Drivers and Barriers for a Hydrogen Economy: from Resources to Social Acceptance

Benjamin C McLellan

Professor, Graduate School of Energy Science, Kyoto University

b-mclellan@energy.kyoto-u.ac.jp

17th of January, 2024

e-ASIA JRP Workshop

Hydrogen Economy – Technologies for Energy Management

- Hydrogen has been considered as an option for clean energy storage and utilization since at least 1875 *(Jules Verne – The Mysterious Island*)
- The "Hydrogen Economy" consists of the production and usage of H_2 and electricity across society
- The "Hydrogen Economy" term was coined in the early 1970`s
- Although the idea is attractive, it has seen only minimal progress
- And there are still many challenges – including social, technical and resources

Hydrogen Economy

Many visions of the "Hydrogen Economy" exist
Hydrogen can be used in various sectors and made by many routes

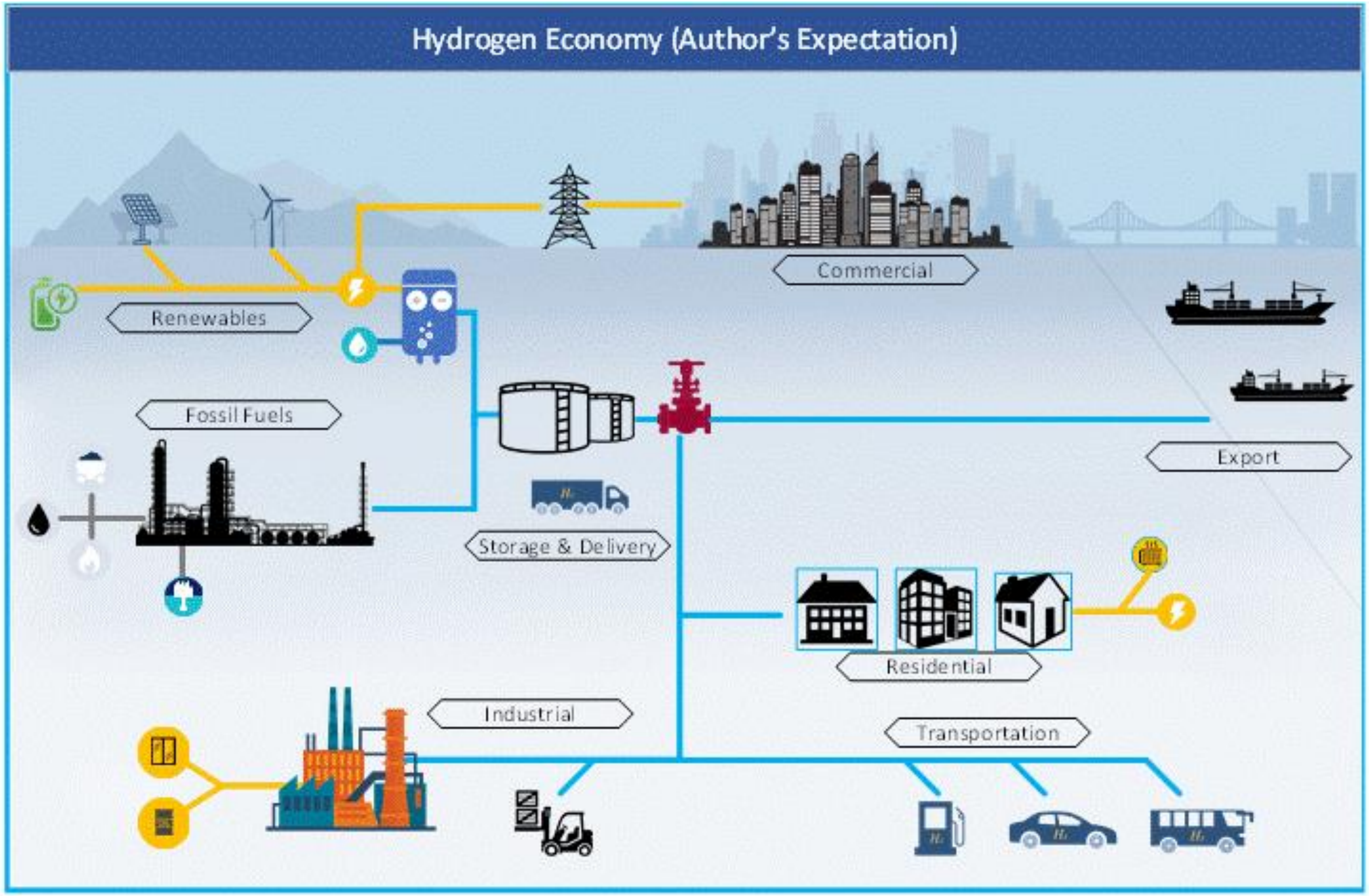


Image credit: Jiazhen Yap, Kyoto University

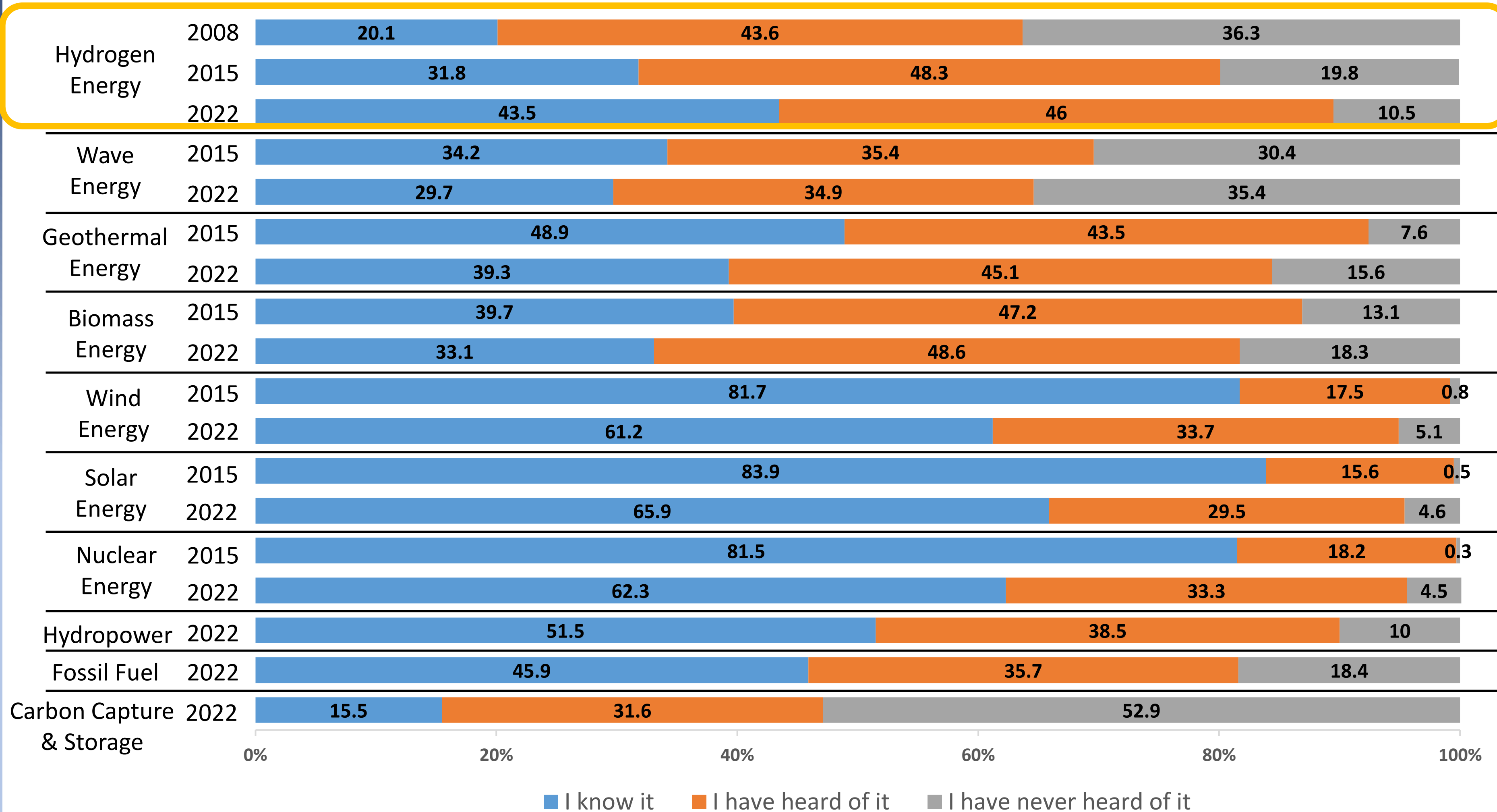
Barriers to a Hydrogen Economy

- Techno-economic – the cost of hydrogen technologies is still not low enough to be competitive
- Social acceptance – there is a lack of understanding of hydrogen in society
- Resources (?) – some critical minerals may be limited in supply for a transition to a hydrogen economy
- Just transitions – how equitable would a Hydrogen Economy be, across the supply chain?

Social perspectives

Knowledge of different type of energy

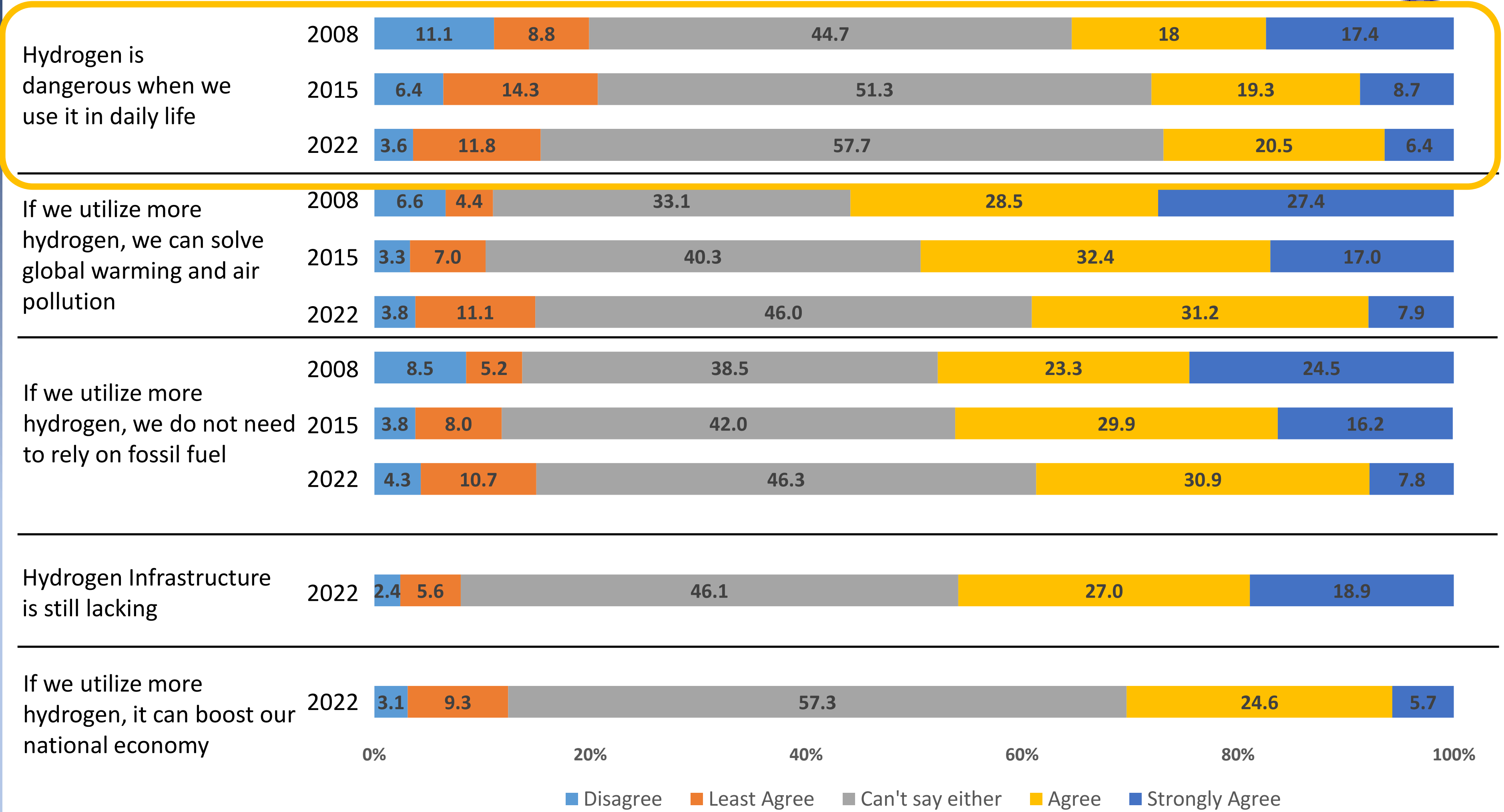
A comparison of how much the general public know of hydrogen energy compare to other energy



