A/Prof. Greg Trencher

Japan's transition to a hydrogen society: The role of Japanese renewables and Victorian brown coal

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ENERGY TRANSITION HUB

JAPAN'S TRANSITION TO A HYDROGEN SOCIETY

The role of Japanese renewables and Victorian brown coal

University of Melbourne Energy Transitions Hub

13 February 2019

Assoc. Prof. Gregory Trencher Tohoku University, Japan

TOHOKU UNIVERSITY

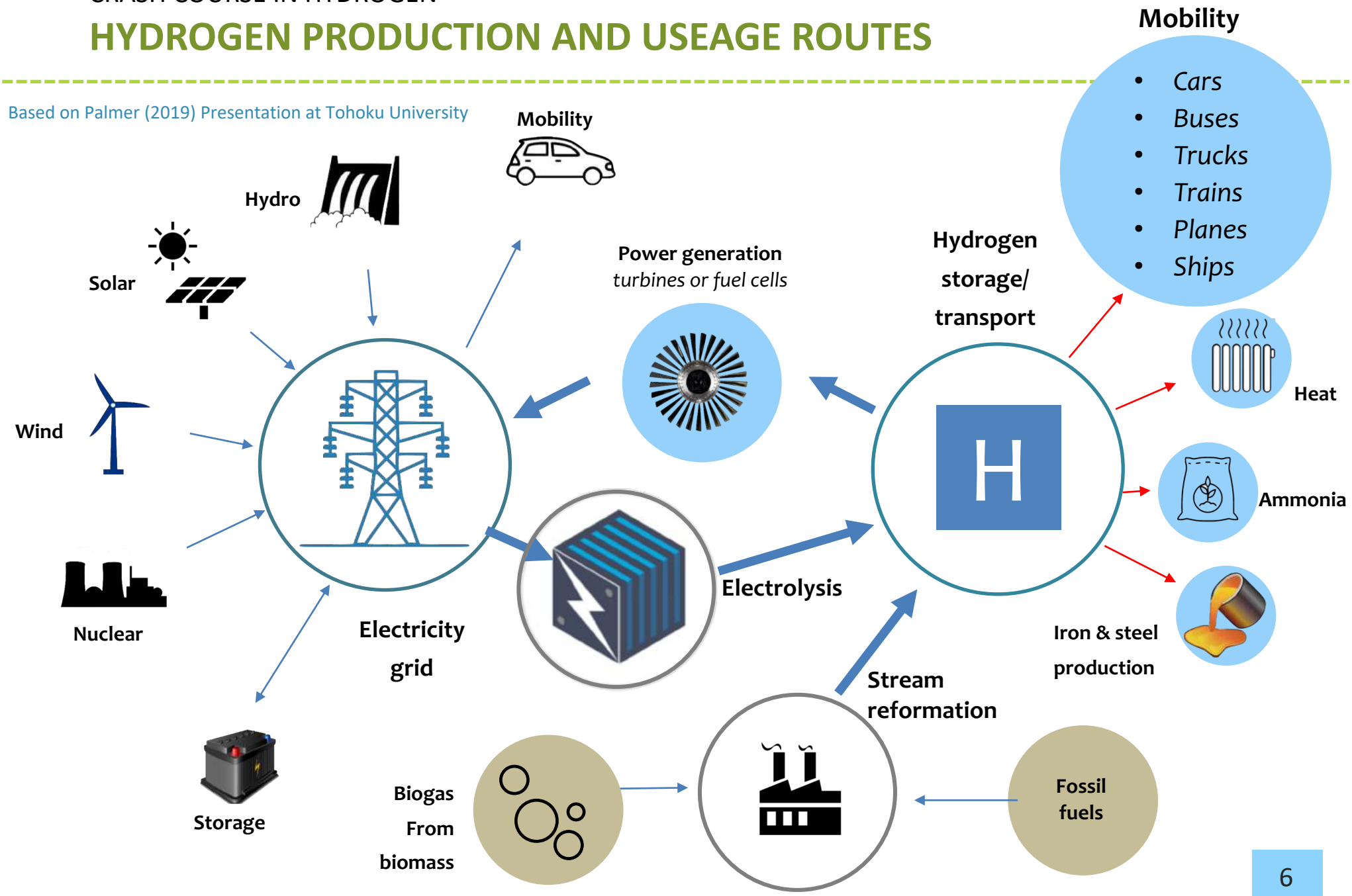
OVERVIEW

1. Crash course in hydrogen
2. Policy aspects and vision of a hydrogen society
3. Fuel-cell vehicle (FCV) diffusion challenges
4. International supply chains

CRASH COURSE IN HYDROGEN

HYDROGEN PRODUCTION AND USEAGE ROUTES

Based on Palmer (2019) Presentation at Tohoku University



POLICY ASPECTS AND VISION OF HYDROGEN SOCIETY

NATIONAL ENERGY POLICY

Formulated by bureaucrats

Ministry of Economy, Trade and Industry (METI) and inhouse *Agency for Natural Resources and Energy design policy and* parliament "rubberstamps"

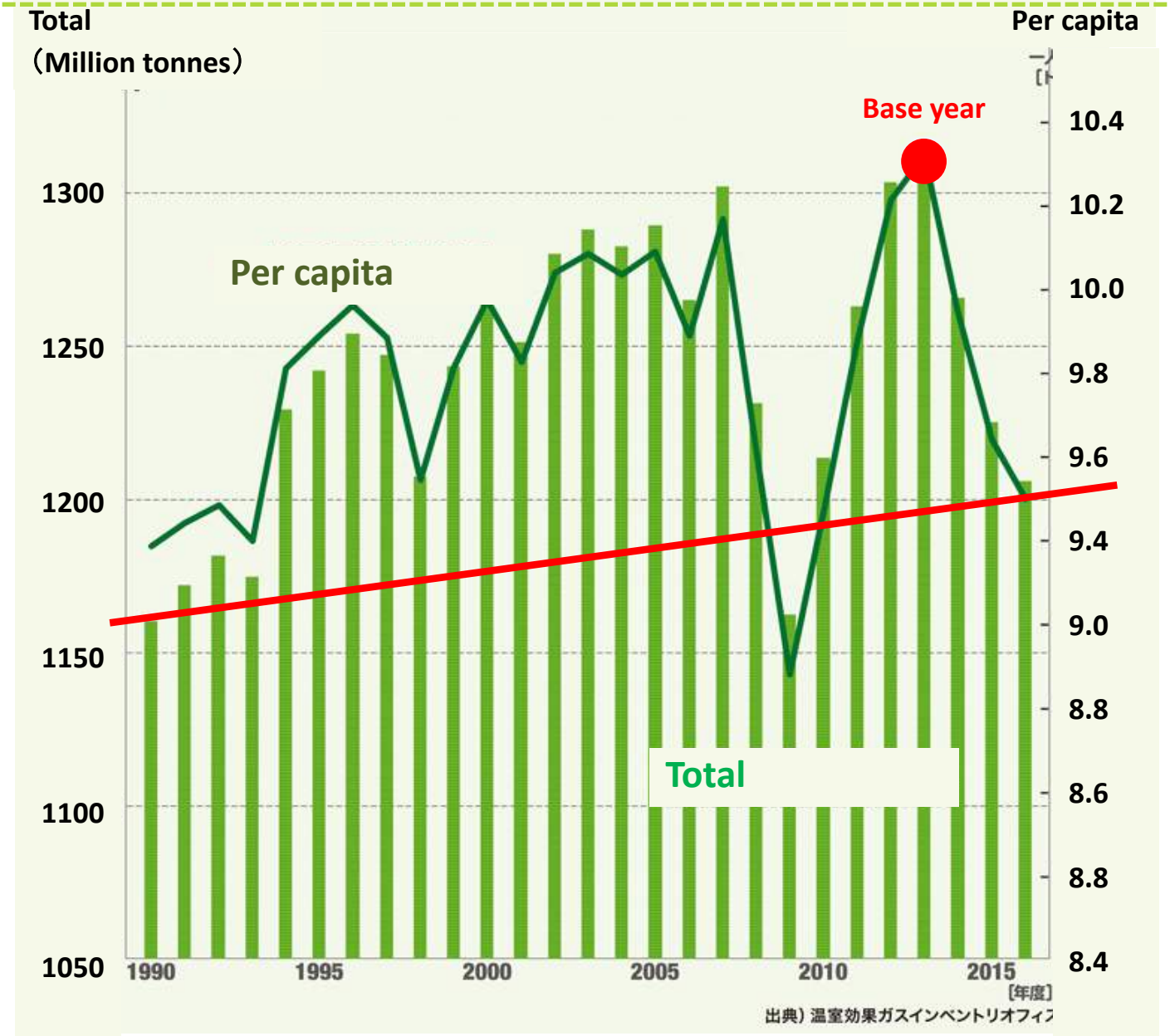
- Rarely affected by change of Prime Minister (Sofer 2016)
- *Ministry of Environment* has little influence (Moe, 2012)
- Distinctly pro-coal and pro-nuclear
- Tight relations with utilities and heavy industry blamed for conservative renewables policy (Moe, 2012; Tanner 2018)

