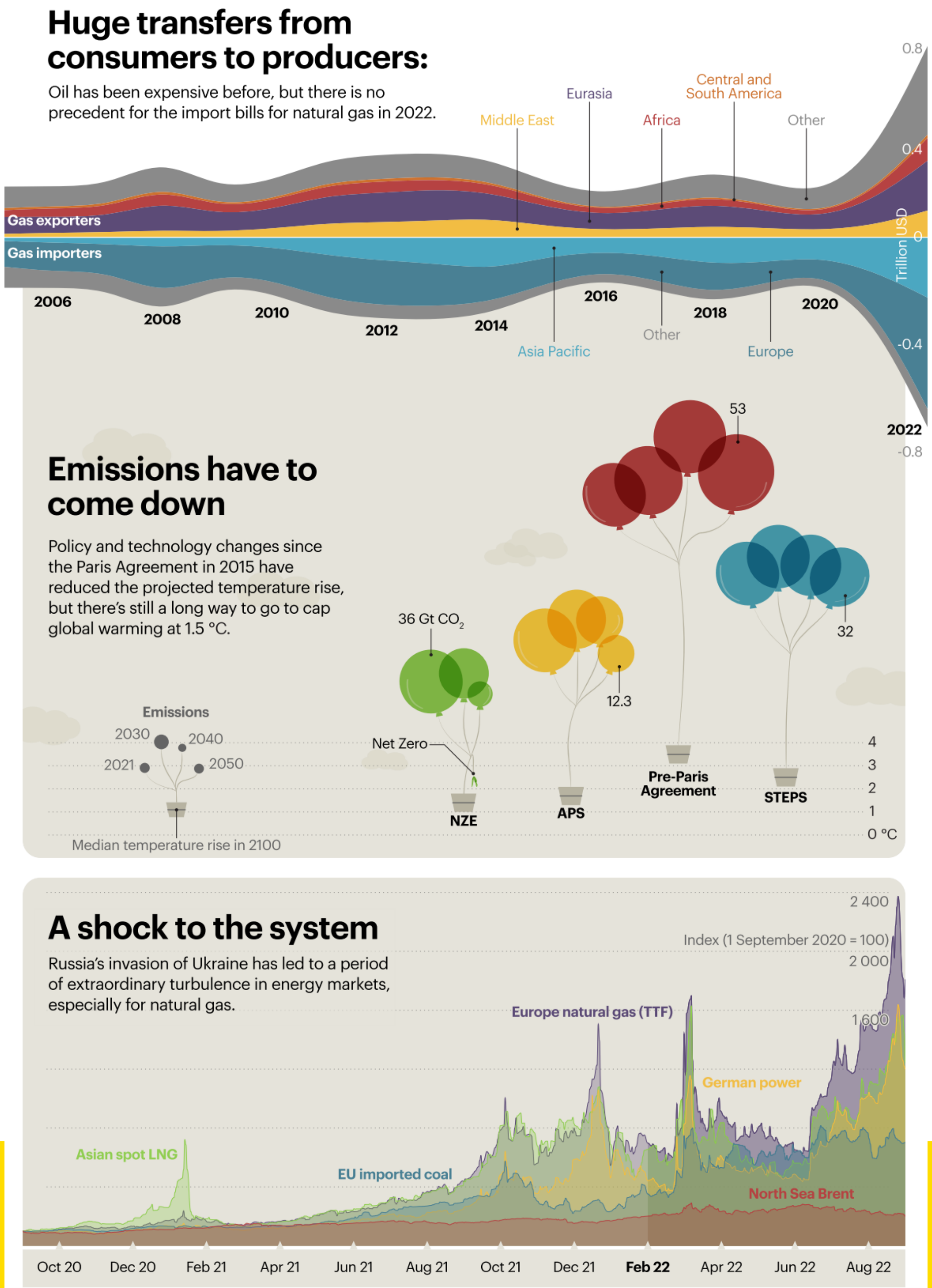
PPA
PACIFIC POWER ASSOCIATION

Australian Government
Department of Climate Change, Energy, the Environment and Water

Three global energy crises to navigate

- Recent inprecedented gas + coal prices, high + volatile oil prices
- Enormous wealth transfers, adverse impacts on societal progress in developing + emerging economies, recession risks in industrialised nations
- Growing climate change impacts, inadequate efforts to date avoid dangerous warming





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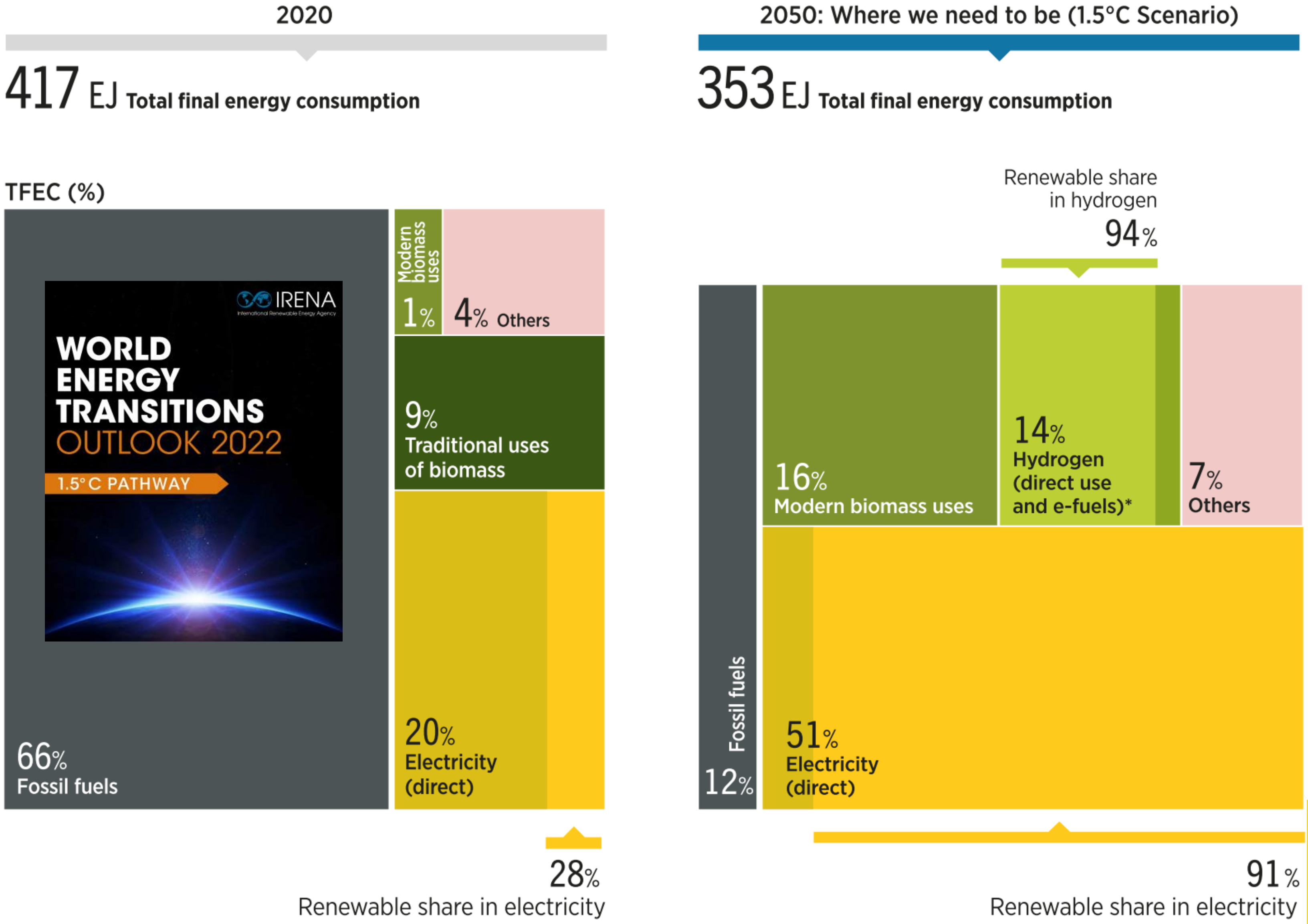
General agreement on desirable global energy pathways but also uncertainties

- Electrification of current non-energy sectors
- Greatly expanded, mostly renewables electricity sectors
- **Key uncertainties – what role for fossil fuels, biomass, hydrogen, other emerging technologies**
- ***A key question – how to undertaking planning to get from here to there given such uncertainties***



What role can emerging technologies such as hydrogen play in achieving our clean energy and climate goals? …. *And how do we make it so?*

Globally?

Regionally?

Jurisdictionally?

Planning – anticipatory decision making

A **decision** is the commitment to irrevocably allocate valuable resources *with consequences*. *Hand waving doesn't count*

Decision-making **framework**

- What objectives? – *lots of them in energy*
- What decisions? *(available choices) – what exists, what is proven, what might be possible*
- How are they taken? *Who are the decision makers, what of stakeholders?*

Good decision making more likely with

- Clear and agreed objectives – *many potential stakeholders, appreciation of tradeoffs*
- Clarity on actually available options – *'real world' data, modelling tools,*
- Well informed decision makers – *lots of decision makers in energy transition*
- With a good process that includes all stakeholders – *everyone a stakeholder in energy transition, how can they participate in planning?*

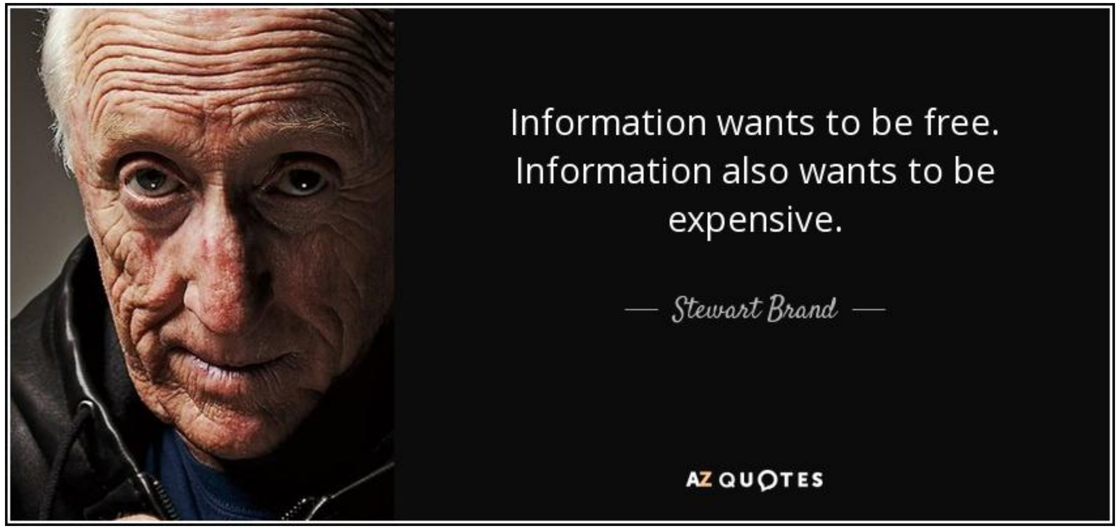
***Data and tools don't do planning**, instead their role is to provide decision support within broader planning frameworks*

Data isn't free.. but can be 'low cost' + 'high value'

*“**information wants to be expensive**, because it's so valuable. The right information in the right place can change everything*

*On the other hand, **information wants to be free**, because the cost of getting it out is getting lower and lower all the time.”*

A particular challenge with emerging technologies – we don't have data about the future



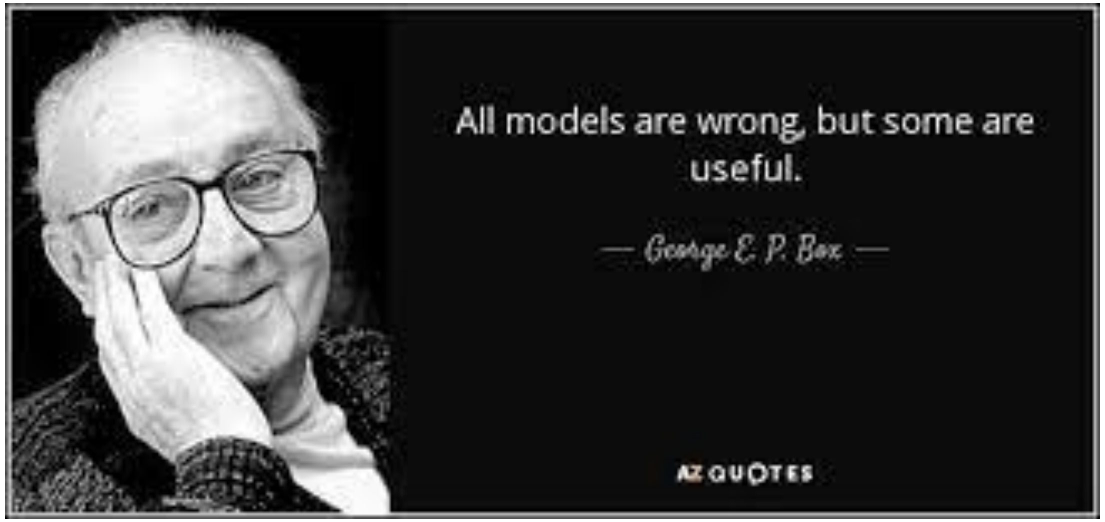
- Open-source data tools to help
  - Make it available
  - Make it pretty
  - *Make it actionable*

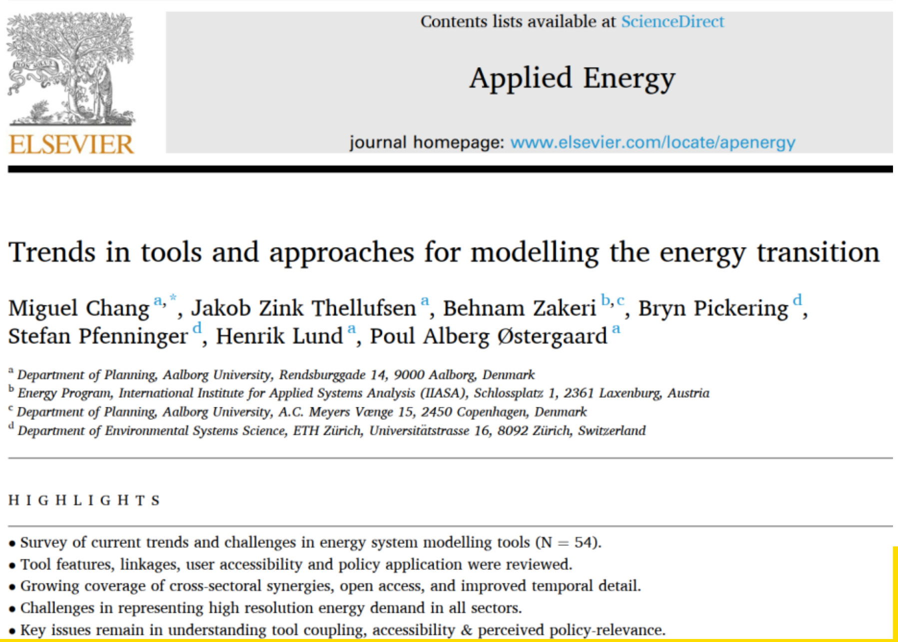
Energy modelling tools

Energy system models crucial to plan energy transition pathways and understand their impacts.