Source: Jiazhen Yap, Kyoto University

Perception towards H2 Economy

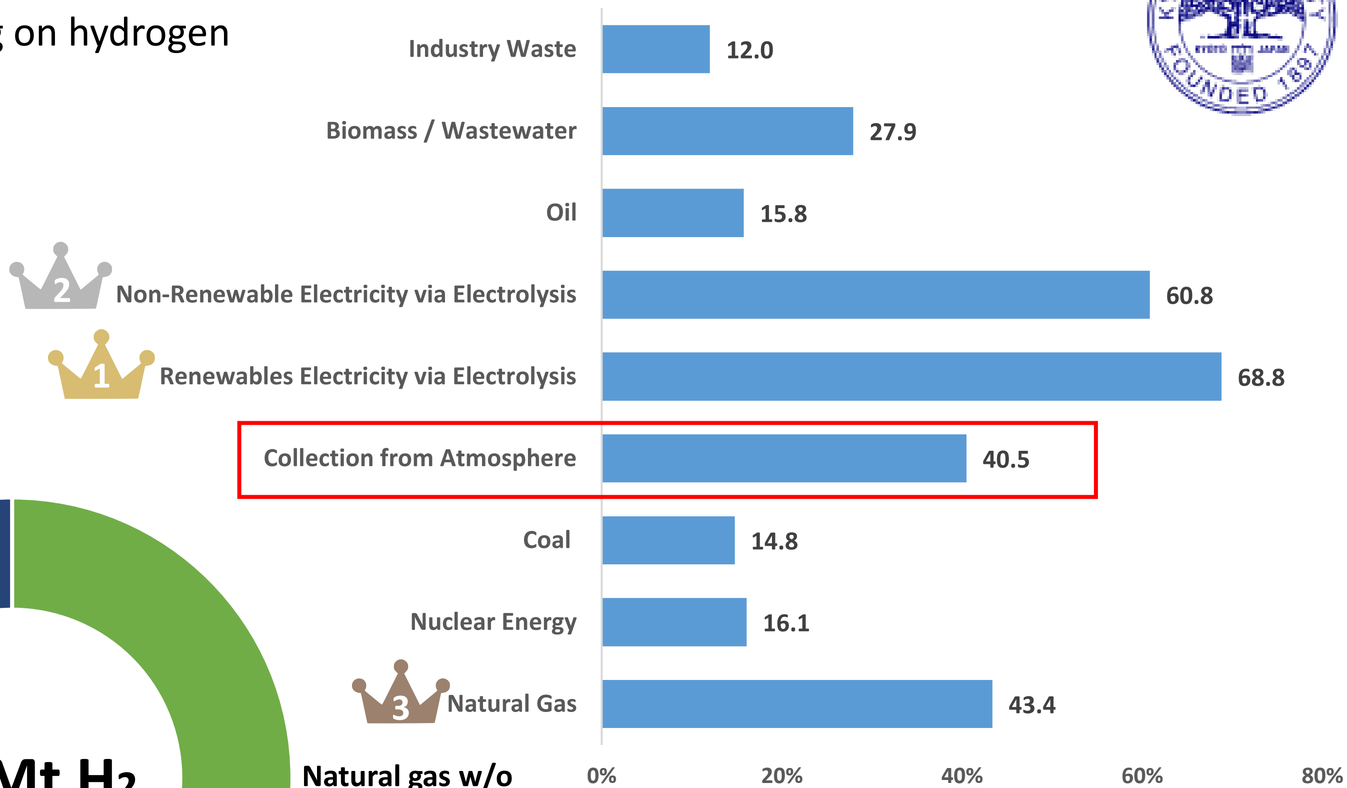
To understand public perception of hydrogen economy