Climate policy (i.e. political ambition) is shaped by energy policy (i.e. industrial policy)

- Economic feasibility over environmental ambition
- Bottom-up calculations (self-determined industry targets/projections) shape energy projections and climate targets

NATIONAL GHG EMISSIONS

http://www.jccca.org/trend_japan/state/



Paris Agreement targets (2013 base year):

-26% by 2030
-80% by 2050

Post-2011 spike explained by increase of LNG and coal after nuclear shutdown

Japanese climate/energy policy widely criticized internationally as lacking ambition and promoting coal

TOTAL ANNUAL POWER GENERATION (%): ACTUAL & PROJECTED

132 GW generation capacity in 2017	2010	2017
Nuclear	28.6	2.8
Coal	25	30.4
LNG	29.3	38.7
Oil	6.6	4.1
Hydro	8.5	7.6
Renewables (non-hydro)	1.1	8
Geothermal	*	0.2
Biomass	*	1.5
Wind	*	0.6
Solar	*	5.7

* Data not available in source, but each is close to 0%.

Source: ANRE (2016) for 2010, ISEP (2018) for 2017 and METI (2015) for 2030

3-PHASES IN NATIONAL ROADMAP

2020: 40,000
2025: 200,000

2020: 160
2030: 900

2020: 1.4 million
2030: 5.3 million

PHASE 1

- **Diffuse FCVs and stationary FCs**
- **Hydrogen from steam reformation**

PHASE 2

- **Mass production from overseas**
- **Gradual integration into power plants**

PHASE 3

- **Carbon free hydrogen**
- **Full integration into transport (FCVs and ships, trains, planes) and power sector**

Starting now:

- Fuel-cell vehicles (FCVs)
- Fuelling stations
- Co-generation fuel-cells

- R&D
- Demonstration projects

Around 2030

- Materialisation
- Diffusion

- R&D
- Demonstration projects

Around 2040

- Materialisation
- Diffusion

2020

2030

2040

KEY DIFFUSION AND PRODUCTION TARGETS

	Phase 1	Phase 2	Phase 3
	Current to 2020	2025 onwards	Around 2040~
Mobility FCVs	40,000 by 2020 (Currently 62 million ICEs)	200,000 by 2025 800,000 by 2030	Replace all ICE vehicles
Buses	100 by 2020	1,200 by 2030	Replace all ICE vehicles
Forklifts	500 by 2020	10,000 by 2030	Replace all ICE vehicles
Fuelling stations	160 by 2020 (currently 100) 320 by 2025	900 by 2030	Replace all gasoline stations (by 2050)
Combined heat/power stationary fuel cells	1.4 million by 2020 (currently 230,000)	5.3 million by 2030	Replace gas power generation (by 2050)
H2 production volume	4,000 t/yr by 2020	300,000 t/yr by 2030	5-10 million t/yr by 2050
H2 cost	~$10kg (current)	~$3kg by 2030	~$2kg by 2050

Japanese population/aging projections:

- 2015 127 million (25% over 65 yr)
- 2020 120 million
- 2040 111 million (33% over 65)

Targets: METI (2016b) and NEDO (2017)
Population data: IPSS (2017)

INTERNATIONAL COMPARISON

	2020	2025	2030
Mobility (FCVs)			
Japan	**40,000**	**200,000**	**800,000**
California			5 million (Zero-emission)
EU		5,000 (light) 200 (heavy)	20 - 50,000 (light) 800 - 2,000 (heavy)
China	5,000	50,000	1 million
Fuelling stations			
Japan	**160**	**320**	**900**
California		200	
EU		100 (by 2023)	
China		350	1000

Sources: METI (2016b) and NEDO (2017)

CHARACTERISTICS OF NATIONAL VISION

Shaped jointly by government and industry

Only country with coherent, national and institutionalised vision and policies for a hydrogen economy

- Visible in *Basic Energy Plan*, *Basic Hydrogen Strategy* and NEDO roadmaps
- Consistency of vision and narratives across multiple policies, agencies and industry groups

Hydrogen often framed as "inevitable" because:

- EVs cannot meet all transport needs
- Batteries cannot provide large-scale, seasonal or portable storage

Unlike Germany/France, starting point is not renewables diffusion but diffusing hydrogen and related technologies

KEY POINT

Why is Japan pursuing a hydrogen society when most other countries are pursuing decarbonisation through *renewables* instead?

WHY IS JAPAN PURSUING A HYDROGEN SOCIETY?

Lack of international competitiveness in large-scale renewable implementation and manufacturing

Historical strengths in hydrogen R&D

- Global leader historically in public investment, sales and patents (Behyling et al 2015)
- Widespread awareness of export opportunities

Response to emerging EV market

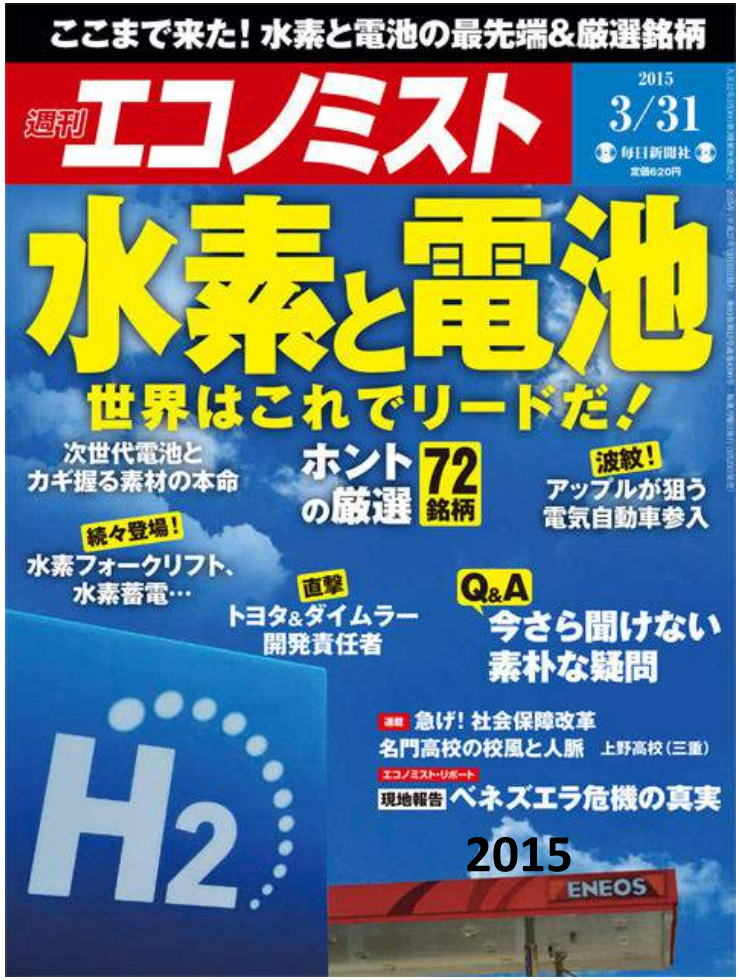
Need to protect competitiveness of domestic auto manufacturers