A vast range of energy system modelling tools is available, providing modelling practitioners, planners, and decision-makers with multiple alternatives to represent the energy system according to different technical and methodological considerations.

A particular challenge – how to appropriately model future technologies wrt not just themselves, but also integrated with existing energy sector infrastructure

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Trends in tools and approaches for modelling the energy transition

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HIGHLIGHTS

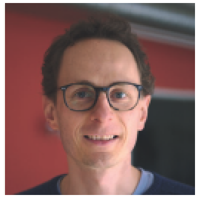
- Survey of current trends and challenges in energy system modelling tools (N = 54).
- Tool features, linkages, user accessibility and policy application were reviewed.
- Growing coverage of cross-sectoral synergies, open access, and improved temporal detail.
- Challenges in representing high resolution energy demand in all sectors.
- Key issues remain in understanding tool coupling, accessibility & perceived policy-relevance.

Open data, tools and processes

Transparency versus 'black boxes' – supporting verification, impact of assumptions, sensitivity analysis

Wider stakeholder engagement by reducing costs for participation

Opportunity to explore wider scenarios



Energy scientists must show their workings

Public trust demands greater openness from those whose research is used to set policy, argues **Stefan Pfenninger**.

The global transition towards a clean and sustainable energy future is well under way. New figures from Europe this month show that the continent is on track to reach its goal of a 20% renewable-energy share by 2020, and renewable capacity in China and the United States is also rising. But many technical, political and economic uncertainties remain, not least in the data and models used to underpin such policies. These uncertainties need open discussion, and yet energy strategies all over the world are based on research not open to scrutiny.

Researchers who seek, for example, to study the economic and energy model used by the US government (called NEMS) are met with a forbidding warning. On its website, the Energy Information Administration, which is developing the model, pronounces: "Most people who have requested NEMS in the past have found out that it was too difficult or rigid to use."

At least NEMS (National Energy Modelling System) is publicly available. Most assumptions, systems, models and data used to set energy policy are not. These black-box simulations cannot be verified, discussed or challenged. This is bad for science, bad for the public and spreads distrust. Energy research needs to catch up with the open-software and open-data movements. We energy researchers should make our computer programs and data freely accessible, and academic publishing should shun us until we do.

Our community's models are relevant to policy because they explore alternative scenarios or seek to understand the technical constraints on deploying new energy technologies. It is modelling for insight (by an academic exploring a range of qualitatively different scenarios for a clean energy supply, say) and for numbers (as in a government agency deciding on the remuneration level of a technology-support scheme).

Trust in this research matters because it contributes to policies on energy — and, by extension, on climate mitigation — that produce winners and losers throughout the global economy, and so can be hotly contested. Such policies are among the crucial driving forces that led to the current surge in the development of wind and solar power.

The list of reasons why energy models and data are not openly available is long: business confidentiality; concerns over the security of critical infrastructure; a desire to avoid exposure and scrutiny; worries about data being misrepresented or taken out of context; and a lack of time and resources.

This secrecy is problematic, because it is well known that closed systems hide and perpetuate mistakes. A classic example is the spreadsheet error discovered in the influential Reinhart–Rogoff paper used to support economic policies of national austerity. The European Commission's Energy Roadmap 2050 was based on a model that could not be viewed by outsiders, leaving it open to criticism. Assumptions that remain hidden, like the costs of technologies, can largely determine what comes out of such models. In the United Kingdom, opaque and overly optimistic cost assumptions for onshore wind went into models used for policymaking, and that may well have delayed the country's decarbonization.

This closed culture is alien to younger researchers, who grew up with collaborative online tools and share code and data on platforms such as GitHub. Yet academia's love affair with metrics and the pressure to publish set the wrong incentives: every hour spent on cleaning up a data set for public release or writing open-source code is time not spent working on a peer-reviewed paper.

BLACK-BOX **SIMULATIONS** CANNOT BE **VERIFIED,** DISCUSSED OR **CHALLENGED.**

Nevertheless, some academic-led projects are pushing towards more openness. The Enipedia project is building a worldwide open database on power plants, with data such as their locations and emissions. The Open Power System Data project gathers data such as electricity consumption from government agencies and transmission-network operators, and pushes for clarity on the licensing under which these data are made available. The Open Energy Modelling Initiative is emerging as a platform for coordinating and strengthening such efforts.

Regulation can also help. The European Union has mandated open access to electricity-market data, resulting in the creation of the ENTSO-E Transparency Platform to hold it, and there are good arguments for the creation of national energy-data agencies to coordinate the collection and archiving of a range of important data.

The vast majority of published research is still untouched by these fledgling initiatives. Only one energy journal — *Energy Economics* — currently requires data and models alongside submissions. Other journals should follow suit.

The open sharing of code and data is also important because it permits more meaningful collaboration between academics. Sharing a DNA sequence in an established format is, of course, easier than sharing the unstructured assumptions behind a techno-economic scenario study, for which no standard format exists yet. So the energy community must decide on standards for sharing code, data and assumptions.

A change in journal policies would help to kick-start these discussions. In policy-focused research, where one 'truth' does not exist, one cannot assess whether a modelled scenario is 'correct', so the important yardstick is not truth, but trust. The arrival of the post-truth world shows that trust in experts is lower than ever — and surely this is partly the experts' fault. ■

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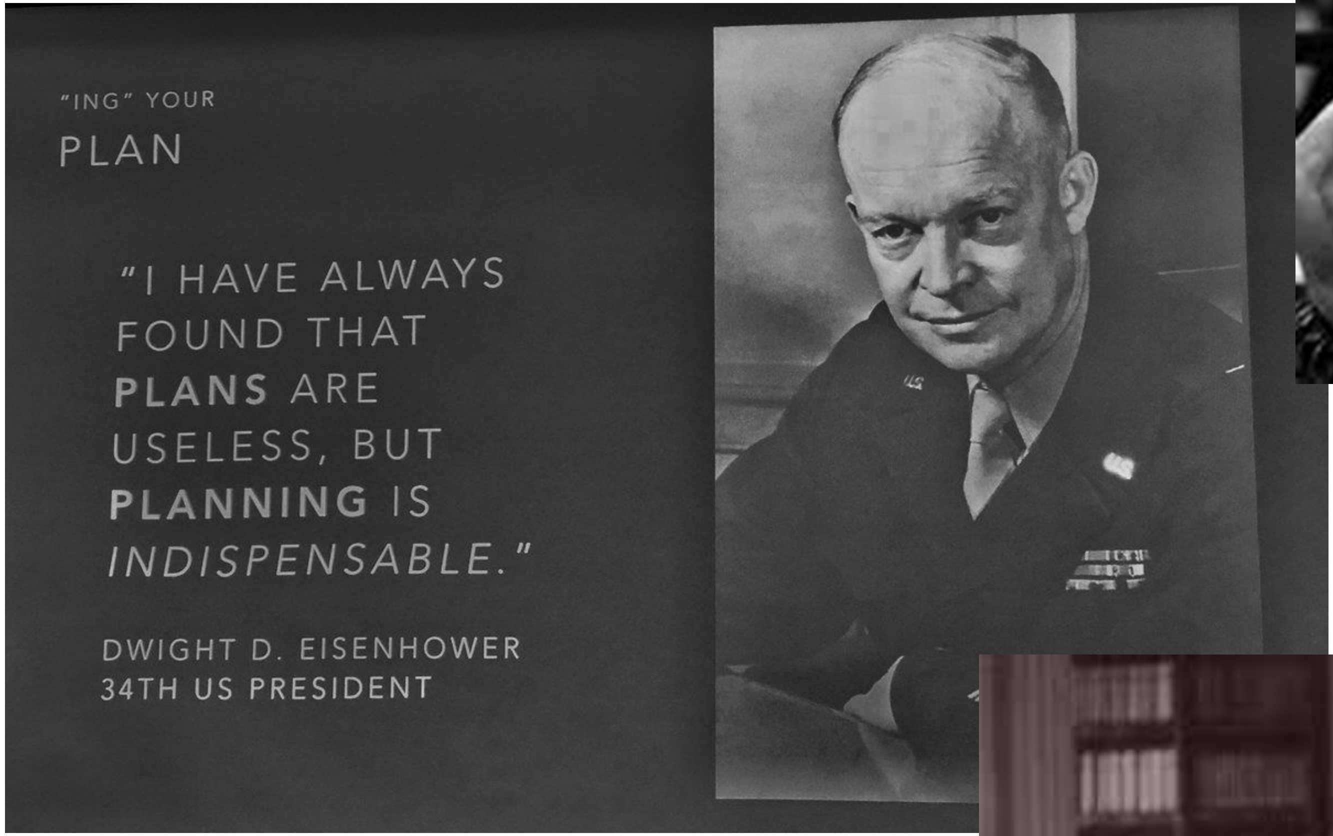
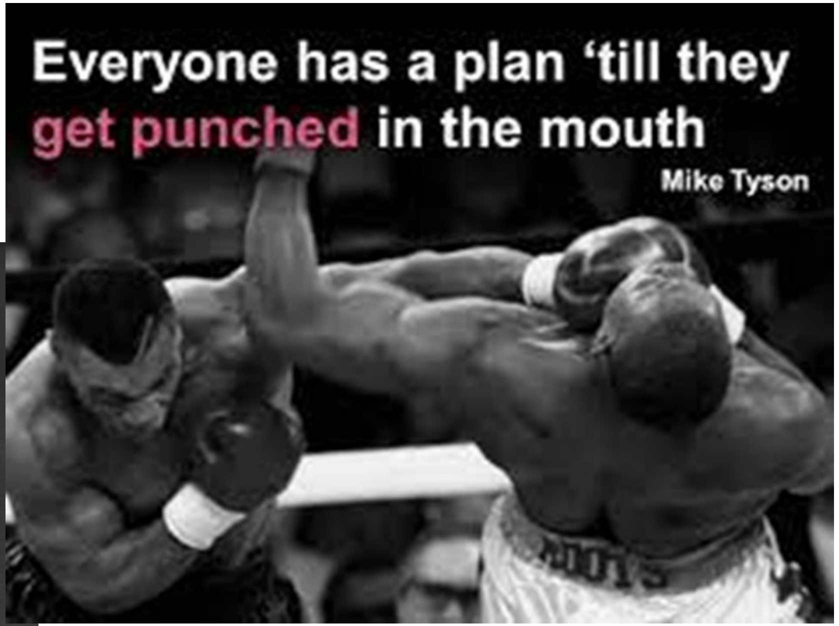
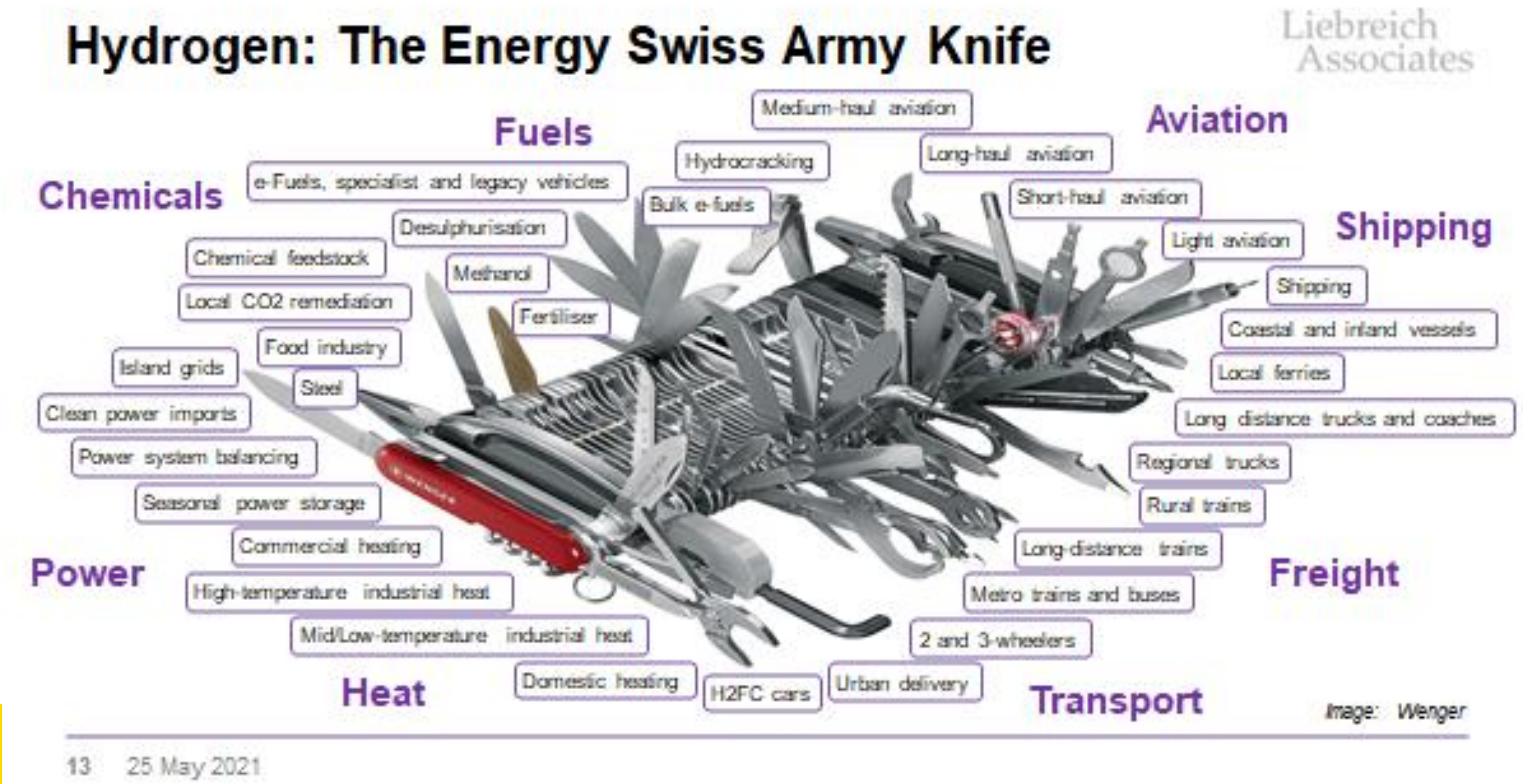
Plans vs planning