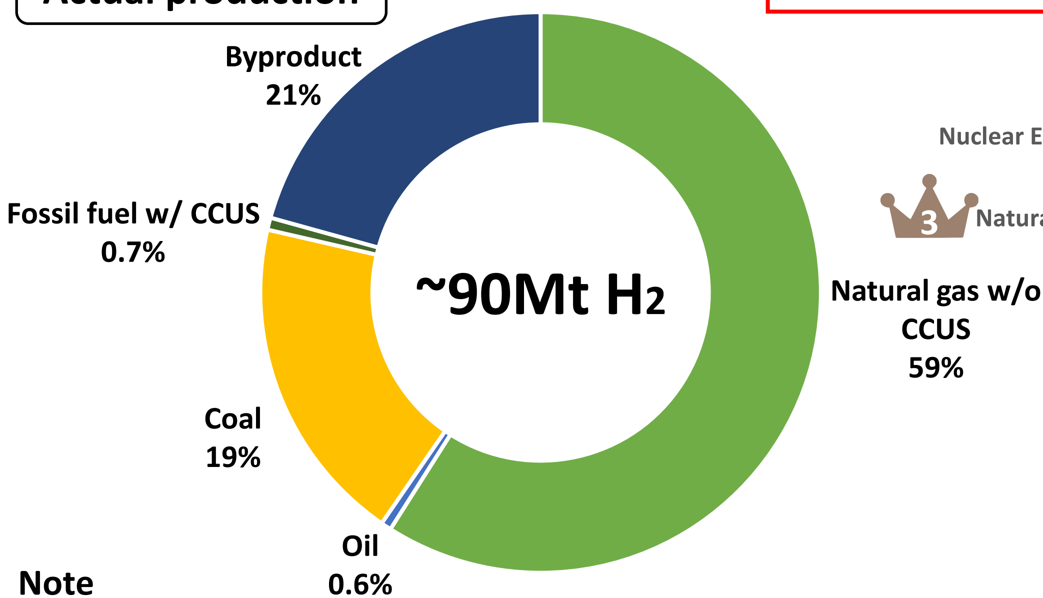
Source: Jiazhen Yap, Kyoto University

Perception towards H2 production

To check public understanding on hydrogen production



Actual production



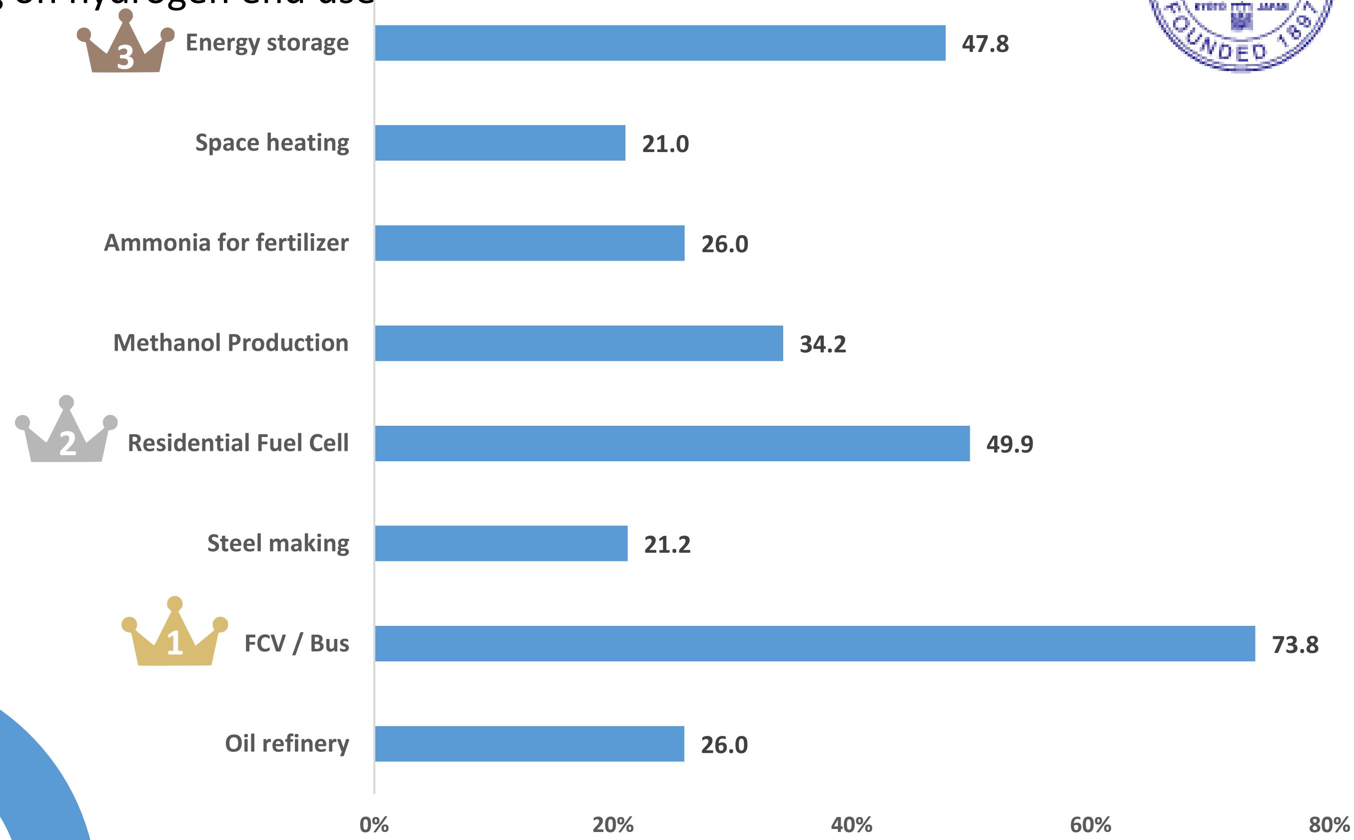
Note

- CCUS: carbon capture, utilization and storage
- Water electrolysis made up of 0.03% (30kt H_2) of global production
- Byproduct: hydrogen produced in facilities designed primarily for other products, mainly refineries in which the reformation of naphtha into gasoline results in hydrogen

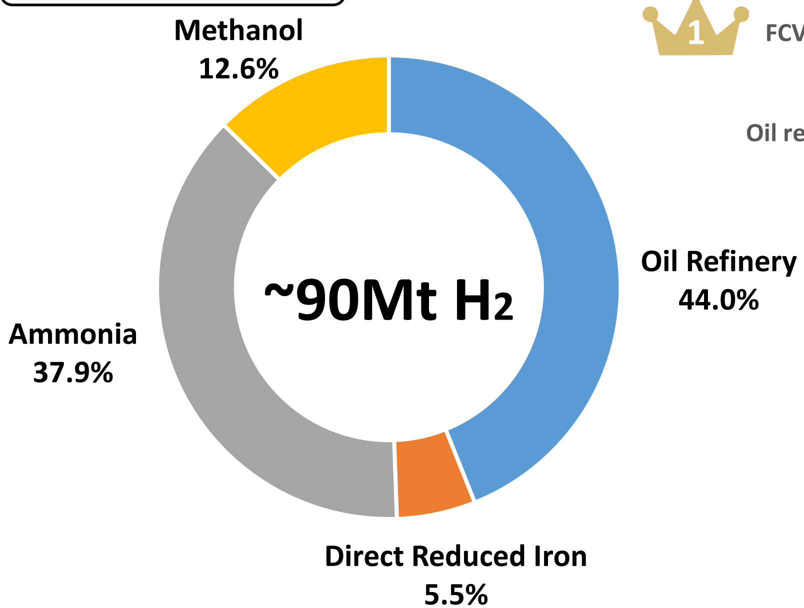
[1] IEA, "Global Hydrogen Review 2021," 2021. doi: 10.1787/39351842-en.

Perception towards H2 end-use

To check public understanding on hydrogen end use



Actual end-use

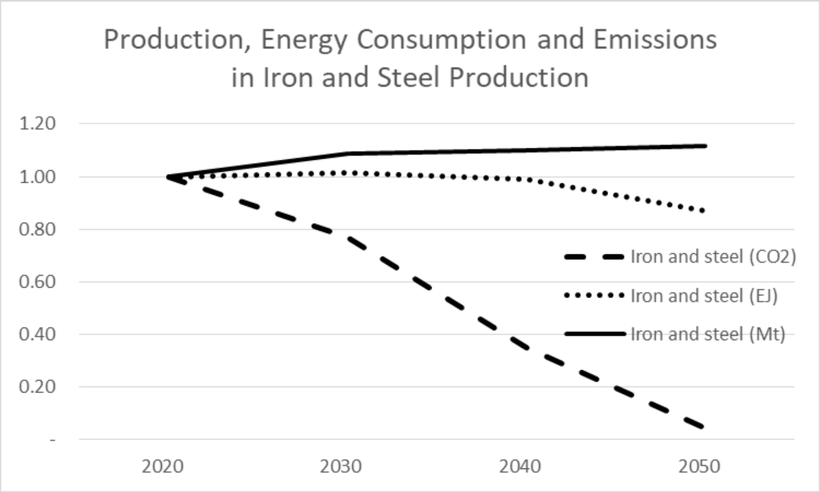


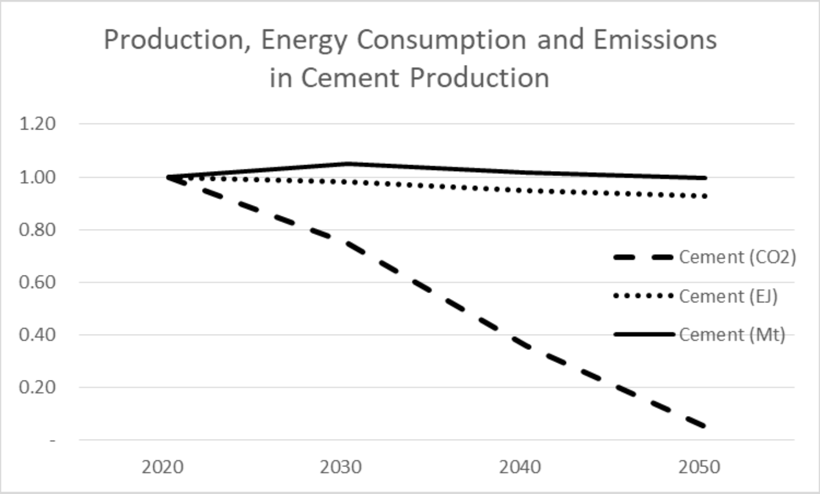
[1] IEA, “Global Hydrogen Review 2021,” 2021. doi: 10.1787/39351842-en.

Resources

Bulk Minerals – large scale target for hydrogen?