Few opponents: Fossil fuel regime actors driving the transition

- Example: JTXG Energy, Iwatani, J-Power
- Fossil fuel actors will shape low-carbon visions to their interests

(Bergman 2018)

COVERAGE IN MEDIA (2015)

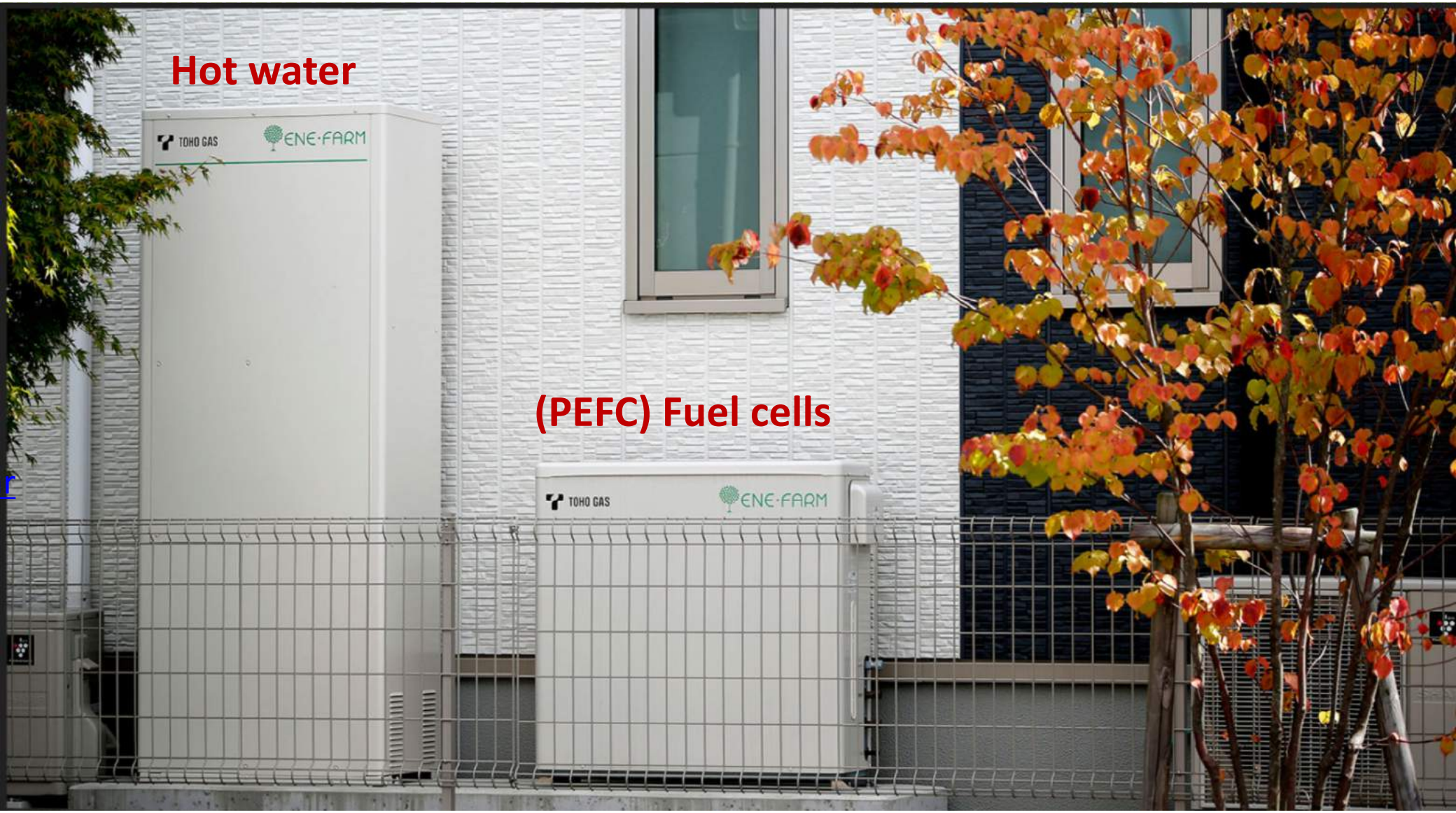


2015

www.weekly-economist.com/2015/03/31/週刊エコノミスト-2015年3月31日号/

www.amazon.co.jp/Newton-水素社会の到来-科学雑誌Newton-ebook/dp/B01HPPT4C2

HOME CO-GENERATION UNIT (ENEFARM)



http://www.bloomberg.com/news/articles/2015-01-15/fuel-cells-for-homes-japanese-companies-pitch-clean-energy

FUELLING STATION IN TOKYO

https://clicccar.com/2015/04/23/304336/

FUEL CELL BUS AT TOKYO STATION

HYDROGEN FORUM: FUKUSHIMA

HYDROGEN FORUM: FUKUSHIMA

ANNUAL IWATANI HYDROGEN FORUM TOKYO 2018

HYDROGEN HEALTH BOOM

- Selling under US $2 a bottle
- Contains pure hydrogen between 0.3 to 0.8 ppm
- Promotes health, anti-aging and prevents disease

How?

- H_2 moves freely throughout body (through tissue and bones)
- Destroys free radical *hydroxyl*
- Can drink, breathe or bath in H_2 for same effect
- Mechanism proven in rats in *Nature* article
  Ohsawa et al. 2007

www.itoen.co.jp/news/detail/id=24620

FUEL-CELL VEHICLE (FCV) DIFFUSION CHALLENGES

HONDA CLARITY

https://www.honda.co.jp/CLARITYPHEV/

HONDA CLARITY

COMMON CHALLENGES WITH ELECTRIC/HYBRID VEHICLES

Infrastructure challenges

- Consumer unlikely to buy with few charging/fueling stations
- Government and industry investment required
- Which industries should assume cost/risk burden?

(Rezvani 215; Berkeley 2017; Leibowicz 2018)

Lack of scale/critical mass

- Few models on market discourages purchase opportunities
- Few manufacturers hamper scale of economics

(Hardman 2018; McDowell 2016)

Inferiority to established technologies

- Need for additional features to give edge over competition

Hardman 2018)

FUELLING INFRASTRUCTURE CHALLENGES

1. Reduce risks/burden with government subsidies:

- Current construction costs around US$ 4-5 million with little chance of profit
- Construction costs: Around 50% plus prefectural subsidies
- Operation costs: Around 50%