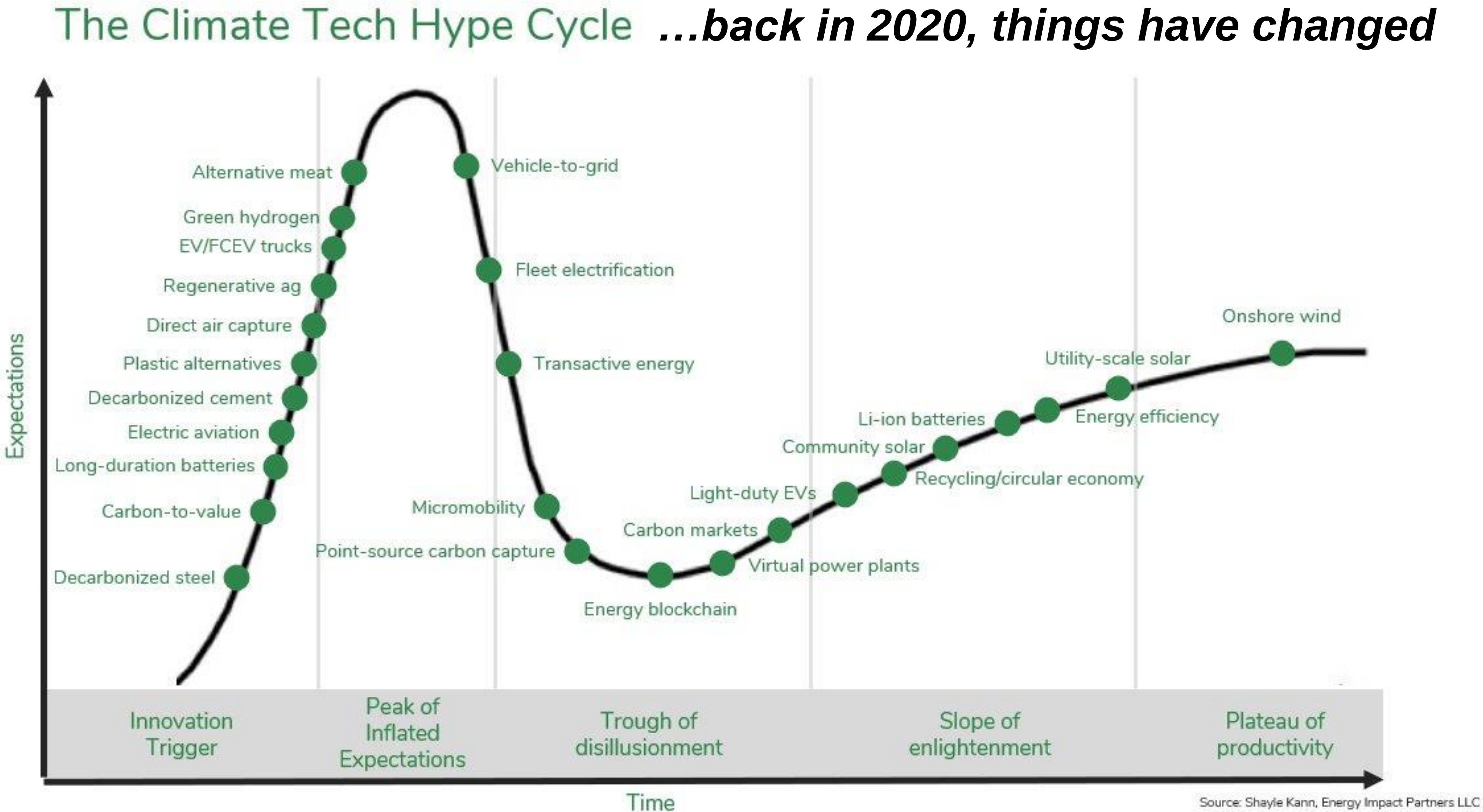




Hydrogen can do just about everything ....
but what does it do better than other options?



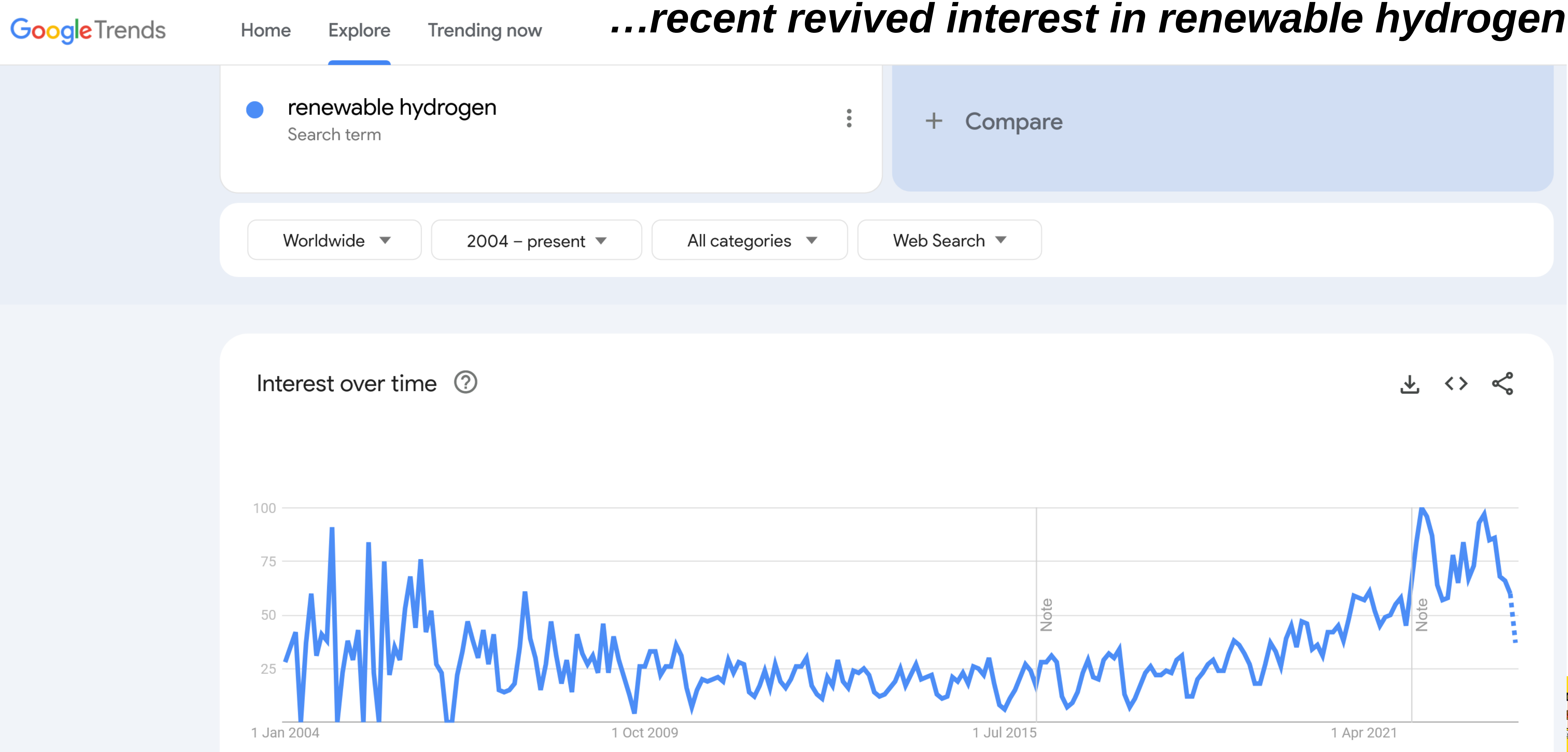
Where are on the renewable h2 hype cycle?



…back in 2020, things have changed

Where are we on the renewable h2 hype cycle?

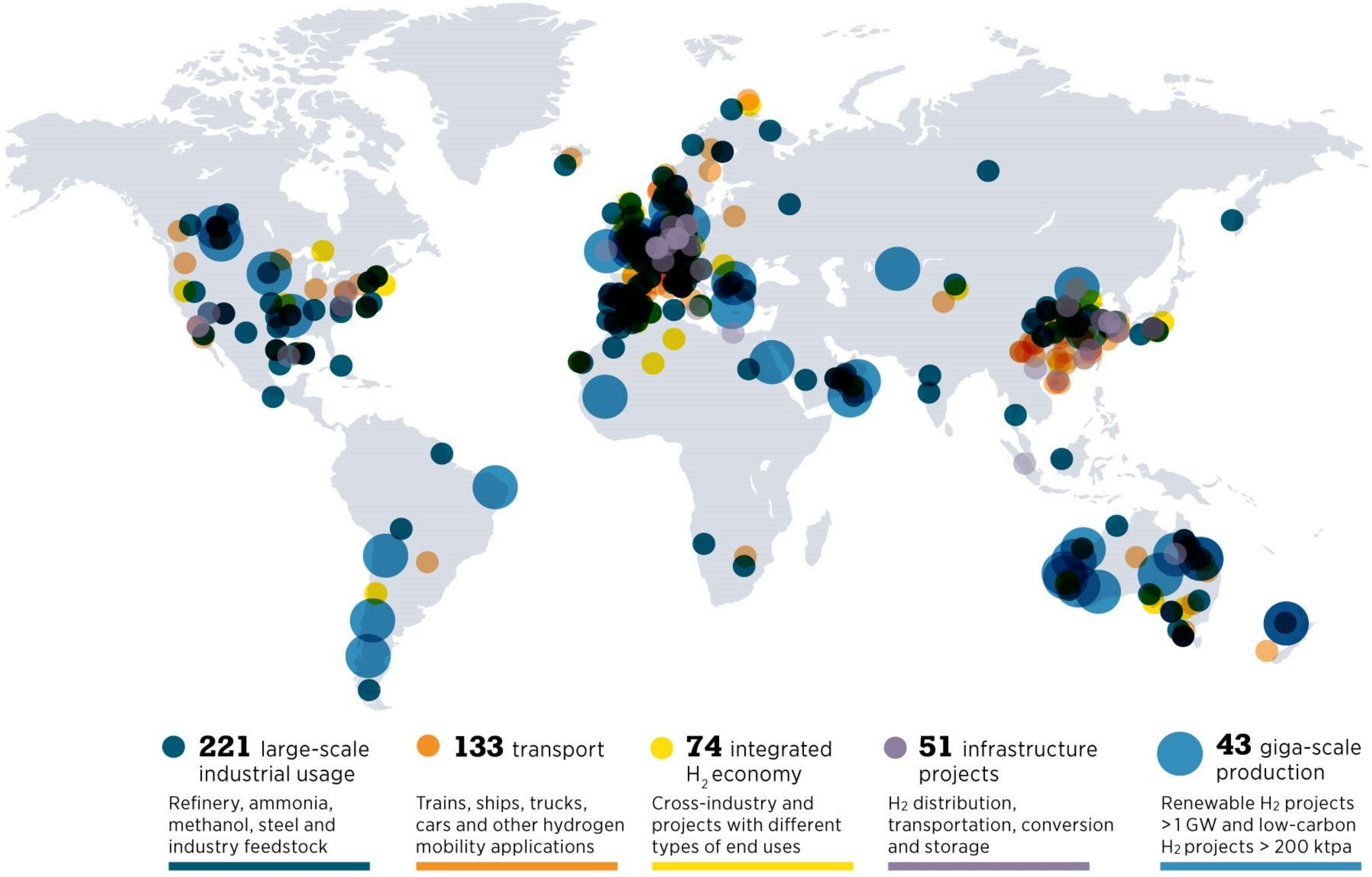
…recent revived interest in renewable hydrogen



Now past peak hype, ready to establish renewable hydrogen's contribution to clean energy transition

Growing global interest in major hydrogen and derivative projects….

although only limited progress to date



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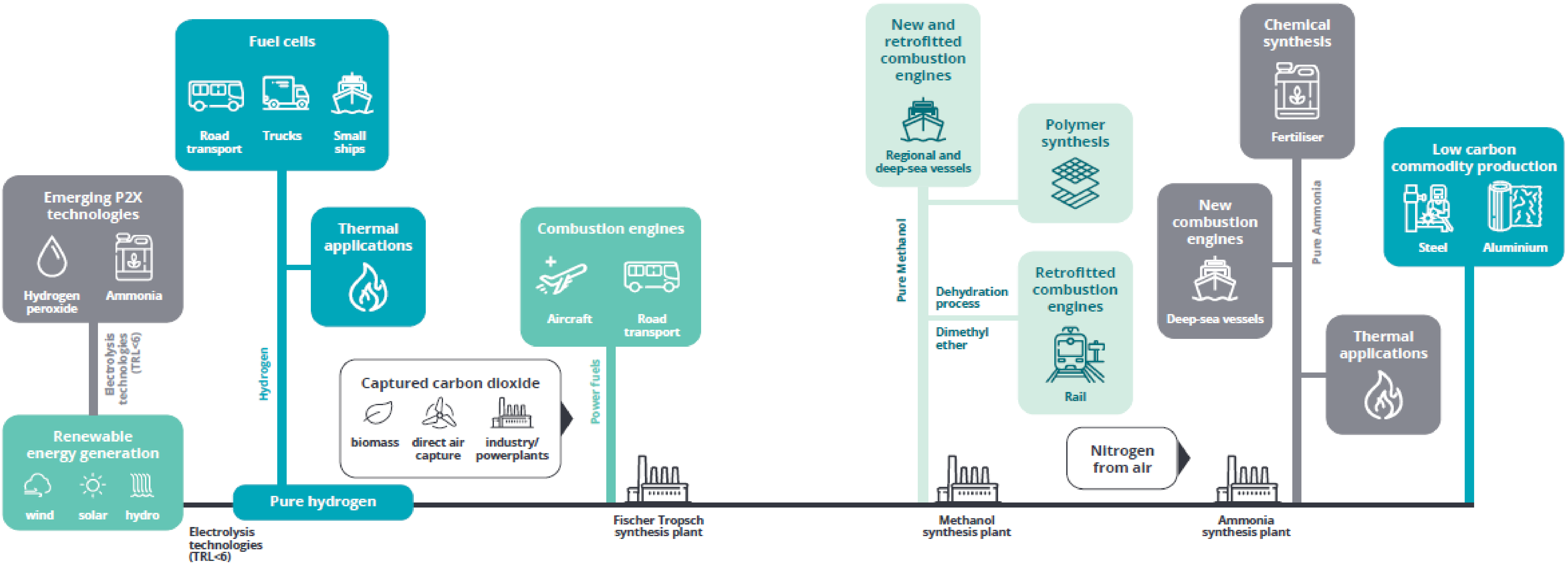
First Q: What are the key roles for hydrogen?