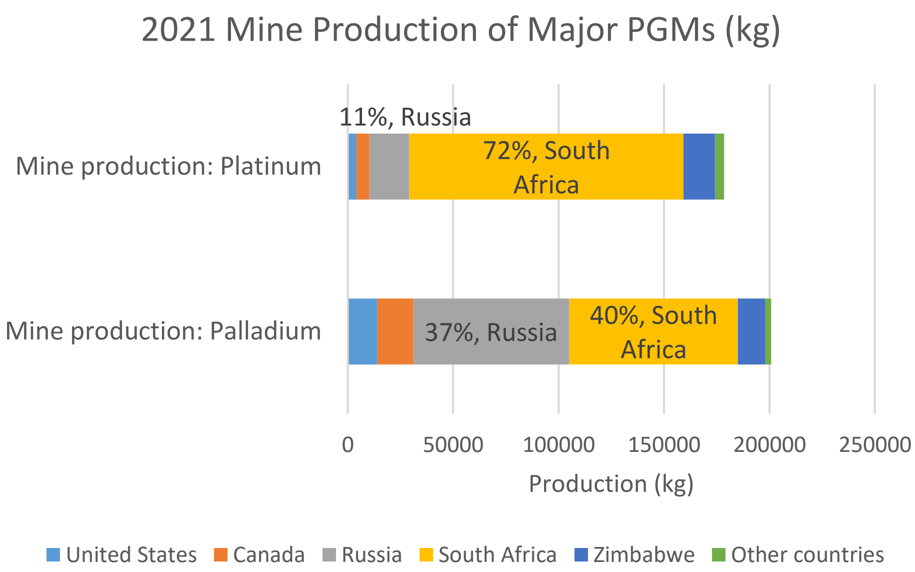
- Iron and Steel, and Cement Production – Bulk Minerals
- Vital for infrastructure
- Difficult to decarbonize due to high temperature, high volume fuel requirement and chemical production of CO_2
- Decoupling of the emissions from energy and production using innovative technologies
- Hydrogen-based Direct Reduced Iron
- CCS for steel and cement





Hydrogen, Fuel Cells and Critical Minerals

- High uncertainty about potential cost reduction in H_2 supply chains
- 6x increase in production by 2050 (IEA NZE)
- PGMs and REE for Fuel Cells and electrolysers
- Palladium / Vanadium for purification



India, 2016

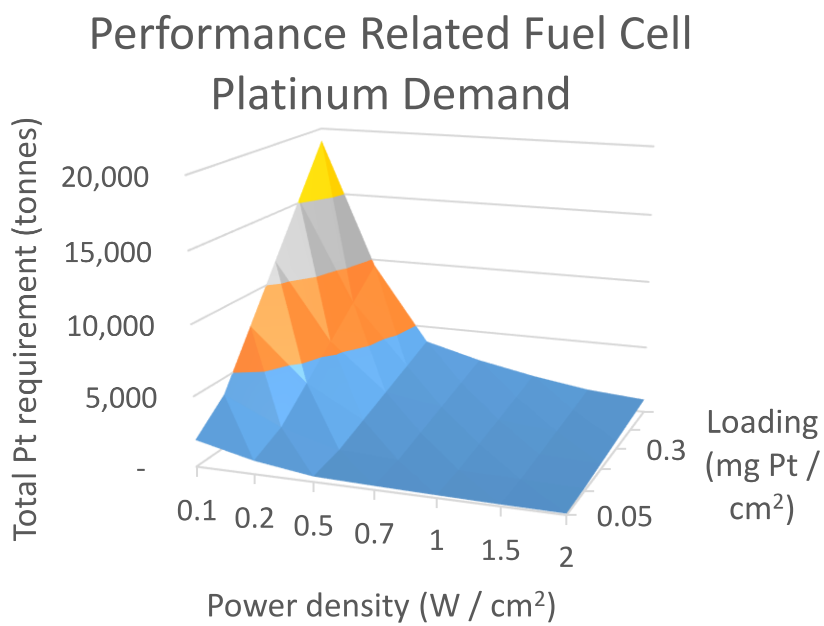
Fukushima, 2022

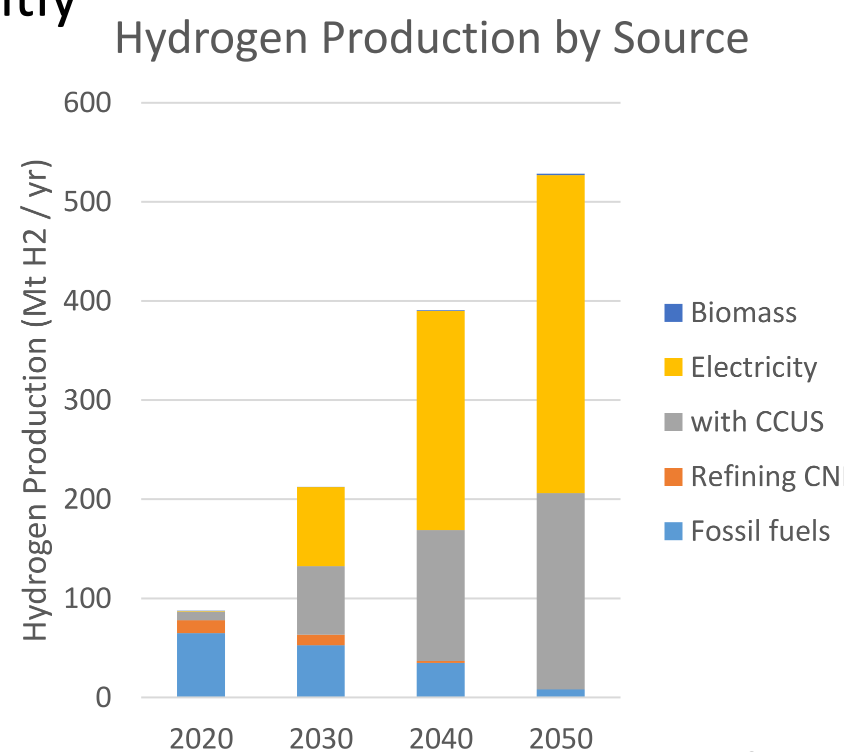
Technological improvements vital

Electrolysis technologies are basically the same as Fuel Cells – in reverse

Contain many of the same materials

Need to reduce costs through scale-up and innovation, otherwise H2 is unlikely to contribute significantly