2. Share cost/risks across industry

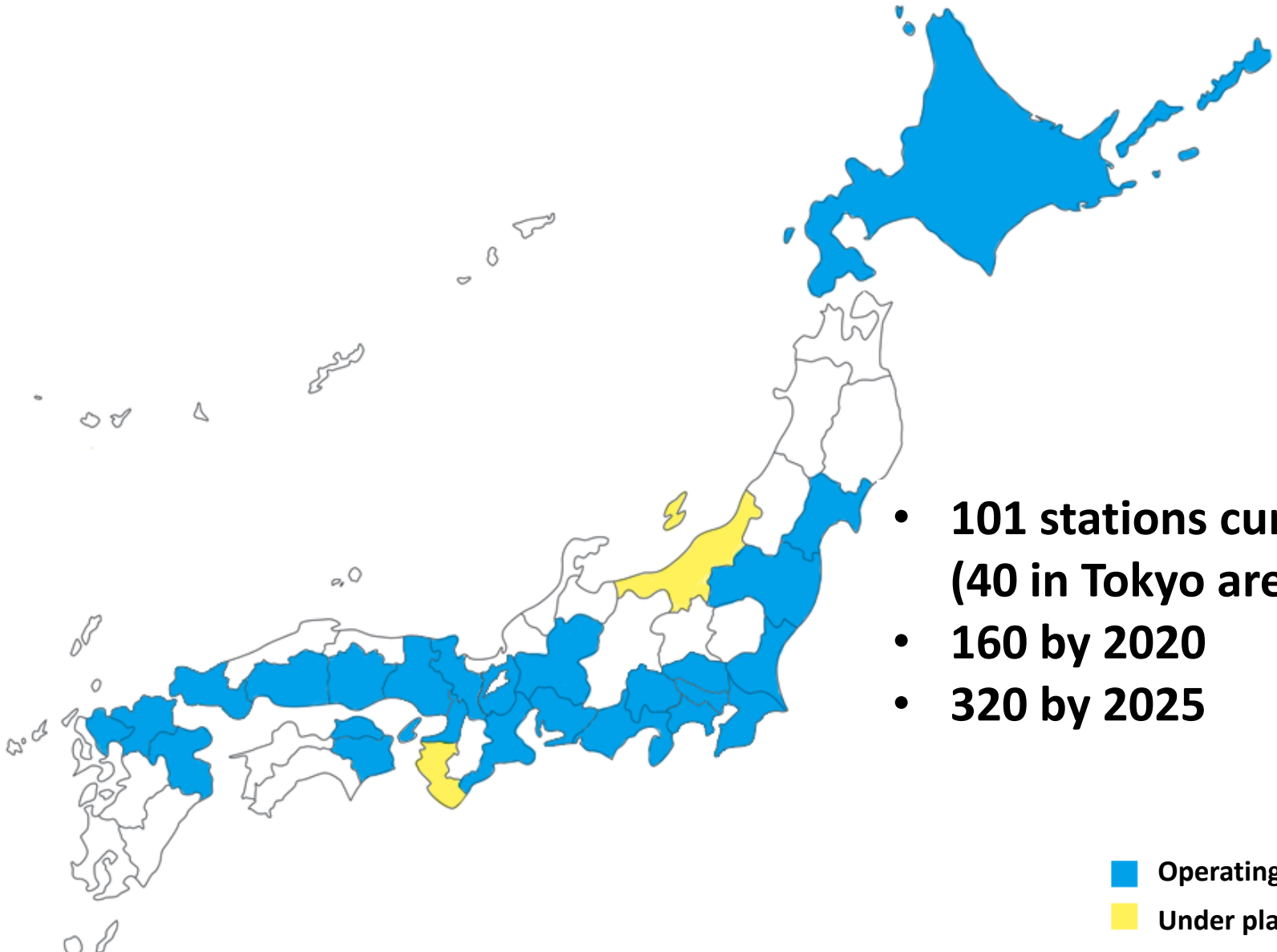
- **Vehicle manufacturers** partner with **fuel suppliers** in JHyM platform
- Cost and risk sharing covers construction and operation

3. Concentrate resources while building national network

- JHyM platform target: 80 more stations within 4 years
- Focus on Tokyo, Osaka, Nagoya and Fukuoka
- In parallel, fill gaps in national network

FUELLING STATION NETWORK

http://fccj.jp/hystation/#list



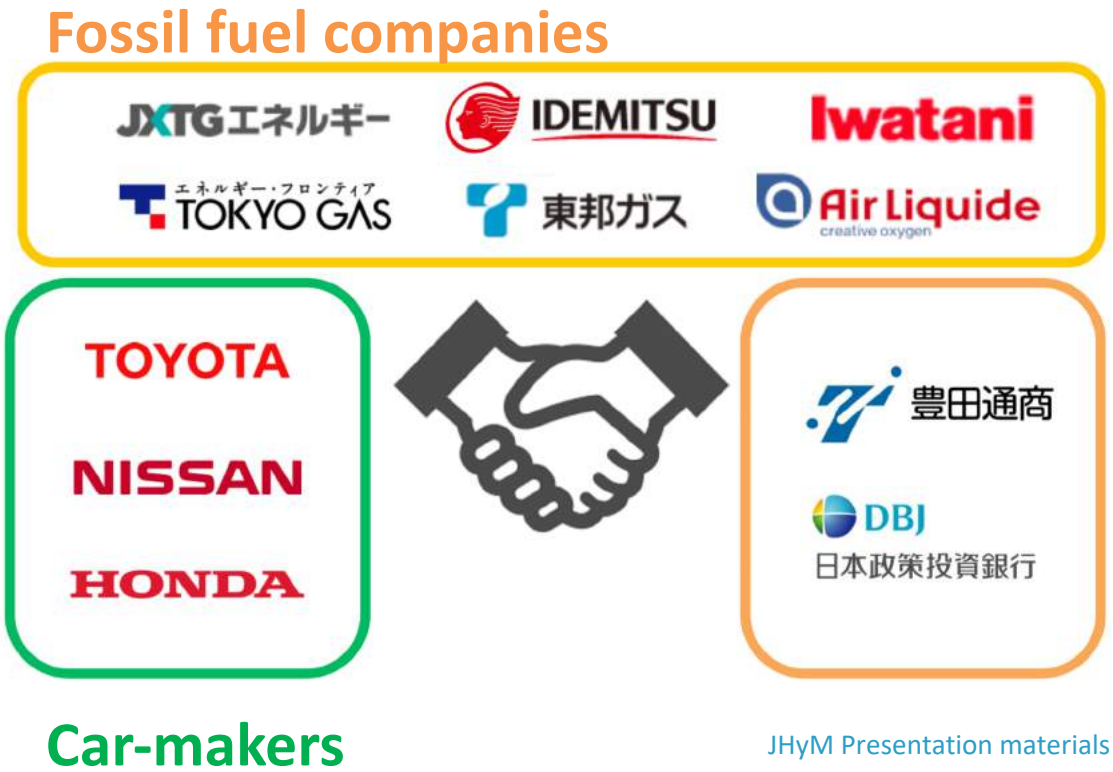
- **101 stations currently (40 in Tokyo area)**
- **160 by 2020**
- **320 by 2025**