A: Assist in sectors which are otherwise hard to decarbonize

Next Q: Is it h2 or an h2 derivative that we really need?

A: It depends (intended use, other factors)



Liquids particularly promising – various PtL Pathways

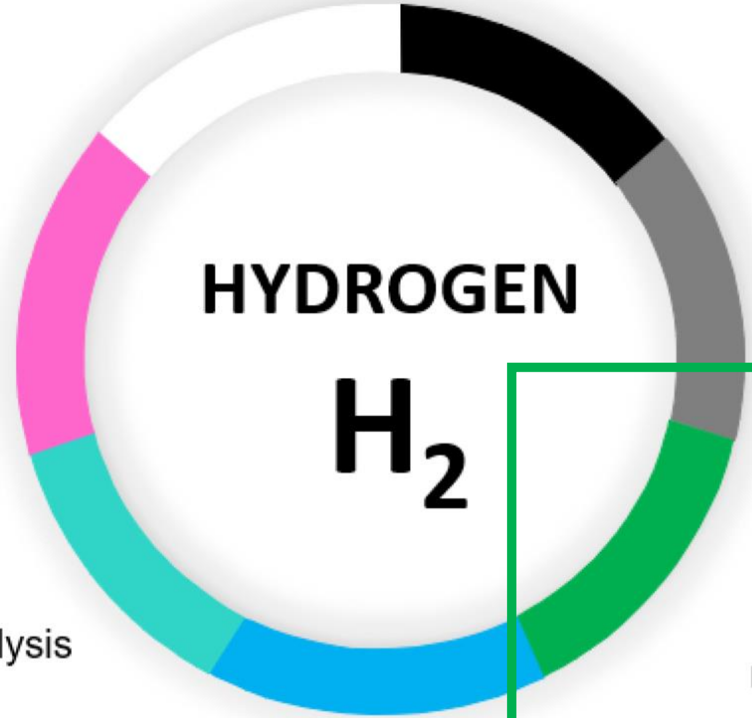
PowerFuel Comparison

Each of the powerfuels evaluated offer pathways for decarbonising existing and emerging applications. However, there are parameters that must be considered when developing the value chain for these powerfuels, including decarbonisation benefits, safety and storage conditions, which are summarised in the table below:

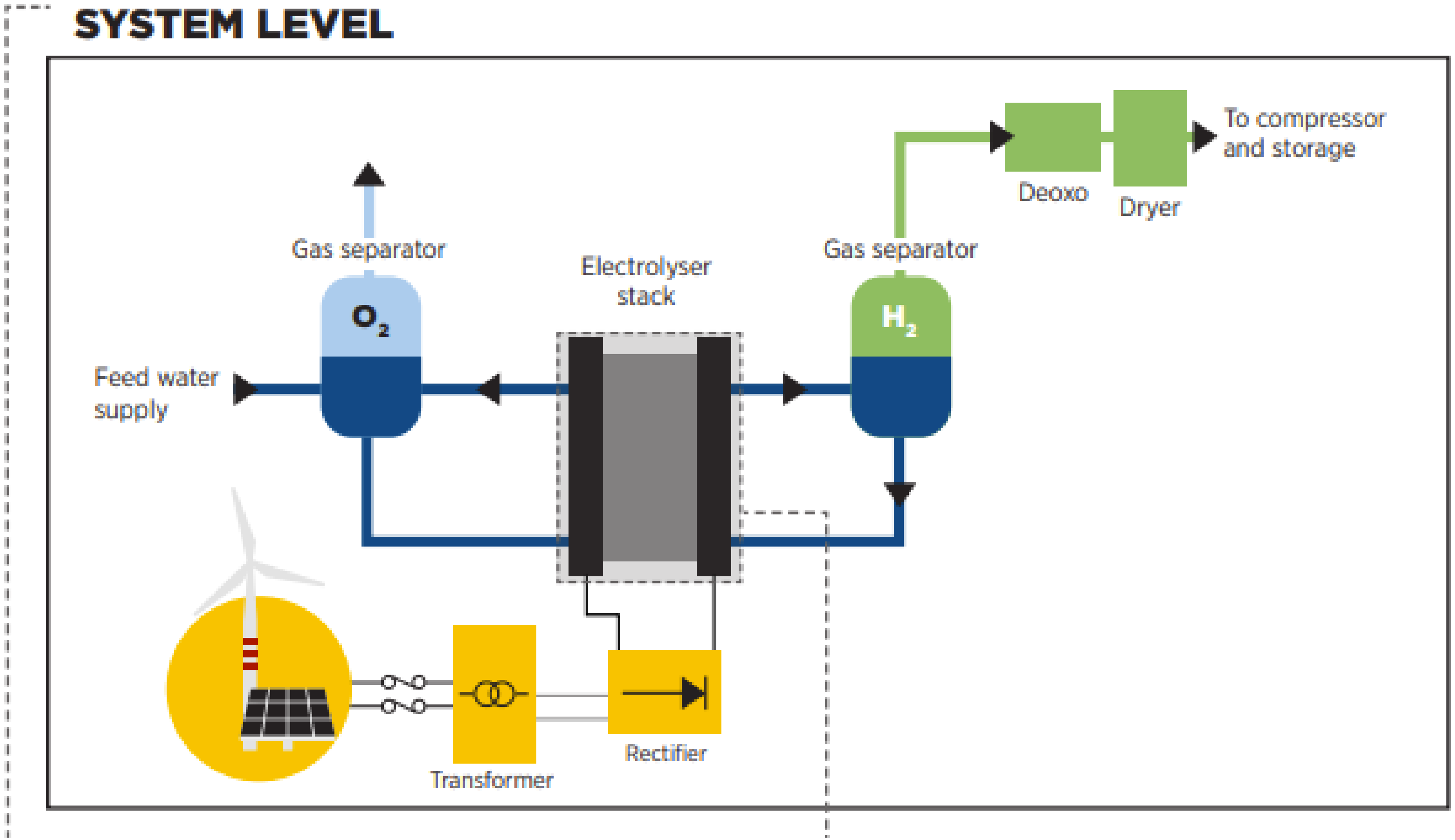
	NH_3 Ammonia	CH_3OH Methanol	SNG Synthetic Natural Gas	SAF Sustainable Aviation Fuel
Production, Storage & Transport Technology Readiness Level	TRL 9	TRL 8	TRL 9	Production via PtL[c,d]: TRL 7 – 8 Storage & Transport: TRL 9
Powerfuel Storage Conditions	Pressurised: Ambient temperature and 16-18 bar Low-Temperature Liquid: minus 33°C and 1.1-1.2. bar	Ambient conditions as liquid	Pressurised:200-250 bar at ambient temperature Liquified: -162°C	Ambient conditions as liquid. Can use conventional jet fuel storage infrastructure
Volumetric Energy Density (MJ/L)[a,b]	12.7	16.0	20.6	33.2
Gravimetric Energy Density (MJ/kg)[a,b]	18.6	20.0	53.6	44.2
Decarbonisation Benefit (kg CO_2-e/kg fuel)[e,f]	0	0.25	0.18	0.33-0.52 for bio-based production. Lower values for PtL production
Safety	Flammable with toxic fumes and dangerous for the environment if released	Flammable, toxic and dangerous for the environment if released	Highly flammable and will explode at gas-to-air ratio between 5% and 15%	Aviation
End-Use Sectors	Agriculture, Mining, Power Generation, Maritime, Chemical Feedstock	Power Generation, Mining, Maritime, Chemical Feedstock	Power Generation, Residential Appliances	Aviation

References:
a.- H2 Tools.Link
b.- IATA. Link
c.- Johnson Matthey. Link
d.- Collis, J., Duch, K. & Schomäcker, R. Techno-economic assessment of jet fuel production using the Fischer-Tropsch process from steel mill gas. Front. Energy Res. 10, (2022). DOI: 10.3389/fenrg.2022.1049229
e - ICAO. Link
f.- Sean M. Jarvis, Sheila Samsatli, Renewable and Sustainable Energy Reviews Link

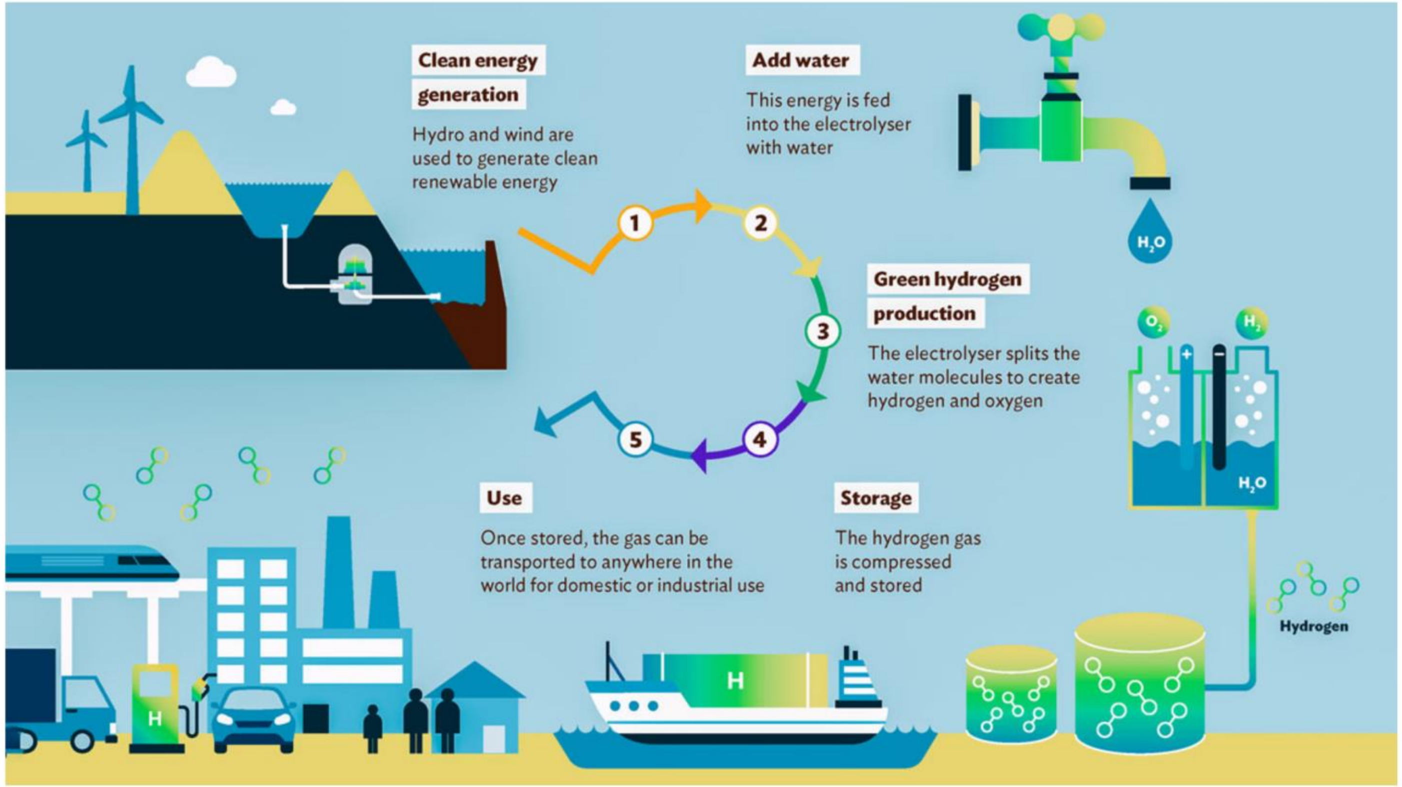
Why the different colors of hydrogen … *and which will sellers want to sell, buyers want to buy?*



Green / renewable hydrogen from electrolysers the only sustainable option in the longer term



Renewable hydrogen – energy and climate hero … or villain?



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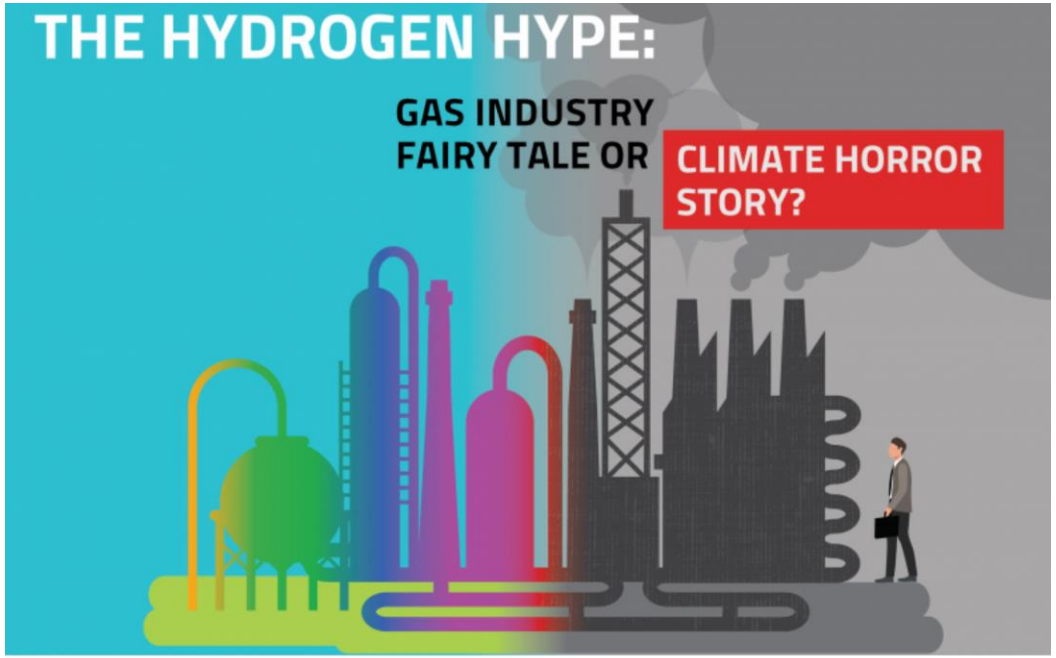
Renewable Hydrogen: Driver of Green Revolution in Europe?