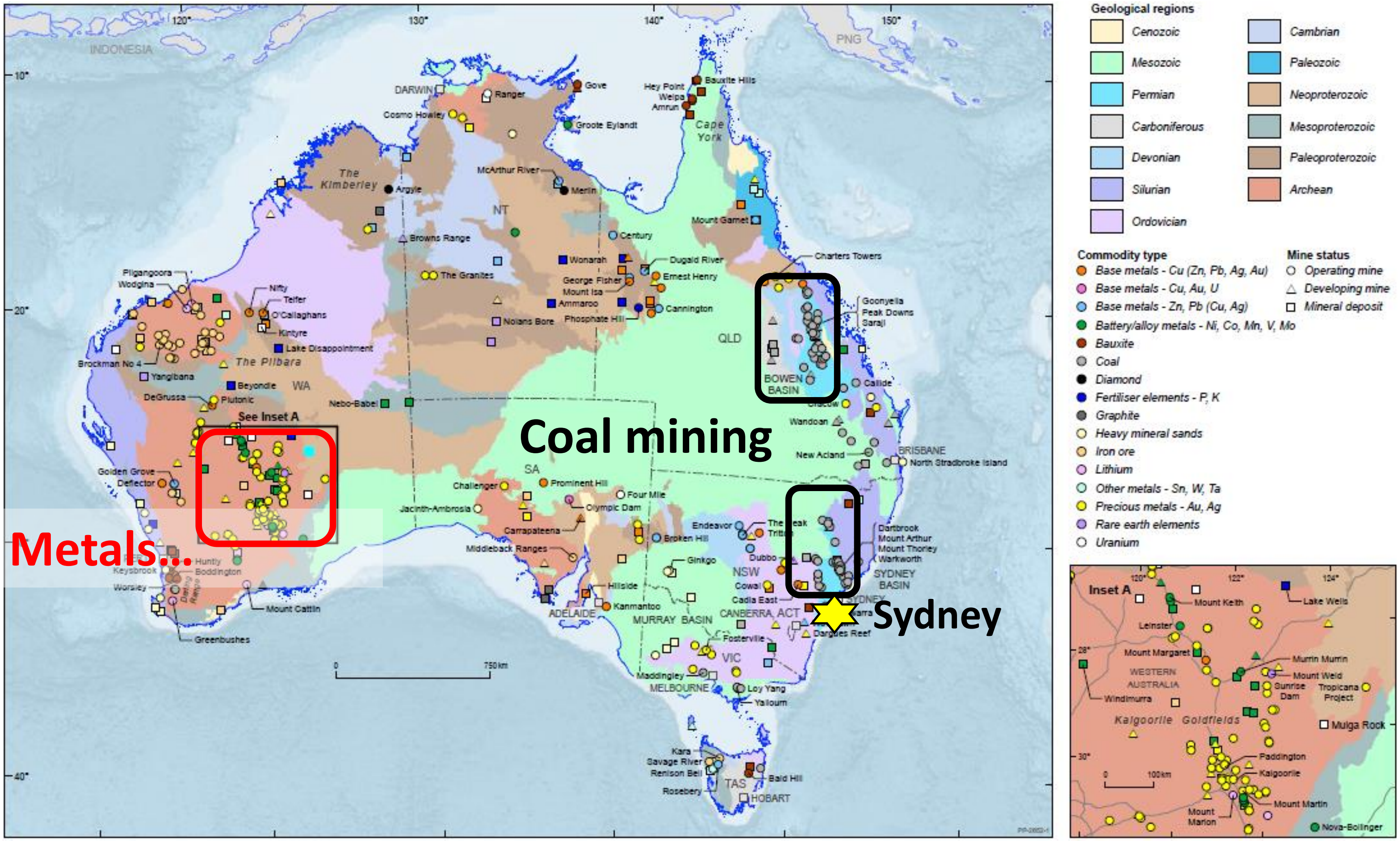




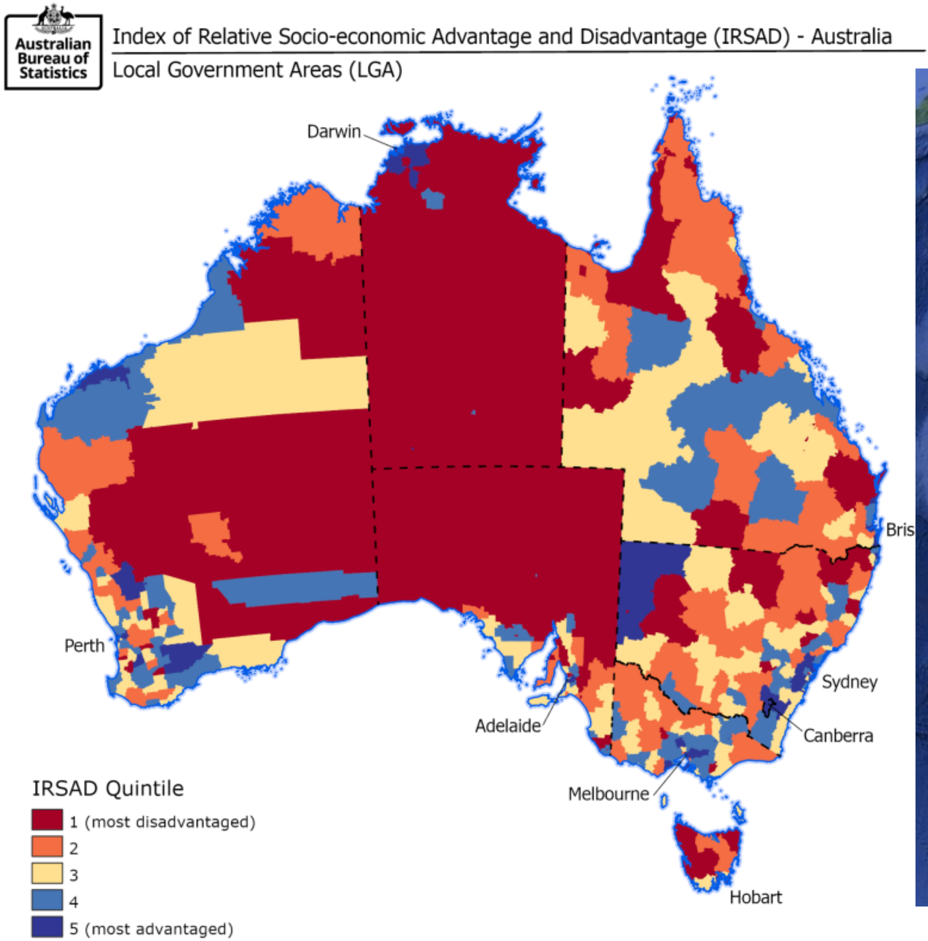
Data: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Just transitions

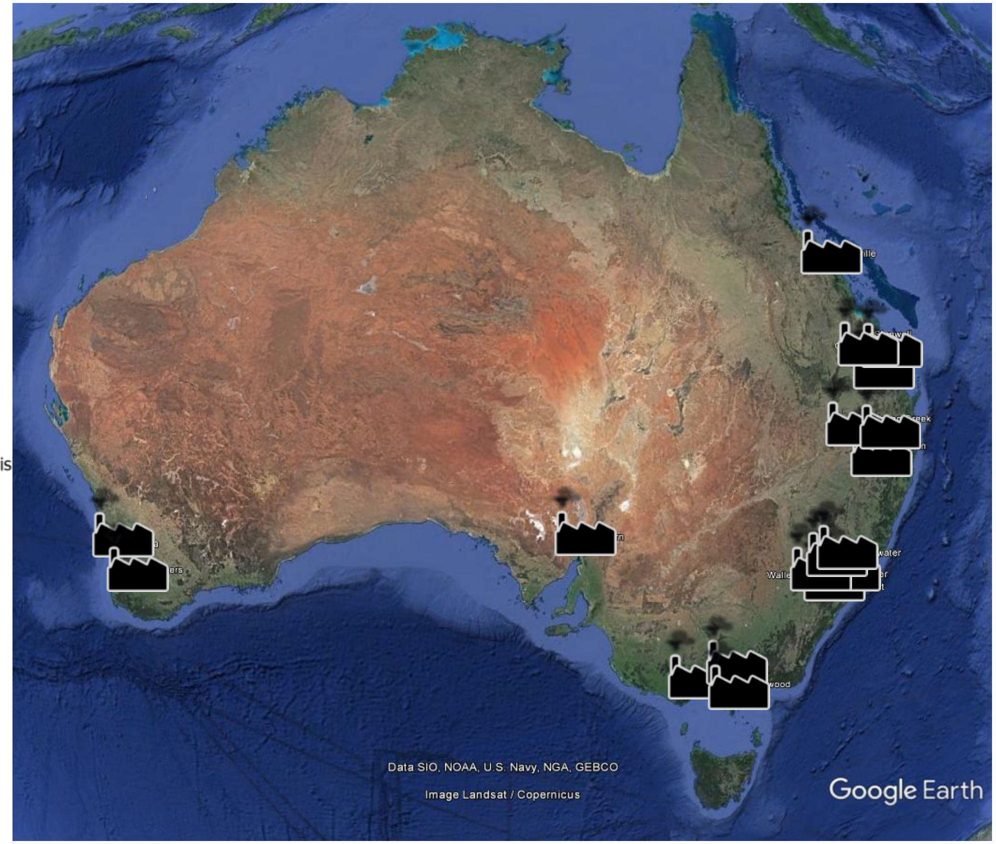
Where will the impacts be?