Operating

Under planning

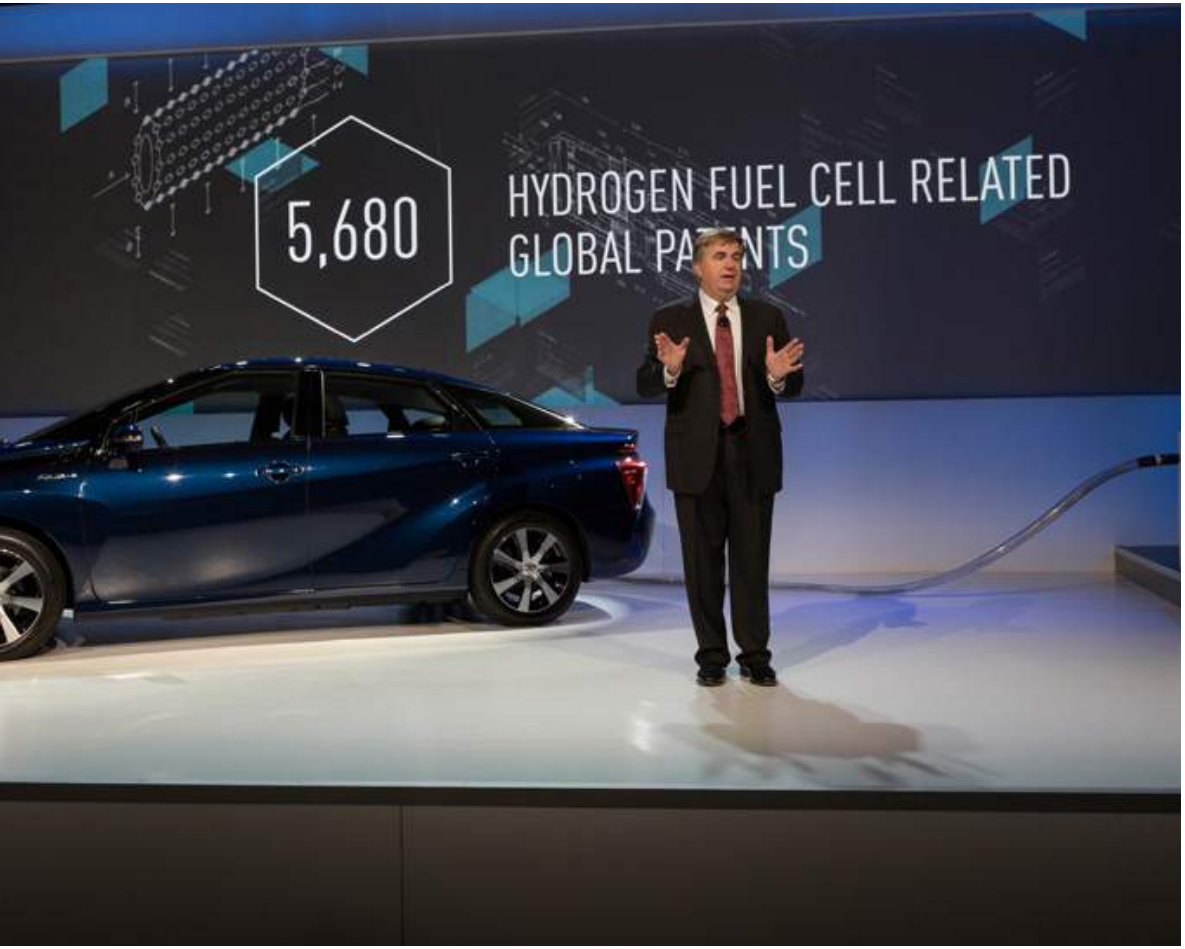
LACK OF CRITICAL SCALE & MASS

- JHyM mobilises Japan's largest auto-manufacturers and oil/gas companies into a critical mass of hydrogen advocates
- Risks and economic burdens are shared
- Fossil fuel "regime" actors are thus behind the hydrogen transition



JHyM Presentation materials

LACK OF CRITICAL SCALE & MASS



Toyota allows royalty free use of 5600 patent licenses during 2015-20 for:

- Fuel stacks
- Hydrogen tanks
- Fueling infrastructure

Aims to spur low-cost FCV development in domestic and international manufacturers

INFERIORITY TO ESTABLISHED TECHNOLOGIES ($US)

	EVs	FCVs
Range (km)	• 400 (2018 Leaf)	• 650-750 • Target of 1000

INFERIORITY TO ESTABLISHED TECHNOLOGIES

- Blackouts from earthquakes are a major concern in Japan
- Additional feature of emergency power supply
- Output of 9.0kVA 100-200 volts
- Full-tank supply average household electricity needs for 7 days
- **Cost: US $10,500**

https://www.honda.co.jp/CLARITYFUELCELL/POWER_EXPORTER/

UNRESOLVED CHALLENGES

Principal barriers to FCV diffusion framed simplistically as:

- Lack of fueling stations, and
- Up front costs

Other barriers under-emphasised:

- Running costs relative to EV
- Inconveniences posed even by future fueling station numbers of 160 in 2020 and 320 by 2025

www.toyotasantamonica.com/where-are-mirai-hydrogen-fuel-stations-located/

INTERNATIONAL SUPPLY CHAINS

APPROACH TO HYDROGEN PRODUCTION

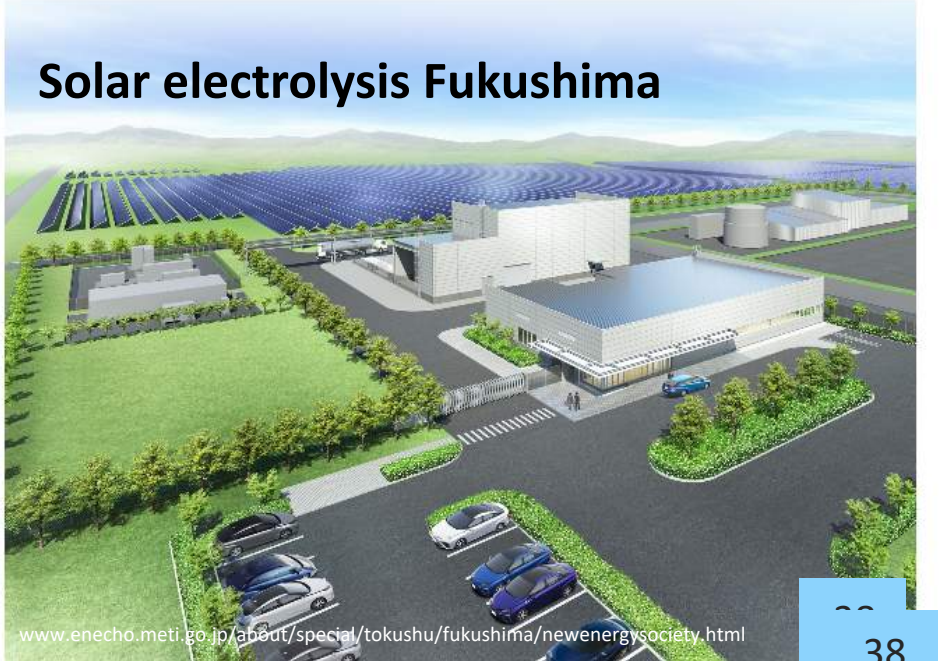
- Government commitment to CO2-free hydrogen in mid- to long-term
- Widespread experimentation for production from renewables:
  - Wind and solar (electrolysis)
  - Biogas from livestock manure and sewerage
- Renewables projects intended as demonstrations for Phase 3 (around 2030~) rather than business models for today
- In mid-term, majority of mass-production of CO2 will:
  - Occur overseas for cost and scale reasons
  - Involve fossil fuels and renewables
  - Involve different carriers (liquefaction, metal hydrides etc.)

DOMESTIC RENEWABLE HYDROGEN PROJECTS

www.heco-spc.or.jp/kiban/shikaoi1.html

Barriers to diffusion include:

- High costs of renewables
- Resources far from cities
- Better economics if directly using biogas/electricity
- Production is technically possible but hydrogen demand is low