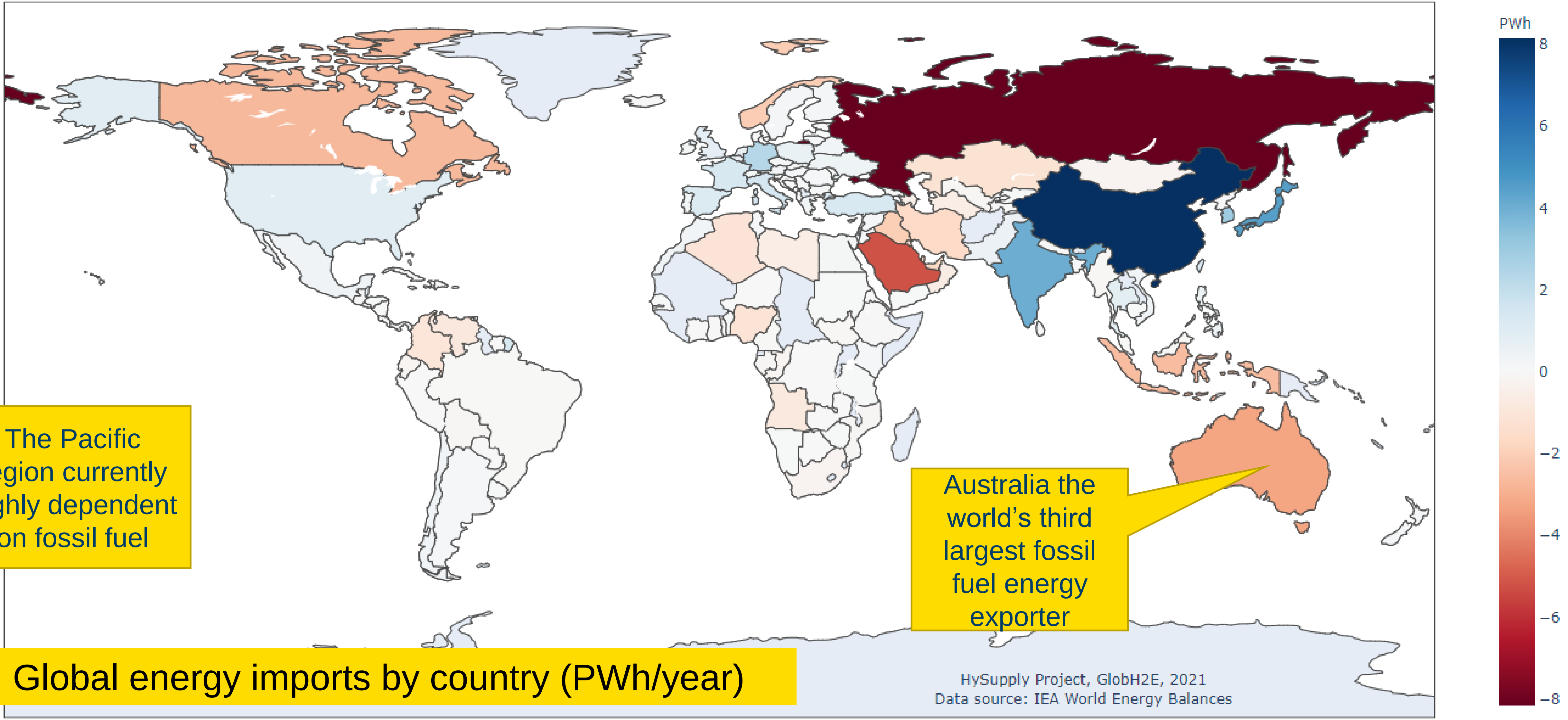
Rona Rita David · August 11, 2021 Last Updated: August 11, 2021 4,338 12 minutes read



The hydrogen hype: Gas industry fairy tale or climate horror story?

Will we import it or make our own?

Current global energy trade largely an outcome of the availability of easily extracted low-cost fossil fuels



The Pacific region currently highly dependent on fossil fuel

Australia the world's third largest fossil fuel energy exporter

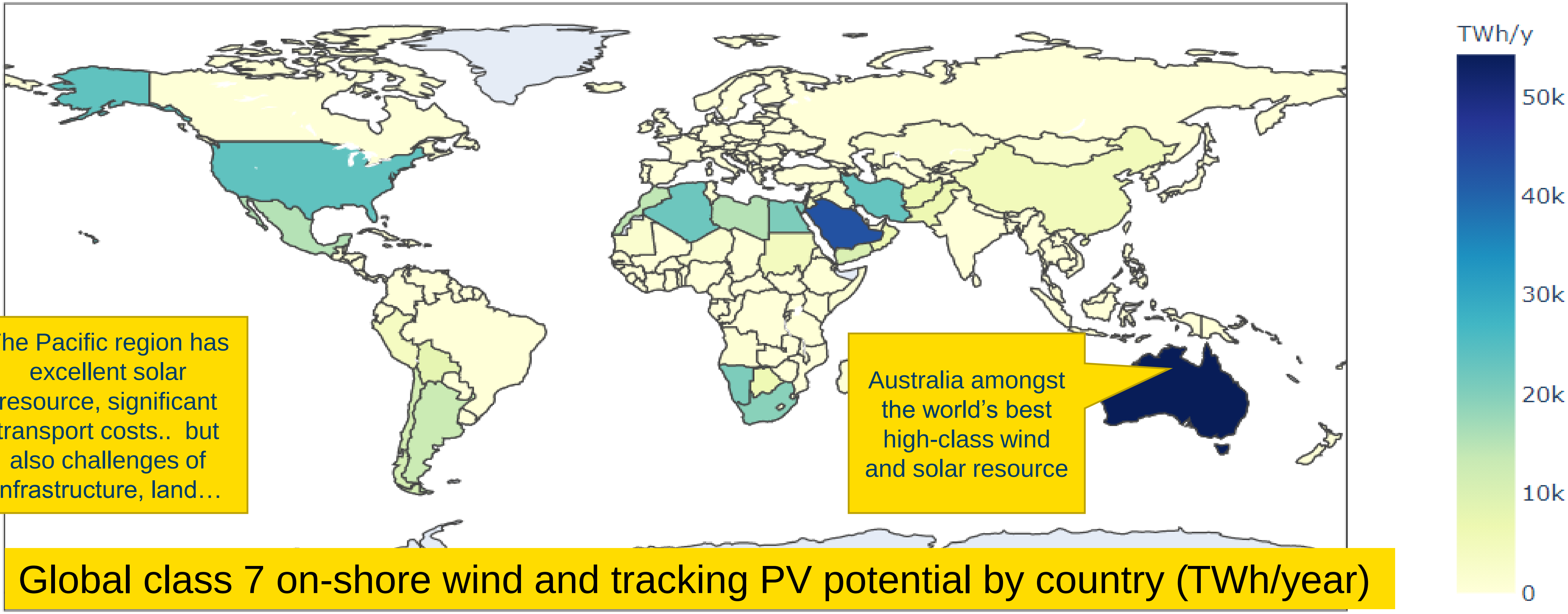
Global energy imports by country (PWh/year)

A mostly renewable world more self reliant

… however, some countries/regions still likely to require energy imports including Germany and some others in Europe, Japan, Korea

Potentially new renewables 'electrostate' exporters, likely some old ones

What of the pacific? A buyer, self reliant, a seller?



The Pacific region has excellent solar resource, significant transport costs.. but also challenges of infrastructure, land…

Australia amongst the world's best high-class wind and solar resource

Global class 7 on-shore wind and tracking PV potential by country (TWh/year)

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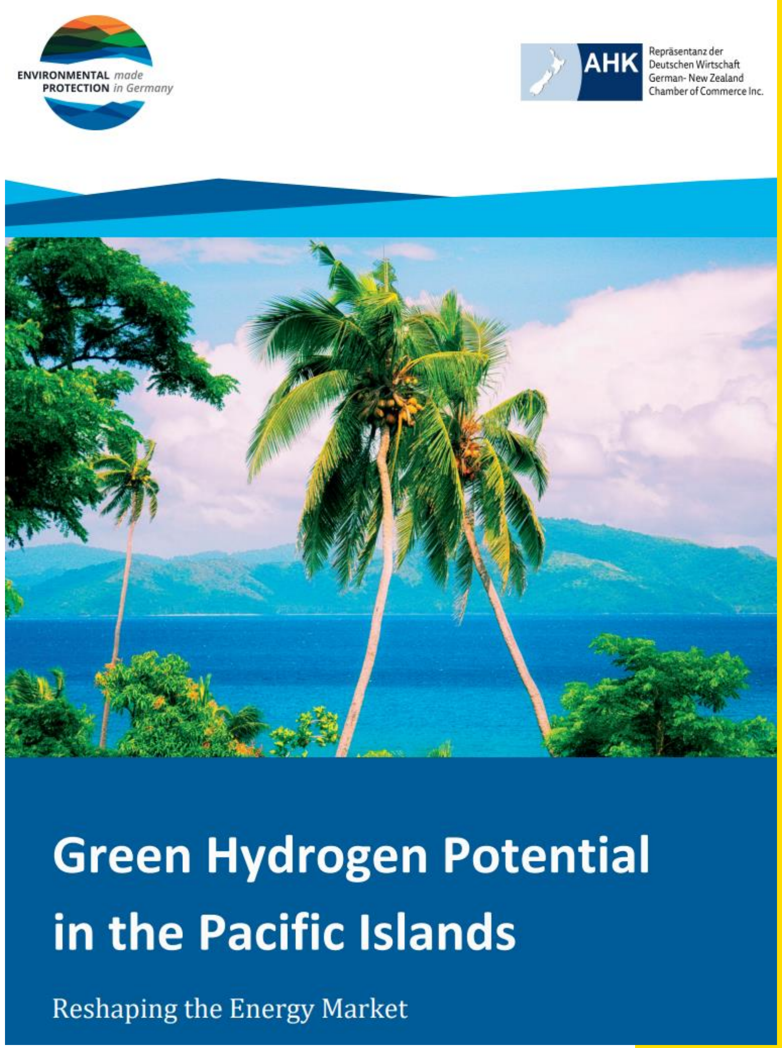
Pacific Green Hydrogen Project

- The German New Zealand Chamber of Commerce’s (GNZCC) regional responsibility includes seven countries in the Pacific – Fiji, Samoa, Tonga, Cook Islands, Kiribati, Niue, and Tuvalu.
- Roles of the GNZCC include:
  - Business Intelligence
  - Consulting Services for Market Entry
  - Sourcing for Business Partnerships
  - International Trade Fair Participation
- The Pacific Green Hydrogen Project aims to connect small-to-medium German enterprises that manufacture hydrogen technologies for an off-grid application in the Pacific Islands.
- Excess energy from renewable energy plants is stored in the form of hydrogen and oxygen by electrolysis. This green hydrogen can be used to generate electricity with the help of a fuel cell.



Reference: https://neuseeland.ahk.de/en/services/projects/pacific-green-hydrogen-project

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Renewable H_2 to Palau

- Queensland-produced renewable hydrogen will be exported to the Republic of Palau from 2023 as part of a collaboration between Sojitz Corporation, Nippon Engineering Consultants and CS Energy.
- The project will assess the potential of renewable hydrogen for use in fuel cells and marine vessels in Palau to reduce its reliance on fossil fuels and has received subsidies from Japan’s Ministry of the Environment.
- Renewable hydrogen for the project will be supplied from CS Energy’s Kogan Renewable Hydrogen Demonstration Plant, which will be built on the Western Downs and produce renewable hydrogen from behind-the-meter solar energy.

Figure: Kogan renewable hydrogen plant (1 MW electrolyser, 2 MW solar PV farm).

Reference: https://www.csenergy.com.au/news/queensland-renewable-hydrogen-to-power-pacific-islands-demonstration-project

HDF Project in Fiji

- The HDF Energy Australia team is currently developing a green hydrogen project on Fiji's Viti Levu island.
- The plant could generate 6 MWe of electricity during the day and evening, and 1.5 MWe throughout the night.
- HDF develops, finances, builds and operates multimegawatt industrial power generation infrastructures.
- HDF marketed the Renewstable® power plants, which capture intermittent renewable energy and store it massively in the form of hydrogen. HDF Energy currently has around ten Renewstable® projects in the advanced development phase in several countries.

Figure: Concept images of the solar PV farm and the hydrogen generation, storage, and fuel cell facilities.

Reference: https://www.hydrogenpower-fiji.com/

H_2 Powered Boats in Fiji

- Fiji aims to begin replacing its current Government shipping fleet with hybrid and green hydrogen solutions.
- During Fiji's Presidency of COP23, it launched the 'Oceans Pathway', with the expectation to place oceans where it belongs – at the heart of climate action.
- In Fijis's Low Emissions Development Strategy 2018-2050, the potential for methanol, ammonia, and hydrogen as the most likely alternative fuels for maritime transport is discussed.

FIJI NEWS | NATION | NEWS

PM: Fiji To Replace Govt Vessels With Hybrid, Green Hydrogen Solutions

During Fiji's Presidency of COP23, it launched the 'Oceans Pathway', with the expectation to place oceans where it belongs – at the heart of climate action.

By **Rosi Doviverata**

05 Nov 2021 15:30

References:

https://fijisun.com.fj/2021/11/05/pm-fiji-to-replace-govt-vessels-with-hybrid-green-hydrogen-solutions/

https://unfccc.int/sites/default/files/resource/Fiji_Low%20Emission%20Development%20%20Strategy%202018%20-%202050.pdf

Hydrogen Production in Papua New Guinea

- Two agreements between Fortescue Future Industries and Papua New Guinea signed in 2020 and 2021 enabled feasibility studies on up to 18 hydropower and geothermal projects in the country, including a hydro project along the Purari River on the nation's southern coast.
- These projects would provide renewable hydrogen to TotalEnergies' Papua LNG project.
- However, Fortescue has not provided any updates on the projects since December 2021 when it said a pre-feasibility study was well advanced.