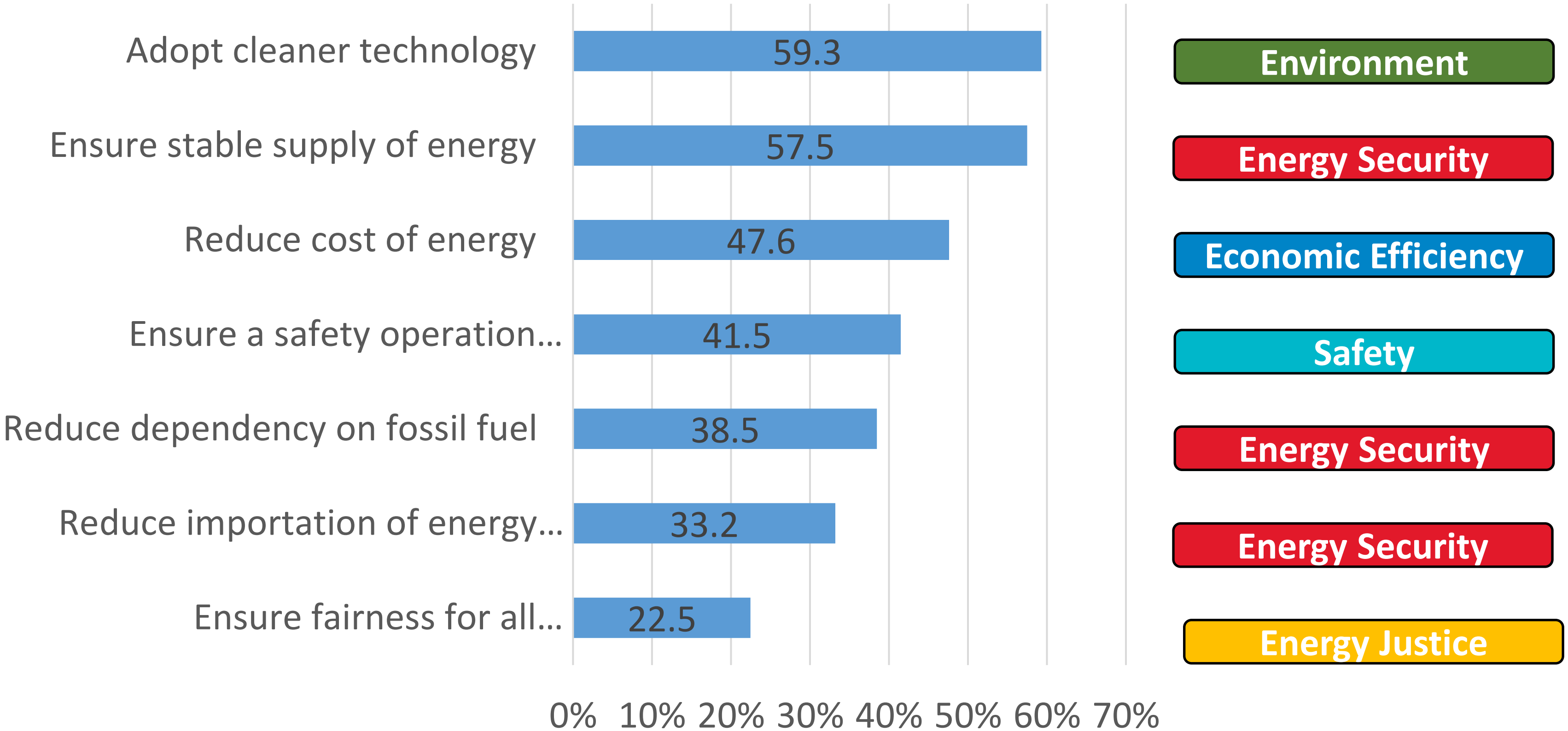
Disadvantage / Advantage and power producing regions



Source: Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), 2021
Australian Statistical Geography Standard (ASGS), 2021
Geocentric Datum of Australia, Australia Albers, 1994



Japan Survey: Priority for Energy Transitions



"Lacking time, … usually means that choices fall into one or a limited number of types: *incrementalism, standard operating procedures, vacillation and indecision, and doing nothing at all.*

Creativity in any case is seldom sought or celebrated."