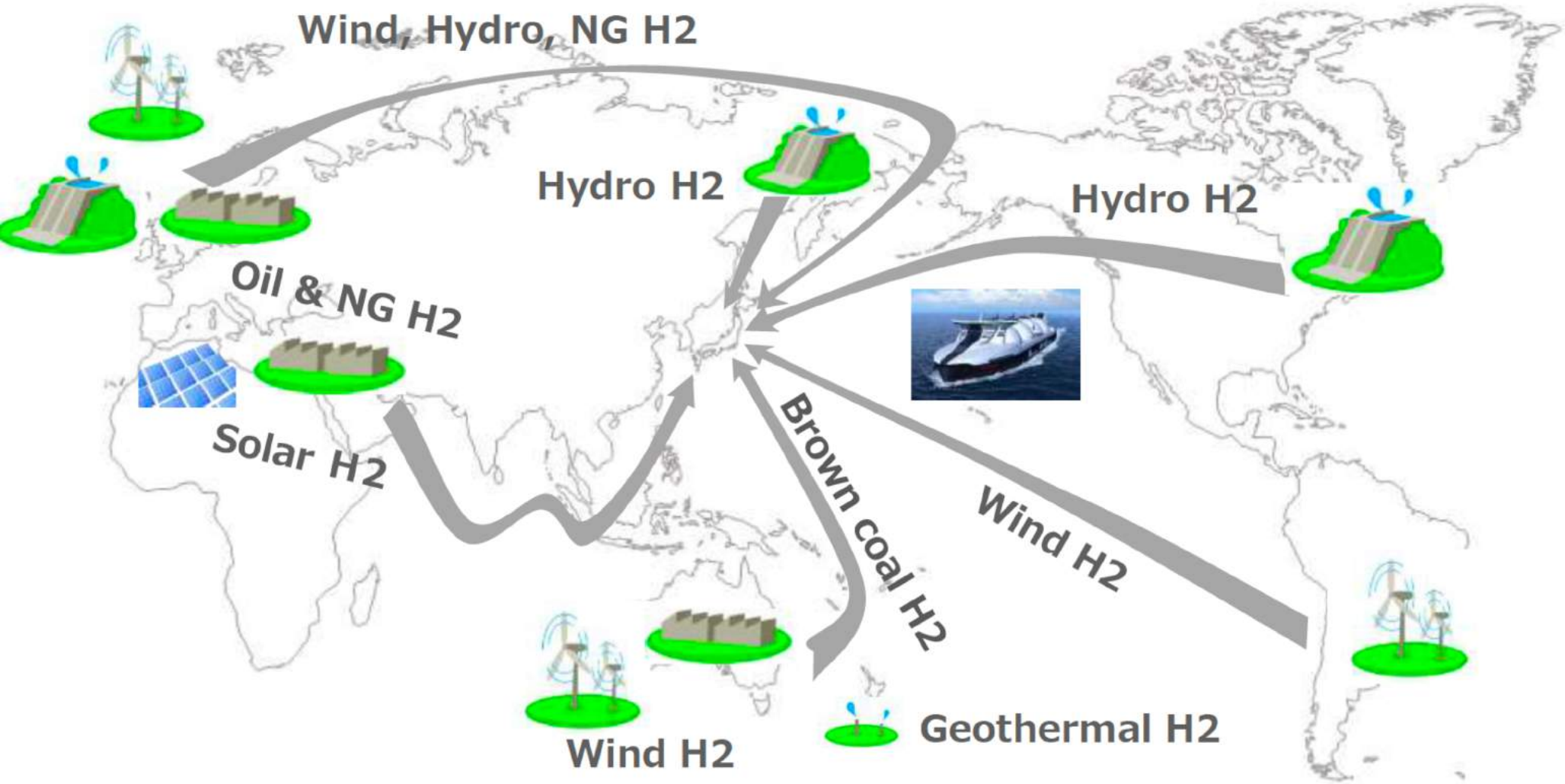


EMERGING SUPPLY CHAINS

	Australia	Brunei	New Zealand
Energy source	Brown coal	• Natural gas • Oil • Coal	Hydro and geothermal
CCS	Yes	Yes	No
Storage/transport	Liquid	Organic chemical hydride Methylcyclohexane [MCH]	??
Volume (tonnes/year)	300,000 in 2030~ =3 million FCVs =1GW H2 power plant	210 in 2020 =40,000 FCVs Full scale in 2025	
Use	Power generation Transport	Power generation Transport	??
Companies	**Kawasaki Heavy Industries** J-Power Iwatani Shell Japan Marubeni	**Chiyoda Corporation** Mitsubishi Mitsui	??
Nature of project	• Long-term Large-scale	• Short-term • Small scale	MOU signed late 2018

Fossil fuel "regime" players

POTENTIAL INTERNATIONAL CO2-FREE SUPPLY CHAINS



Kawasaki Heavy Industries (2018) Presentation at Clean Coal Day Tokyo

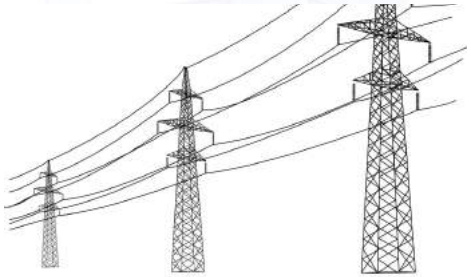
INTERNATIONAL SUPPLY CHAINS

LATROBE COAL TO HYDROGEN

Images
http://www.worldweather.org/185/c00434m.html
http://www.abc.net.au/radionational/programs/scienceshow/coal-mine.jpg/5769782
http://www.itmedia.co.jp/smartjapan/articles/1402/25/news077.html
https://www.khi.co.jp/stories/articles/vol54
https://www.vectorstock.com/royalty-free-vector/silhouette-of-high-voltage-power-lines-vector-1566984

Full scale production in 2030

- 3 million FCVs/year
- 1 GW hydrogen powerplant (Power cost 15 cents/kWh)



Brown coal gasification
Carbon Capture & Storage

World first hydrogen tanker

Usage in transport and power/heat

FRAMING OF PROJECT IN JAPAN

Framed as essential for boosting energy security

- Latrobe brown coal reserves equate to 240 years of Japan's annual electricity needs (Kawasaki Heavy Industry presentations)
- Can reduce dependence on Middle Eastern oil
- Australia's political stability highly trusted

Project implementers assert hydrogen from renewables could not compete in terms of:

- Cost
- Scale (would require 3GW solar installation)
- Stability of supply

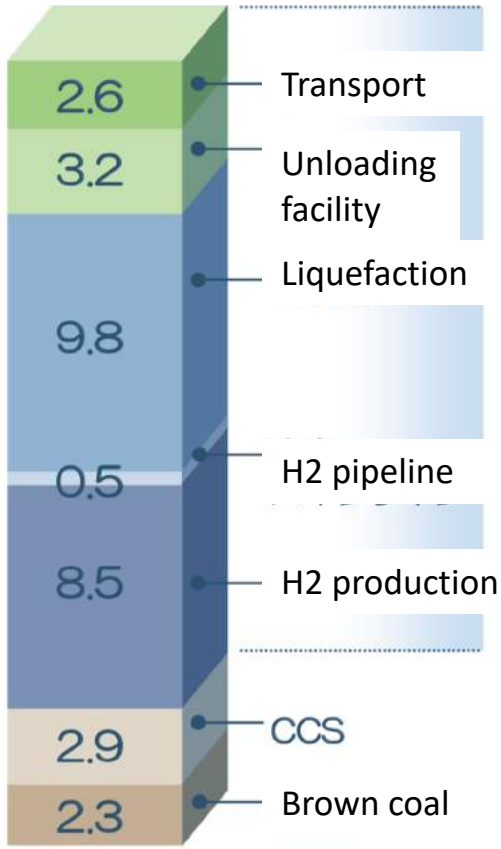
Carbon Capture and Storage (CCS) projects globally have captured precious public funds and failed to produce meaningful GHG emissions

Therefore, might not this project go ahead without CCS?

CCS DIMMENSIONS

- CCS costs make up only 10%
- Most costs in hydrogen production and liquefaction
- For J-Power, this is a flagship project to demonstration CCS + coal gasification
- National policy calls for carbon-free hydrogen (via CCS) when full-scale is reached explicitly in:
  - Fourth Basic Energy Plan
  - Basic Hydrogen Strategy

Import cost of around US $0.26/Nm^3



Kawasaki Heavy Industries (2018)
Presentation at Clean Coal Day Tokyo

IMPLICATIONS AND POTENTIAL

- Cost, scale and stability of supply is essential for integrating hydrogen into mobility and power generation.
- Solar and wind cannot yet compete economically

  Chapman et al. 2017
- Successful demonstration of supply chain would open export prospects for other states and countries and expedite global hydrogen trading

SOCIAL ACCEPTANCE CHALLENGES

Environmental and health concerns:

- No Environmental Impact Assessment required for pilot phase
- Air pollution and waste from coal gasification
- Risk of coal fires and methane leaks from expanded coal extraction

"Do we accept jobs or our health?"
(Interview 12/2/2019)

Ethical concerns:

- Community consultations insufficient

www.heraldsun.com.au/business/agl-to-shut-down-loy-yang-power-plant-over-industrial-action-threat/news-story/0ecf02c1817f9b1aac696d069a2ea262

CLOSING REMARKS

KEY POINTS

Japan's approach is high cost and high risk

- Requires construction of expensive new infrastructure from scratch
- Depends largely on diffusion of FCV and fueling stations
- But, prospects of high reward if exporting supply chain technologies

Hydrogen production not linked to domestic renewable diffusion

- Early focus on imports and centralised production from fossil fuels

Sharp contrast to Germany's low risk approach:

- Focus on renewables and existing gas infrastructure via power-to-gas

Plummeting renewable costs might challenge logic of fossil fuel + CCS

- This would also increase logic of renewable hydrogen export

FURTHER READING (IN ENGLISH)

METI 2017. Basic Hydrogen Strategy

- **Full Version** www.meti.go.jp/english/press/2017/pdf/1226_003b.pdf
- **Key Points** www.meti.go.jp/english/press/2017/pdf/1226_003a.pdf

Chapman, A. et al. 2017. Hydrogen import pathway comparison framework incorporating cost and social preference: Case studies from Australia to Japan. *Energy Research* 41: 2374–2391.