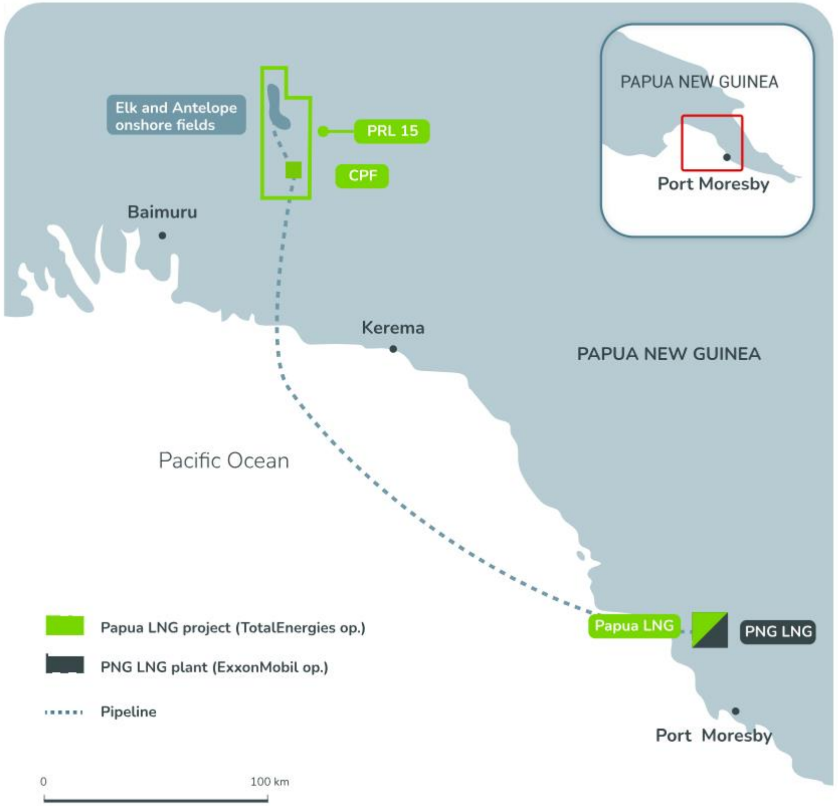

Figure: The Papua LNG project.

Reference: https://www.reuters.com/business/energy/totalenergies-may-buy-green-power-fortescue-papua-new-guinea-regulator-2022-12-08/

Many challenging questions for the pacific region, and its numerous jurisdictions

- Deployment of new technologies in the region – *leading edge* versus *bleeding edge*
- Possible strategies
  - *Leading by example* vs *first to be second*
  - Independent expert review and assistance for the region
  - Tools that can help us assess the potential role of these technologies while minimizing risks and regret
  - Technology roadmapping

Leading Edge vs. Bleeding Edge

- Bleeding Edge: When failure occurs because an organization tries to be too far out on the technological leading edge
  - Time-Warner's Pathfinder portal
- Leading Edge: Let competitors test the new technology first

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Possible pathways – Independent Expert Panels

Planned Release of Radioactively Contaminated Cooling Water from the Fukushima Nuclear Power Plant Disaster

Executive Summary from the Expert Panel to the Pacific Islands Forum June 2, 2022

Prepared by

Dr Ken Buesseler, Senior Scientist and Oceanographer, Woods Hole Oceanographic Institution
Dr Arjun Makhijani, President, Institute for Energy and Environmental Research
Dr Antony Hooker, Associate Professor and Director, Centre for Radiation Research, Education and Innovation, The University of Adelaide
Dr Ferenc (Jacob Rolf) Dalnoki-Veress, Scientist-in-Residence & Adjunct Professor, James Martin Center for Nonproliferation Studies, Middlebury Institute of International Studies at Monterey
Dr Robert H. Richmond, Research Professor and Director, Kewalo Marine Laboratory, University of Hawaii at Manoa.

The Japanese Government is considering allowing the Tokyo Electric Power Company (TEPCO), to begin releasing over 1 million tons of radioactively contaminated cooling water from the Fukushima nuclear power plant disaster, starting in early 2023, over a period of decades. Construction of the associated facilities is planned to begin in July 2022. It is the unanimous opinion of the PIF Expert Panel that these decisions are premature given the scientific data and based upon recent discussions with Japanese government officials and experts as detailed below.

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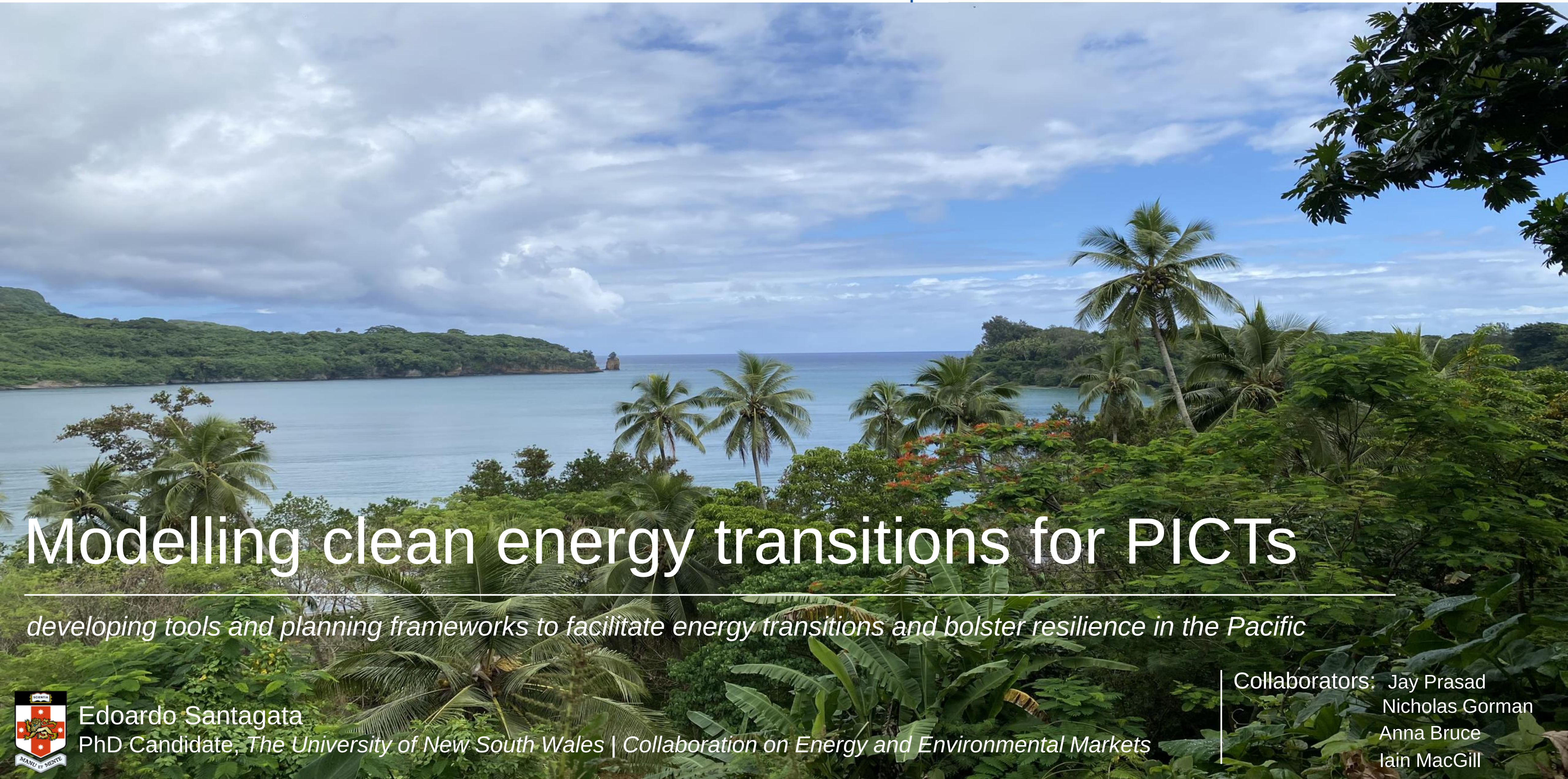


Modelling clean energy transitions for PICTs

developing tools and planning frameworks to facilitate energy transitions and bolster resilience in the Pacific

Edoardo Santagata
PhD Candidate, *The University of New South Wales* | *Collaboration on Energy and Environmental Markets*

Collaborators: Jay Prasad
Nicholas Gorman
Anna Bruce
Iain MacGill

ENERGY MODELLING PRINCIPLES

Energy Supply Chain: **RESOURCES** → **CONVERSION** → **DELIVERY** → **CONSUMPTION**

MODELLING: simplified & organised model structures to represent every step of the supply chain

Accurately represent future scenarios

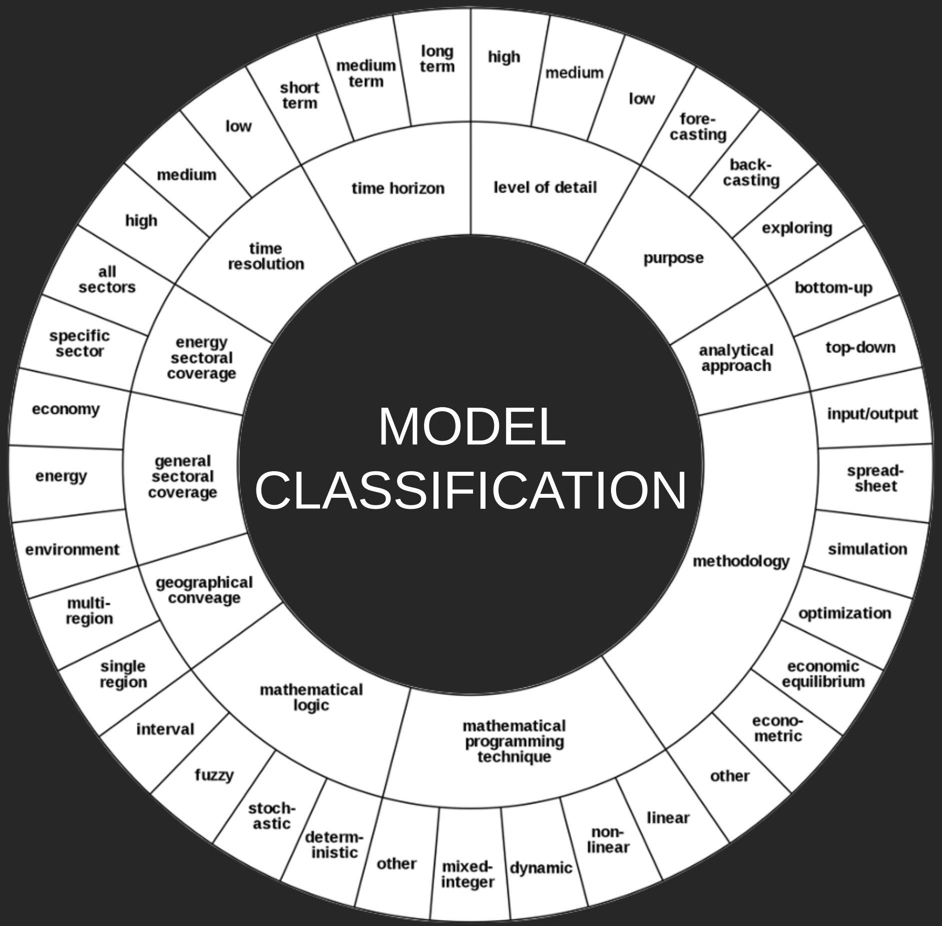
Provide flexible options to forecast demand and the uptake of specific technologies

Assist with energy planning & policy making

Assess the outcomes of specific technologies and trends to make better decisions regarding capacity and policy mechanisms

Track progress against strategic targets

Determine how likely an energy system is to meet current targets relating to specific technologies and emissions

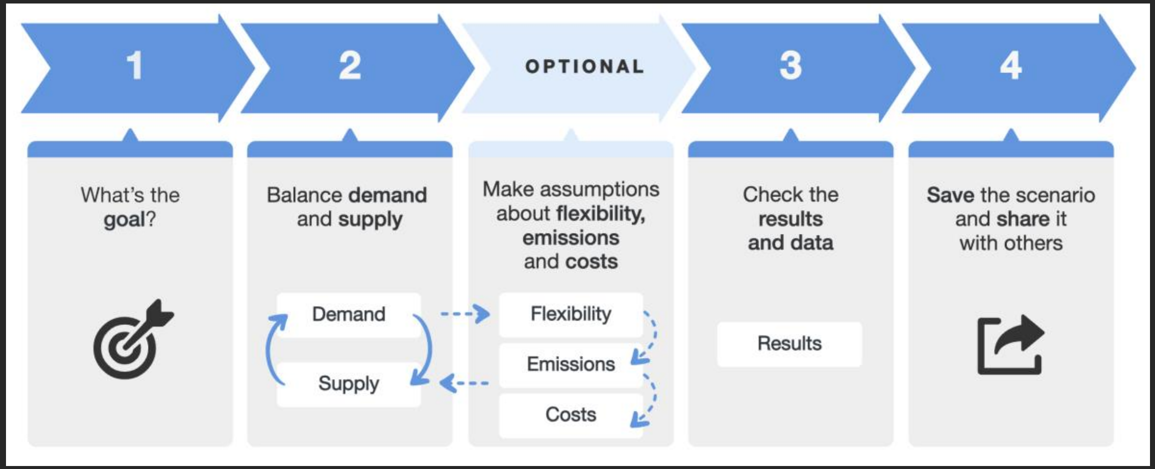


Energy Transition Model (ETM)

ENERGY TRANSITION MODEL
Independent, Comprehensive and Fact-based

Quintel

Open-source multi-sectoral simulation model with interactive dashboard to produce future energy scenarios and assist with transition planning



Piloting study for VANUATU & SOLOMON ISLANDS

Policy & Strategy Development

Assist in developing effective energy policies and goals to support clean energy transitions

Energy Independence

Identify opportunities to reduce need for fuel imports and expand local renewable energy resource utilisation

Economic Development

Identify opportunities to expand economy & infrastructure in conjunction with energy sector

Data Centralisation

Opportunity to adopt a proven database manager to track national/state energy production, conversion, and consumption

Transition Tracking

Understand pathways to achieve targets in energy and related sectors

DATASET MANAGER

Energy Transition Model
Dataset Manager

Information | English | LOG IN

Singapore

Created by Quintel

- General
- ↳ Geography
- ↳ Emissions
- ↳ Emission factors
- ↳ Infrastructure
- Households
- Buildings
- Transport
- Agriculture
- Industry
- Other energy demand
- Energy production
- Hourly curves

Below you will find information about the networks for electricity and district heating. You can see how high the current costs of the electricity network are, how much capacity is still available on the network and how expensive future expansions will be to be. Have a look at our documentation for an explanation of the electricity network calculation in the ETM. For heat networks you will find information about the pipe lengths on this page.