Ref: Brewer, 2007

Questions welcome

Information: b-mclellan@energy.kyoto-u.ac.jp

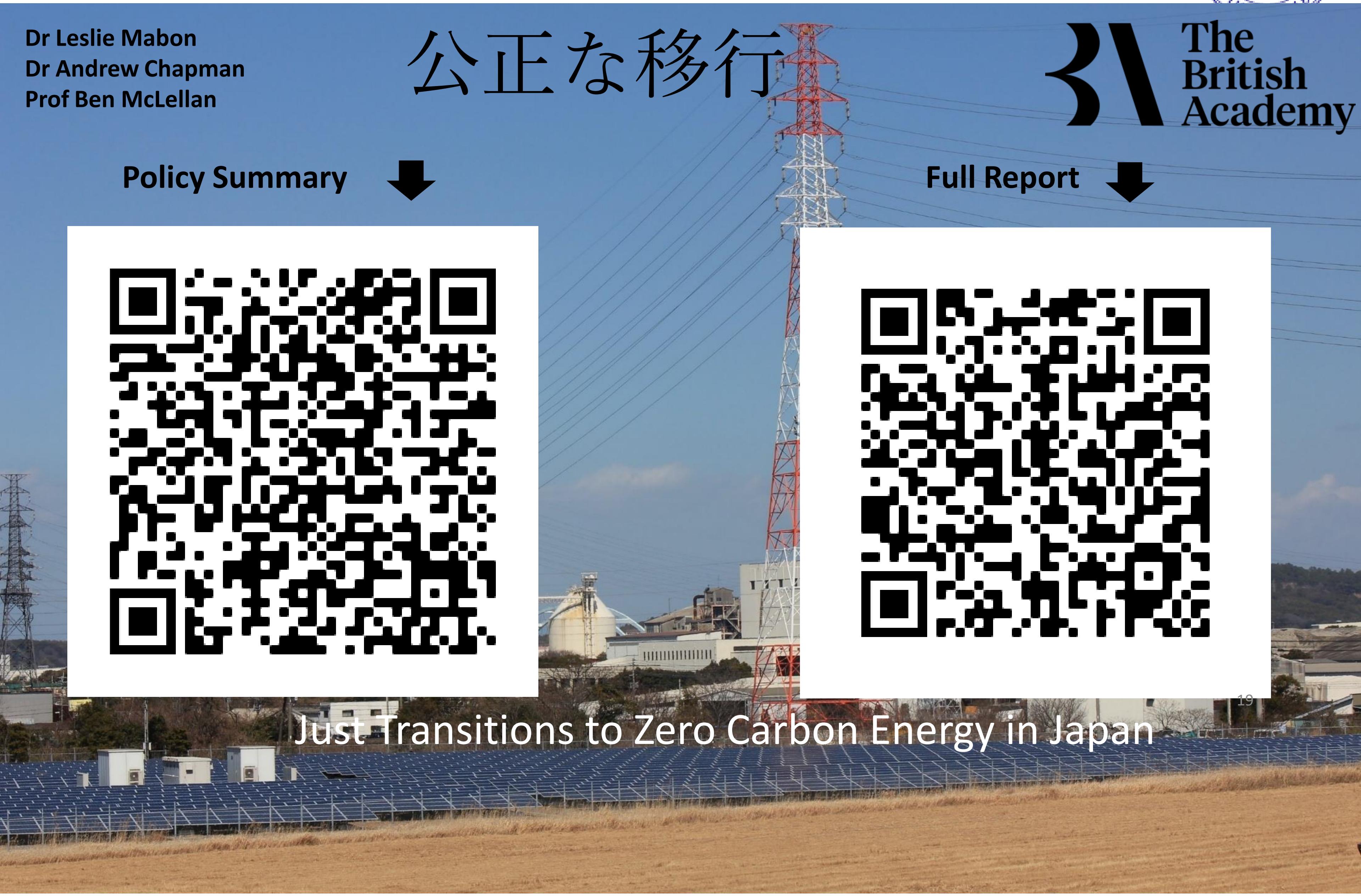
Dr Leslie Mabon
Dr Andrew Chapman
Prof Ben McLellan

公正な移行

The British Academy

Policy Summary ⬇

Full Report ⬇



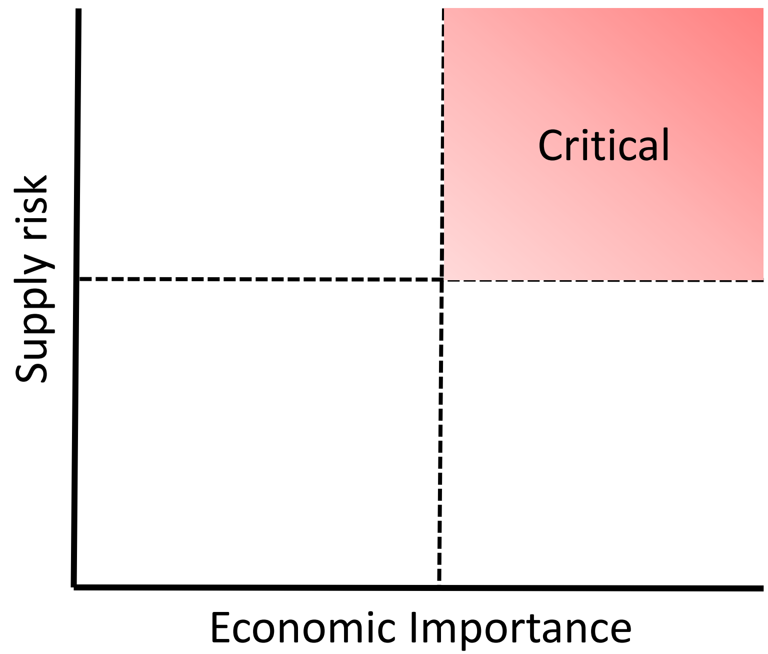
Just Transitions to Zero Carbon Energy in Japan

"Critical" minerals definition

a material can be regarded as critical only if :

AND a high probability that its supply may become restricted, leading to physical unavailability or to significantly higher prices in key applications

- Import dependence
- Concentration of production
- Concentration of reserves
- Political stability
- Substitutability
- Recycling
- Market characteristics
- ⋮



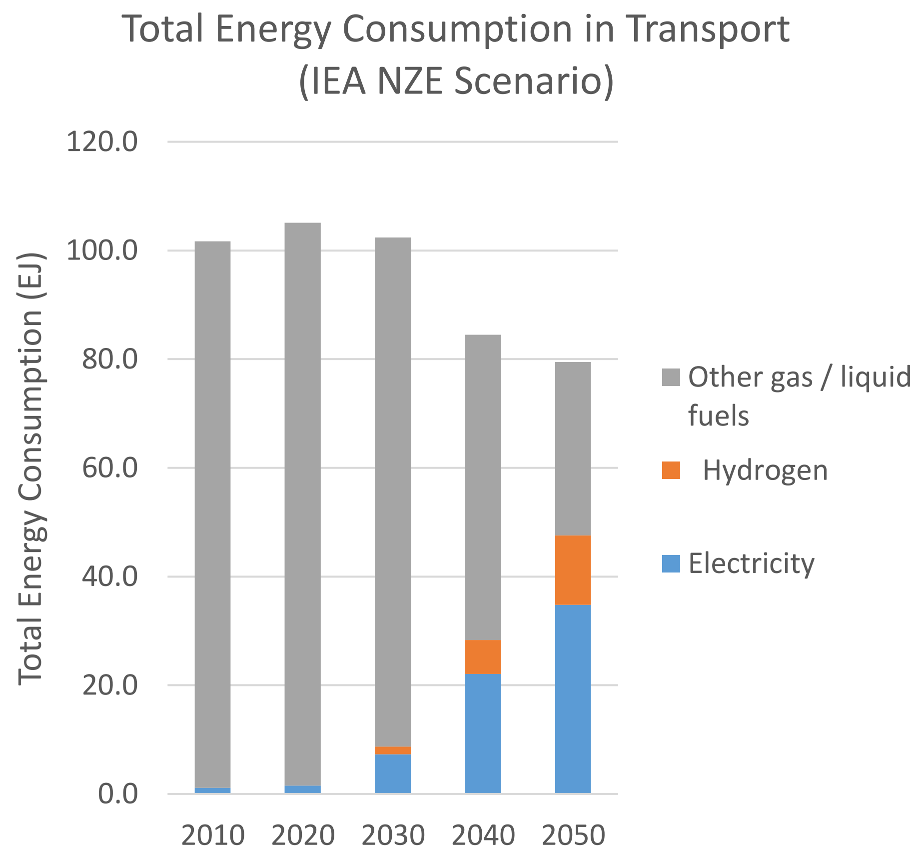
+Environmental implications

- Usage by end-use sectors
- Value-added by end-use sectors
- …

it performs an essential function for which few or no satisfactory substitutes exist

Energy demand and Carbon Neutrality

- Technologies required to:
  - Increase efficiency of energy consumption
  - Enable electrification
  - Utilise low or zero carbon fuels (H_2, biofuels, etc.)



Priority initiatives:

Electrification of transport

Storage of variable renewables