Trencher, G. Van Heidjen, J. 2019. Complementary but also contradictory: National and local imaginaries in Japan and Fukushima around transitions to hydrogen and renewables, *Energy Research and Social Science* 49: 209-218.

Free online copy

- Available at Research Gate

Journal version

- See *Energy Research and Social Science* website

THANK YOU

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Download slides

https://we.tl/t-WE3kN1lMfP

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This research was undertaken with Kaken funds from Japan Society for the Promotion of Science

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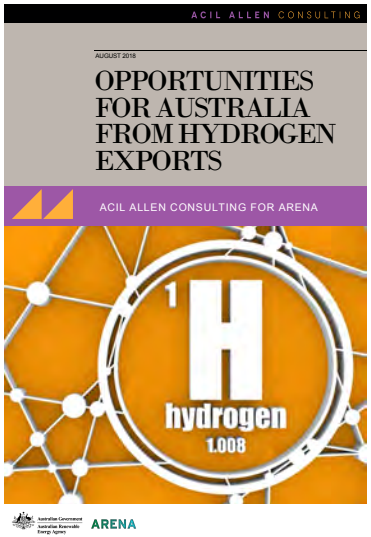

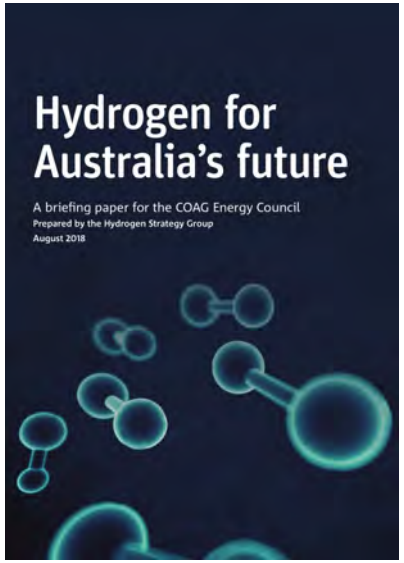

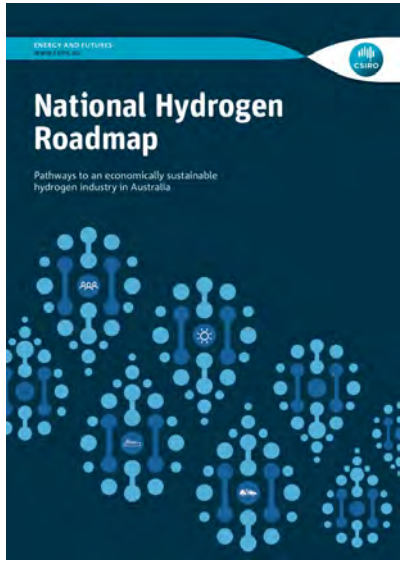

Exporting renewable energy investment priority

FUTURE FUELS CRC

12 April
$26 M

1 Aug

10 Aug

23 Aug

6 Sept
$22 M

2018

Apr | Aug | Sep

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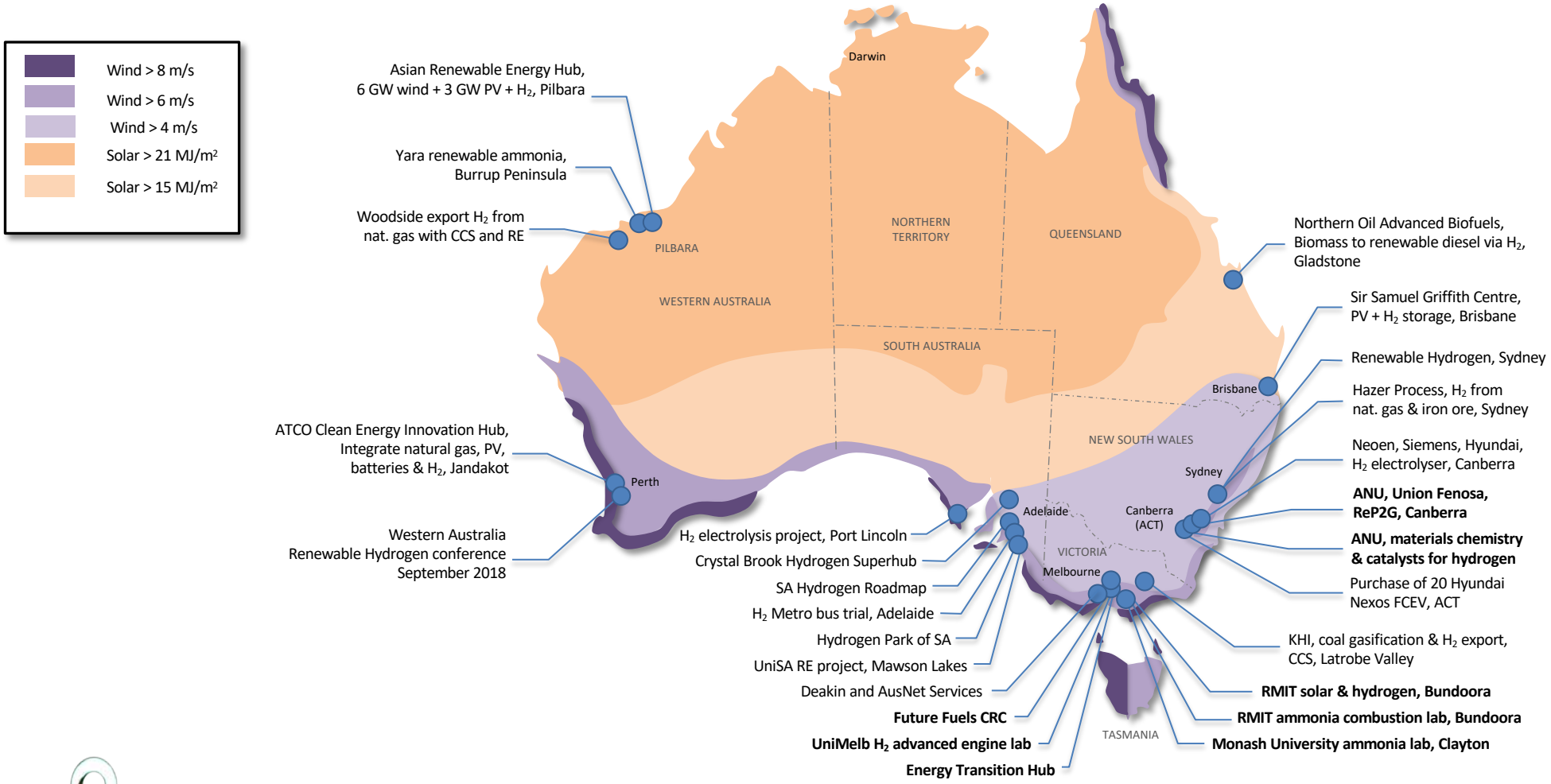
Hydrogen current projects