Present electricity grid costs

Current total investment costs per grid level

Low voltage grid	37,239,554	€
Medium voltage grid	32,002,741	€
High voltage grid	18,805,975	€
LV-MV transformers	13,266,591	€
MV-HV transformers	11,171,866	€
Offshore wind grid	0	€
Interconnector capacity	233,776,220	€

Present gas grid costs

Total gas infrastructure costs	14,520,000,000	€

Present spare capacity electricity grid

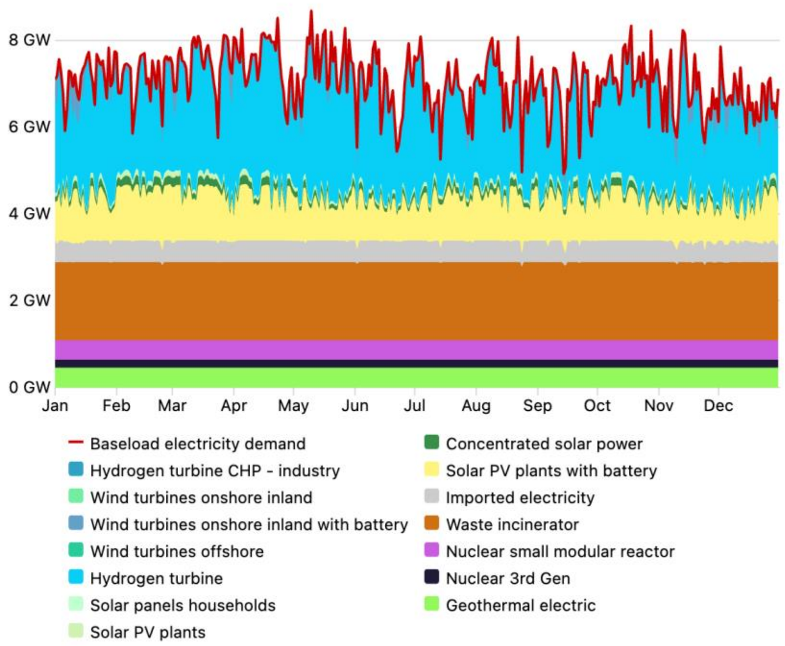
Gemiddeld percentage reservecapaciteit per netniveau

Low voltage grid	25 %

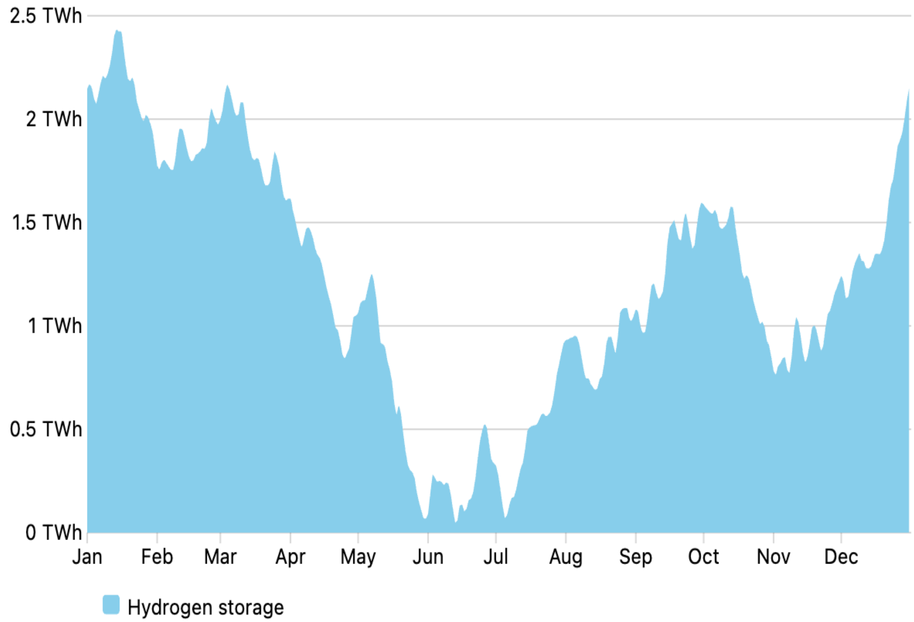
A look at the dashboard…

EXAMPLE OUTPUTS

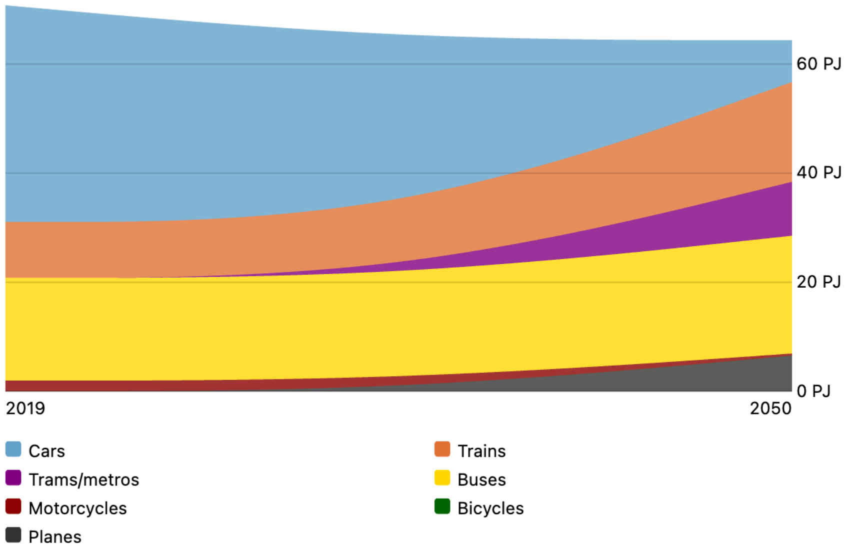
Electricity production per hour



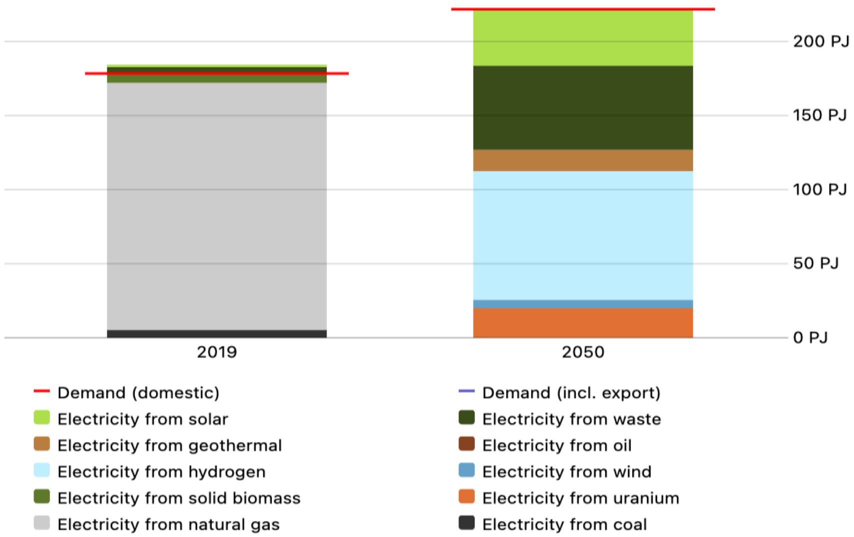
Hydrogen storage



Final energy demand of passenger transport per application



Electricity production



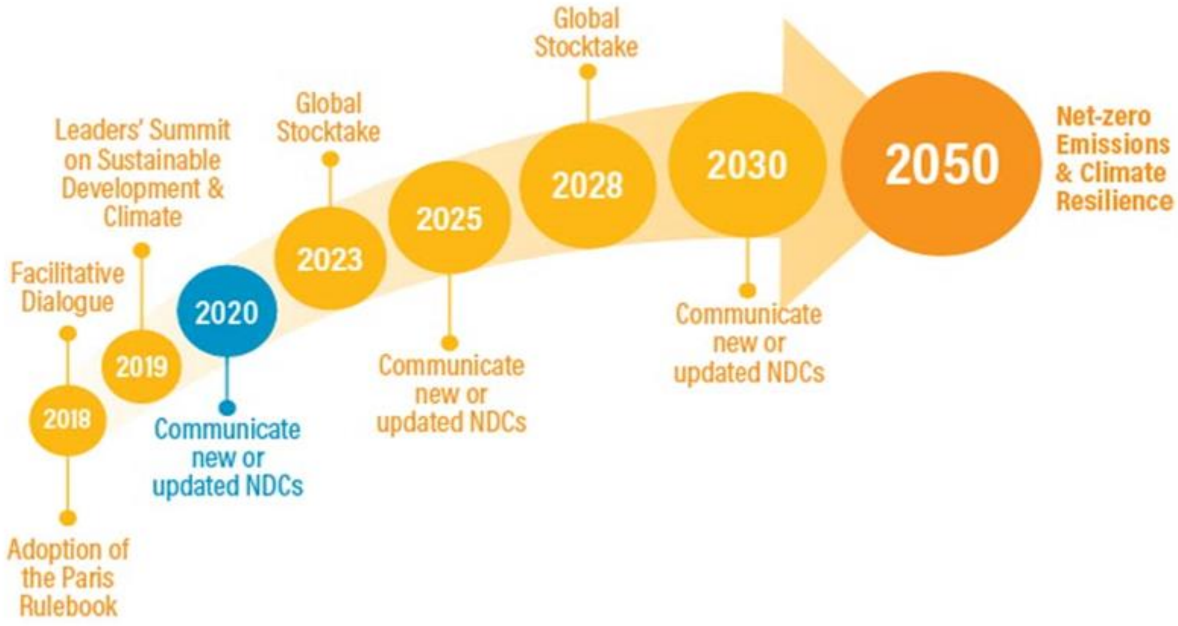
Regional Green Hydrogen Roadmapping

Workplans, Early findings and Possible Ways Forward

Led by Dr Rahman Daiyan, UNSW Sydney

Global Contributions of PICTs

- The Pacific Island Countries and Territories are a minor contributor to global emissions – the assessed PICTs contribute only **0.03%** of global energy-related CO_2 emissions.
- It is understood that the PICTs are in no meaningful way responsible for the emissions of GHGs and their effect on global climate change, however they **feel the effects of climate sooner and more disproportionately** compared to most of the rest of the world.
- As such, the PICTs have put forth ambitious energy and climate targets in their nationally determined contributions (NDCs), to **set forth an example for achieving net zero** by 2050 and limiting the effects of climate change.



Energy and Emissions Overview

Energy Breakdown

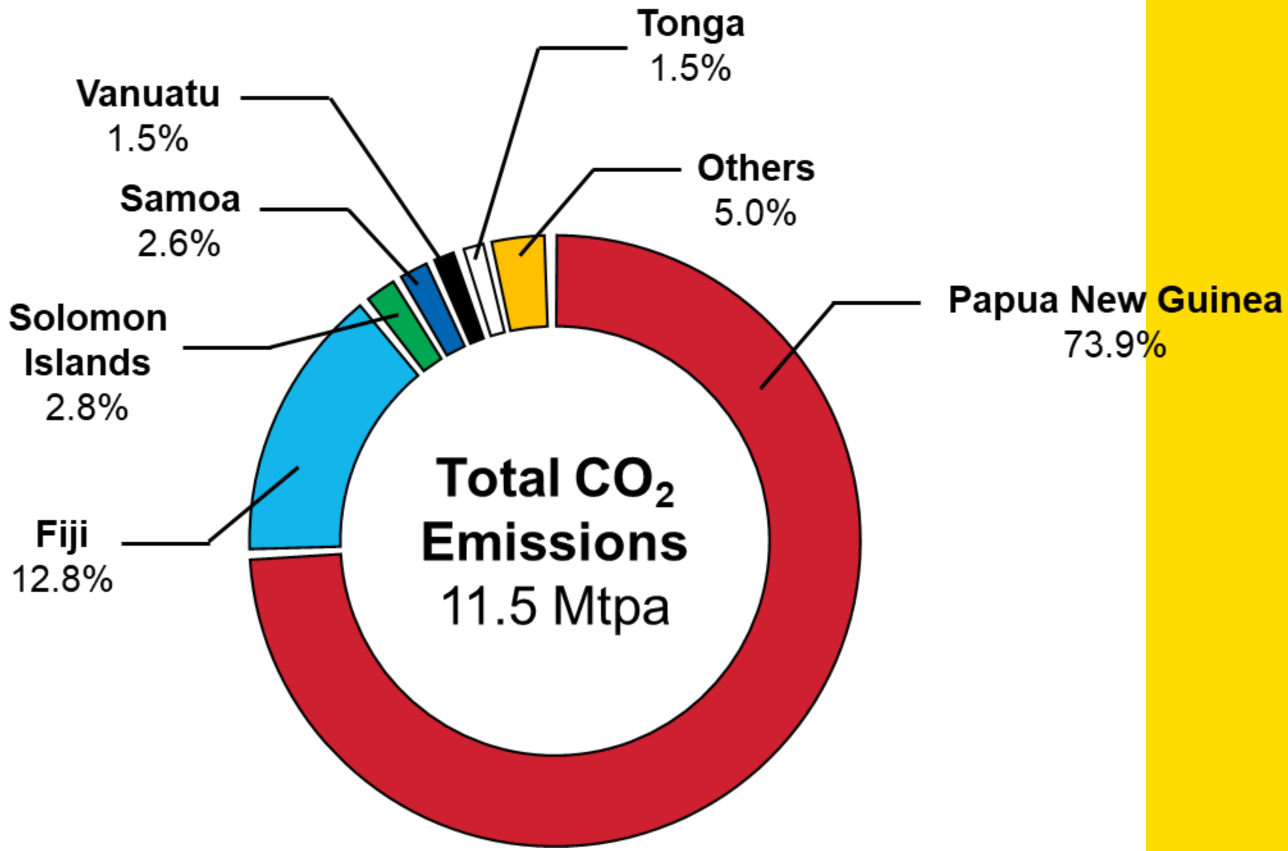
- On average, the total energy usage of each PICT is around 81% fossil fuel based, which is mostly imported, highlighting their heavy exposure to volatile oil prices.
- Whilst only around 60% of total energy use in the Solomon Islands, Papua New Guinea, and Kiribati is fossil fuel based, biomass contributes most of the remainder of their energy, which can be considered sustainable however still contributes to emissions of CO_2.
- Papua New Guinea (9.7%) and Fiji (7.9%) generate the largest proportion of their total energy supply as renewable energy.

PICT	Total Energy Use (TWh)	Fossil-Fuel Based (%)
Fiji	7.24	75
Samoa	1.58	70
Vanuatu	0.90	72
Solomon Islands	2.11	56
Papua New Guinea	54.88	56
Kiribati	0.45	63
Micronesia	0.60	94
Tonga	0.64	98
Cook Islands	0.35	91
Marshall Islands	0.35	99
Tuvalu	0.04	94
Nauru	0.20	99
	Total: 69.33 TWh	**Average:** 81%

Note: Renewable energy sources considered include solar, wind, geothermal, and hydro. Biomass is not included. See the accompanying appendices for further information.