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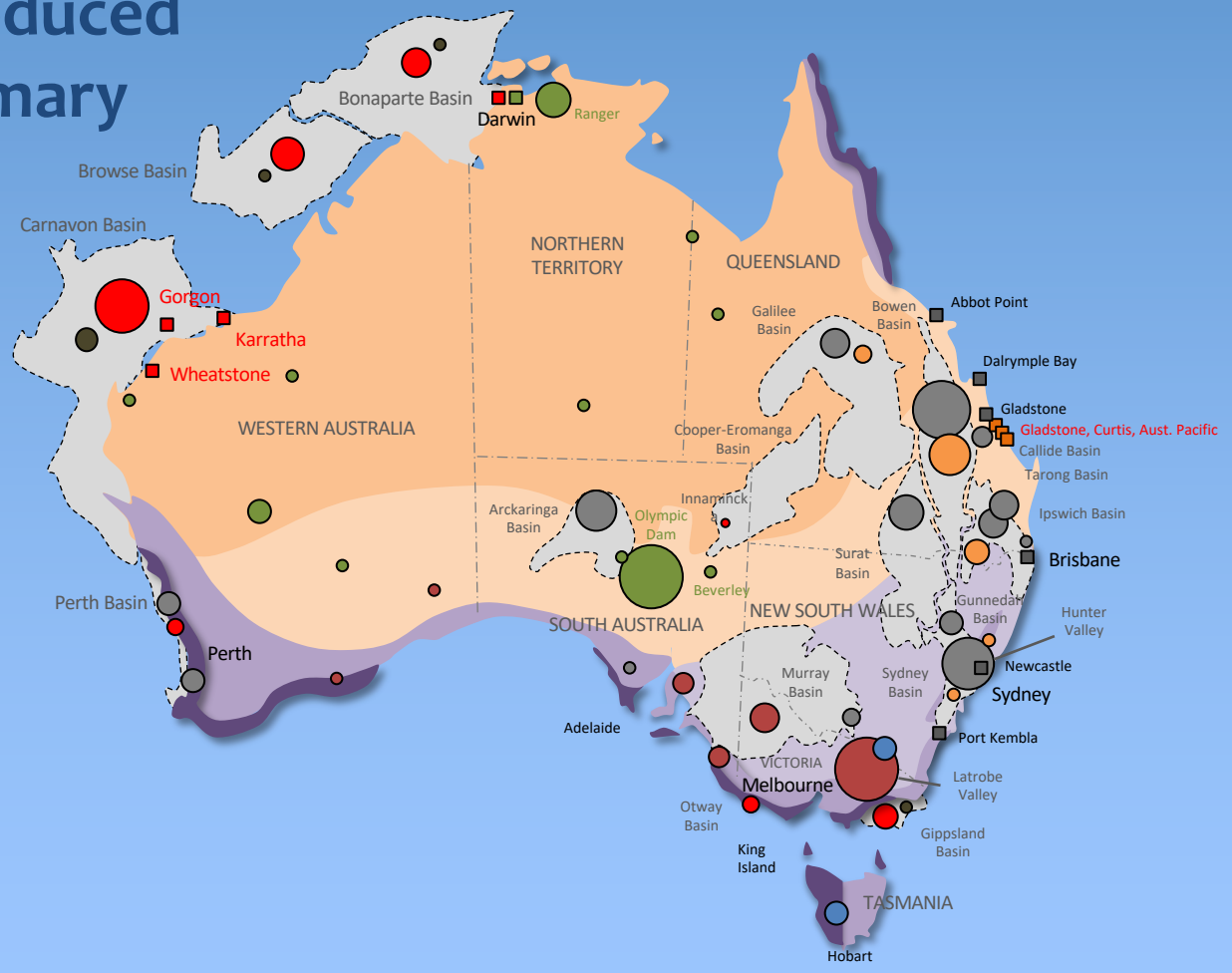
Australian energy resources – hydrogen can be produced from all of these primary energy sources



Wind > 8 m/s	Black coal
Wind > 6 m/s	Brown coal
Wind > 4 m/s	Uranium
Solar > 21 MJ/m²	Conventional gas
Solar > 15 MJ/m²	Oil
Major energy basin	Coal seam gas
	Large scale hydro
	Export terminals

Speaker

Prof Leo Geodegeburre

Leo.geodegeburre@unimelb.edu.au

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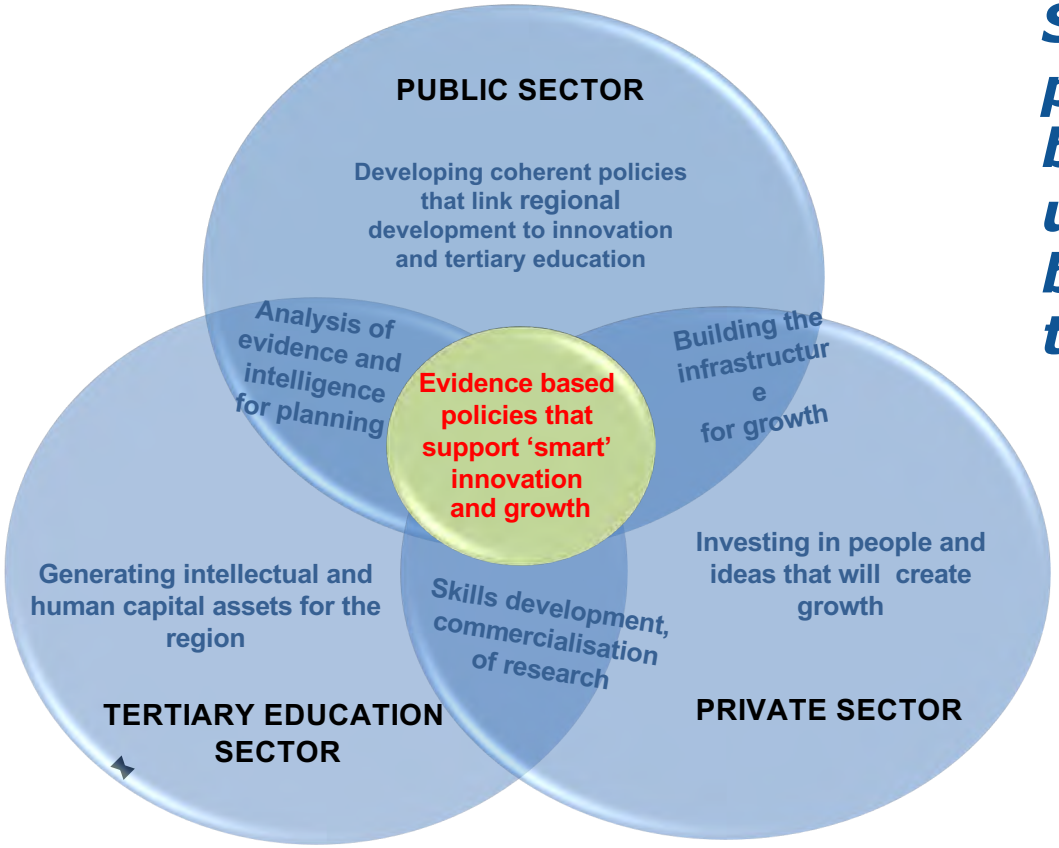
Project Overview: Smart Specialisation for Gippsland

- The Latrobe Valley Authority (LVA) is working on a long-term approach for Gippsland to become a more sustainable regional economy and socially cohesive community.
- The Latrobe Valley Authority has initiated the project to bring together government, business, research and education and the wider local community to codesign a shared vision for the region's future prosperity, environmental sustainability and social wellbeing.
- Applying the 'Smart Specialisation Strategy' (S3) methodology pioneered in the European Union, the project will facilitate a 'place-based' approach to innovation and regional development that connects the local context with evolving national and international economic activities and value chains.
- Four pillars: Food & Fibre, Energy, Health & Wellbeing, Visitor Economy

RMIT UNIVERSITY | LH Martin Institute | THE UNIVERSITY OF MELBOURNE | MELBOURNE SUSTAINABLE SOCIETY INSTITUTE | LATROBE VALLEY AUTHORITY

The ‘connected’ region



Strong partnerships based on shared understanding of barriers and how to overcome them

Source: **Goddard, J and Kempton, L** (2011)
Connecting Universities to Regional Growth,
European Commission

Questions

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