Emissions Breakdown

- Papua New Guinea is responsible for the majority of CO_2 emissions from the assessed PICTs (8.5 Mtpa), whilst ten of the twelve PICTs combined comprise less than 15% of emissions.
- Emissions in the PICTs are mostly associated with electricity generation, use in industry, and transport (domestic land, maritime, and aviation transport).



Other nations: Kiribati, Micronesia, Cook Islands, Marshall Islands, Tuvalu, Nauru

Note: International aviation emissions (i.e., those of national air carriers) are not considered in these values. These values are mostly energy-related CO_2 emissions, and do not include GHG emissions (such as CH_4 or N_2O) from the waste or agricultural sectors. See the accompanying appendices for further information.

Role of Hydrogen in PICTs

In the Pacific Island Countries and Territories, green hydrogen and hydrogen derivatives can play the following role:

- **Penetration of renewables into power generation (for industry and grid electricity)**
- **Displacement of fossil fuels for mobility applications (land transport, maritime transport, and aviation)**

23 **million** bbl diesel equivalent of fossil fuel per year might be replaced by green hydrogen or derivatives in the Pacific Islands.

= 10 **million** tonnes of CO_2 per year abated.

& $2.2 **billion** worth of fossil fuel import savings per year.

The application of hydrogen derivatives in key sectors is expanded upon in following slides.

Disclaimer: Note these demand and saving values on the current and following slides are based on preliminary desktop research assuming 100% of the fossil fuel used in the power and mobility sector can be replaced with hydrogen to provide a baseline case for green hydrogen and its derivatives. Detailed assessments of the potential for hydrogen and the subsequent economic and environmental impact will be conducted in subsequent reports.

Role of Methanol in PICTs

In the Pacific Island Countries and Territories, methanol can play the following role:

- **Replacement of fossil fuels for domestic maritime applications**

0.5 **million** bbl diesel equivalent of fossil fuel per year can be replaced by methanol in the Pacific Islands. = 0.2 **million** tonnes of CO_2 per year abated. & $47 **million** worth of fossil fuel import savings per year.

- **Direct replacement of fossil fuels for small to medium scale power generation in remote and isolated locations with limited or unstable power networks**

8.1 **million** bbl diesel equivalent of fossil fuel per year can be replaced by methanol in the Pacific Islands. = 3.5 **million** tonnes of CO_2 per year abated. & $740 **million** worth of fossil fuel import savings per year.

- **Displacement of fossil fuels for land mobility applications**

6.1 **million** bbl diesel equivalent of fossil fuel per year can be replaced by methanol in the Pacific Islands. = 2.6 **million** tonnes of CO_2 per year abated. & $560 **million** worth of fossil fuel import savings per year.

Other potential applications for methanol in PICTs:

- **Strategic positioning of methanol refuelling for large maritime vessels along international trade routes.**
- **Direct replacement of fossil fuels for commercial and domestic heating applications**
- **Displacement of fossil raw materials in manufacturing and chemical synthesis.**

Role of Ammonia in PICTs

In the Pacific Island Countries and Territories, ammonia can play the following role:

- **Replacement of fossil fuels for domestic maritime applications**

0.5 **million** bbl diesel equivalent of fossil fuel per year can be replaced by ammonia in the Pacific Islands. = 0.2 **million** tonnes of CO_2 per year abated. & $47 **million** worth of fossil fuel import savings per year.

- **Direct replacement of fossil fuels for small to medium scale power generation in remote and isolated locations with limited or unstable power networks**

8.1 **million** bbl diesel equivalent of fossil fuel per year can be replaced by ammonia in the Pacific Islands. = 3.5 **million** tonnes of CO_2 per year abated. & $740 **million** worth of fossil fuel import savings per year.

Other potential applications for ammonia in PICTs:

- **In the production of synthetic fertilisers for the agricultural sector.**
- **In the production of explosives for construction and mining.**

Role of SAF in PICTs

In the Pacific Island Countries and Territories, SAF can play the following role:

- **Displacement of fossil fuels for aviation off-takers:** Airlines in the region are yet to announce any SAF procurement targets. Air Niugini has purchased 4 Trent 1000 engines to power two new Boeing 787-8 Dreamliner aircrafts, which can technically operate at up to 50% SAF blend[7].
- **Displacement of fossil fuels for mining off-takers:** There are also numerous potential mining off takers that may seek to procure renewable diesel: Societe Minere du Sud Pacifique (New Caledonia), Dome Gold Mines (Fiji, PNG), Vatukoulia Gold Mines (Fiji), Lion One Metals Limited (Fiji), Ok Tedi Copper and Gold Mine (PNG), Porgera Gold Mine (PNG), and Lihir Gold Mine (PNG)[7].

- **Displacement of fossil fuels for domestic aviation:**

0.8 **million** bbl diesel equivalent of fossil fuel per year can be replaced by methanol in the Pacific Islands. = 0.3 **million** tonnes of CO_2 per year abated. & $73 **million** worth of fossil fuel import savings per year.

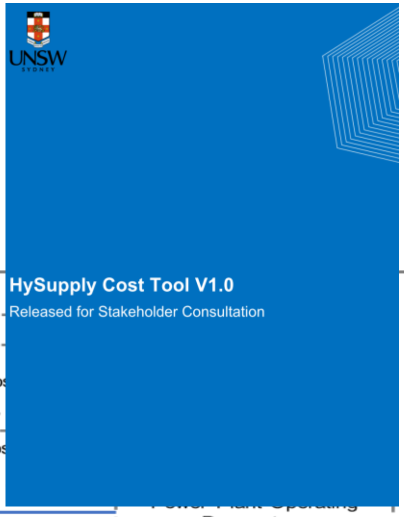
- **Displacement of fossil fuels for national carriers:**

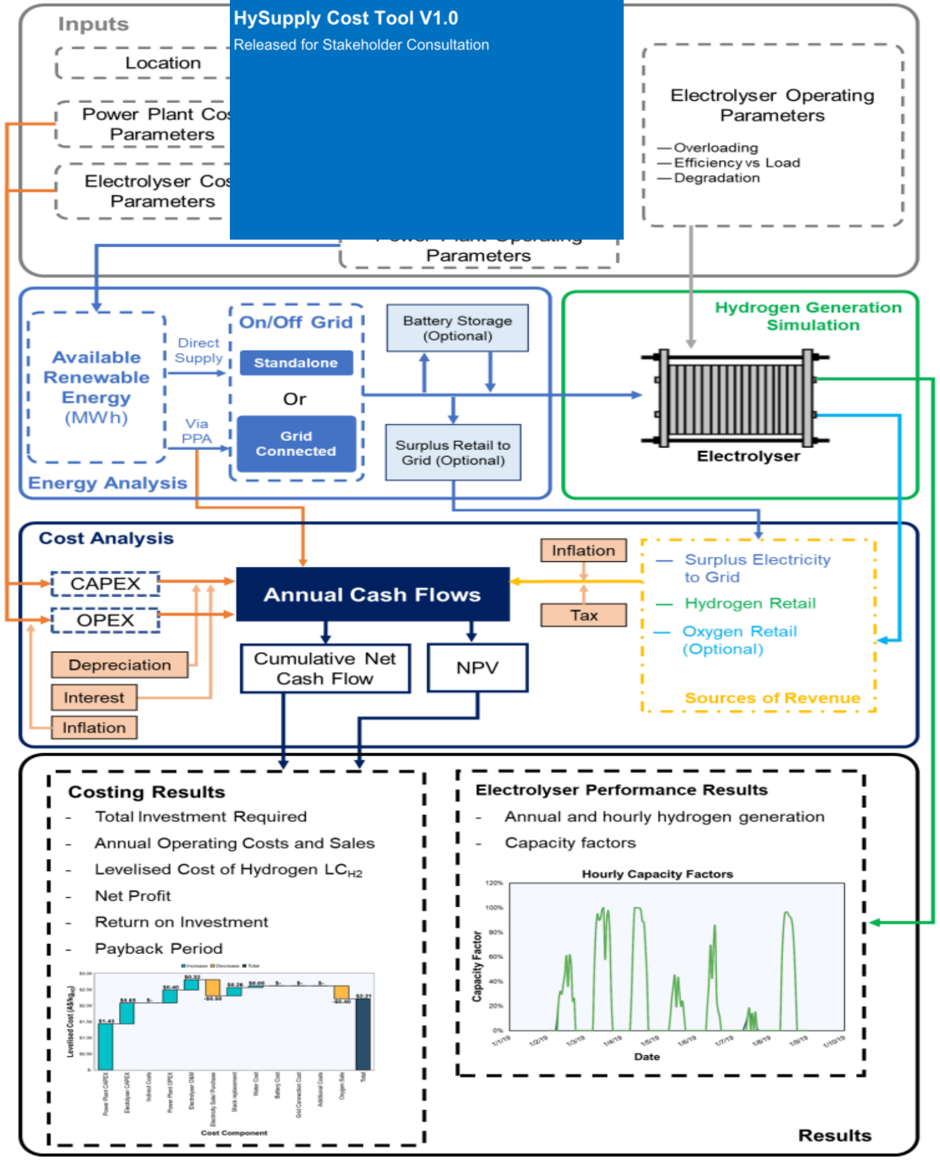
7.9 **million** bbl diesel equivalent of fossil fuel per year can be replaced by methanol in the Pacific Islands. = 3.4 **million** tonnes of CO_2 per year abated. & $730 **million** worth of fossil fuel import savings per year.

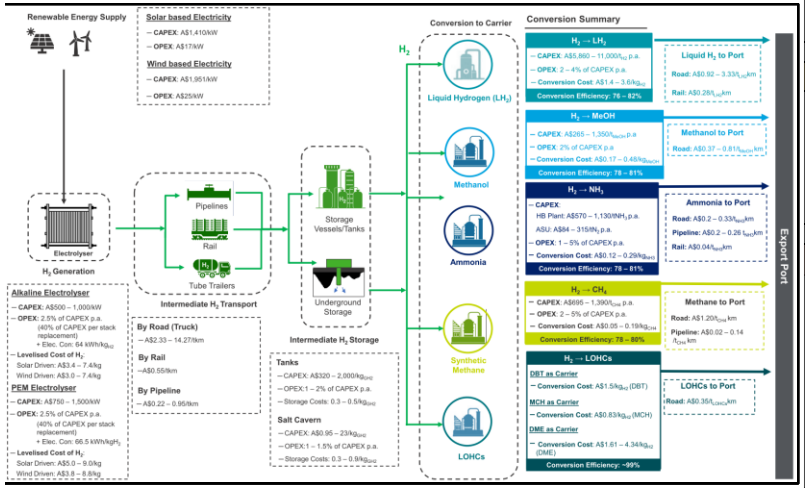
Note: The values for estimated fuel use for national carriers is subject to variation pending updated data.

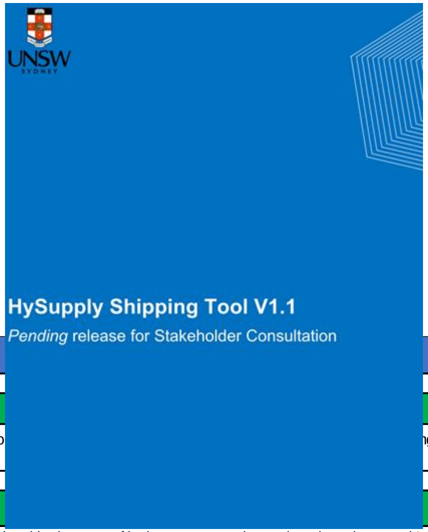
References:
Deloitte, 2023, Sustainable Aviation Fuels in the Pacific.

Modelling renewable hydrogen supply and value chains – open-source tools to assist a potentially wide range of stakeholders to better understand and evaluate a range of possible supply chains, including key uncertainties – e.g. scale effects, technology progress









Project Description

Project Statement

The HySupply Shipping Analysis To ... g hydrogen (and hydrogen carriers) via shipping.

Project Scope

The tool allows the user to analyse the shipping cost of hydrogen, ammonia, methanol, methane and LOHC (DME) on shipping routes of their choice, with the individual system performance parameters adopted from literature and advice from

Tool Competencies

The tool includes a comprehensive range of costs designed to emulate a close to reality analysis for shipping transportation of hydrogen and hydrogen carriers. The tool does not consider costs for intermediate storage before and/or after shipping, analysing only the cost up to and including the loading and unloading process. The tool is a living tool with additional features being and expected to be added after consultation with various stakeholders. We also encourage feedback from the user to help us improve the tool. Feedback can be provided to Associate Professor Iain MacGill (i.macgill@unsw.edu.au) and Dr. Rahman Daiyan (r.daiyan@unsw.edu.au) and further updates on the tool will be provided at https://www.globh2e.org.au/.

Analysis Methodology

The model calculates the levelised cost of transport via shipping for LNG, ammonia, methanol, LOHCs (with DME the LOHC costed) and liquefied hydrogen. The levelised cost is calculated by adding the total annual costs and dividing by the annual total energy delivered.

Total energy delivered is dependent on the ship speed, shipping route length, time at port and days per year the ship is available for operation. Total annual costs are a summation of capital and operating costs. Annual capital costs were calculated using a capital recovery factor for the ship capital costs. Annual operating costs were given through the addition of fuel, labour, canal, port, maintenance, miscellaneous, insurance and boil-off gas (BOG) costs. Users are also given the option to incorporate additional capital and operating costs into the model.

Power to X: Key Challenges and Opportunities

Challenges:

- Geography, natural disasters, and low diversification of economies heavily impact the effect of global climate change on the PICTs, many of which rank highly on the World Risk Index.
- Decarbonisation of electricity generation is impacted by large distances and remote communities
- Further challenges to decarbonisation shared amongst many PICTs include:
  - A lack of adequate data.
  - Insurance and financing.
  - Technical assistance.
  - Enabling policies.

Opportunities:

- Power-to-X can assist in decarbonisation of transport – including land, maritime, and aviation, which are otherwise difficult to decarbonise.
- Green hydrogen and derivatives can be used for energy storage of intermittent renewable energy.
- Green hydrogen derivatives can be used for electricity generation, suitable for replacement of diesel, for use in isolated communities, or during natural disasters.
- Collaboration between the PICTs, Hub and spoke model

Note: See the accompanying appendices for further information.

Some key questions for the Pacific Region

1. Key roles that renewable hydrogen and its derivatives can play in the Pacific to help achieve it's clean energy goals?
2. Which derivatives are likely most appropriate for the region?
3. Key priorities in developing hydrogen pathways for the region?
4. Opportunities for regional collaboration on developing hydrogen pathways in the region
5. Key capacity building needs?

Your participation is requested

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