Japan – a future market for Australian solar ammonia

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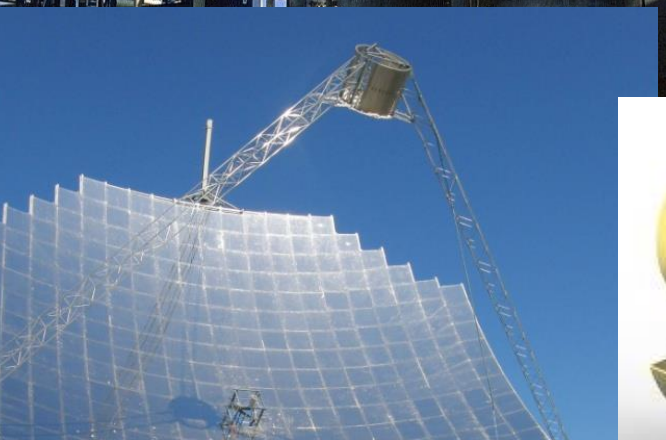
http://www.itpowergroup.com
NH3 Fuel Conference
Los Angeles 18-20 September 2016

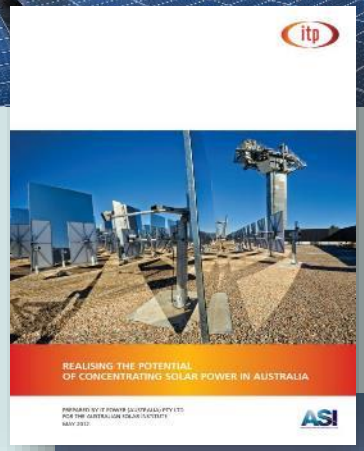


Outline

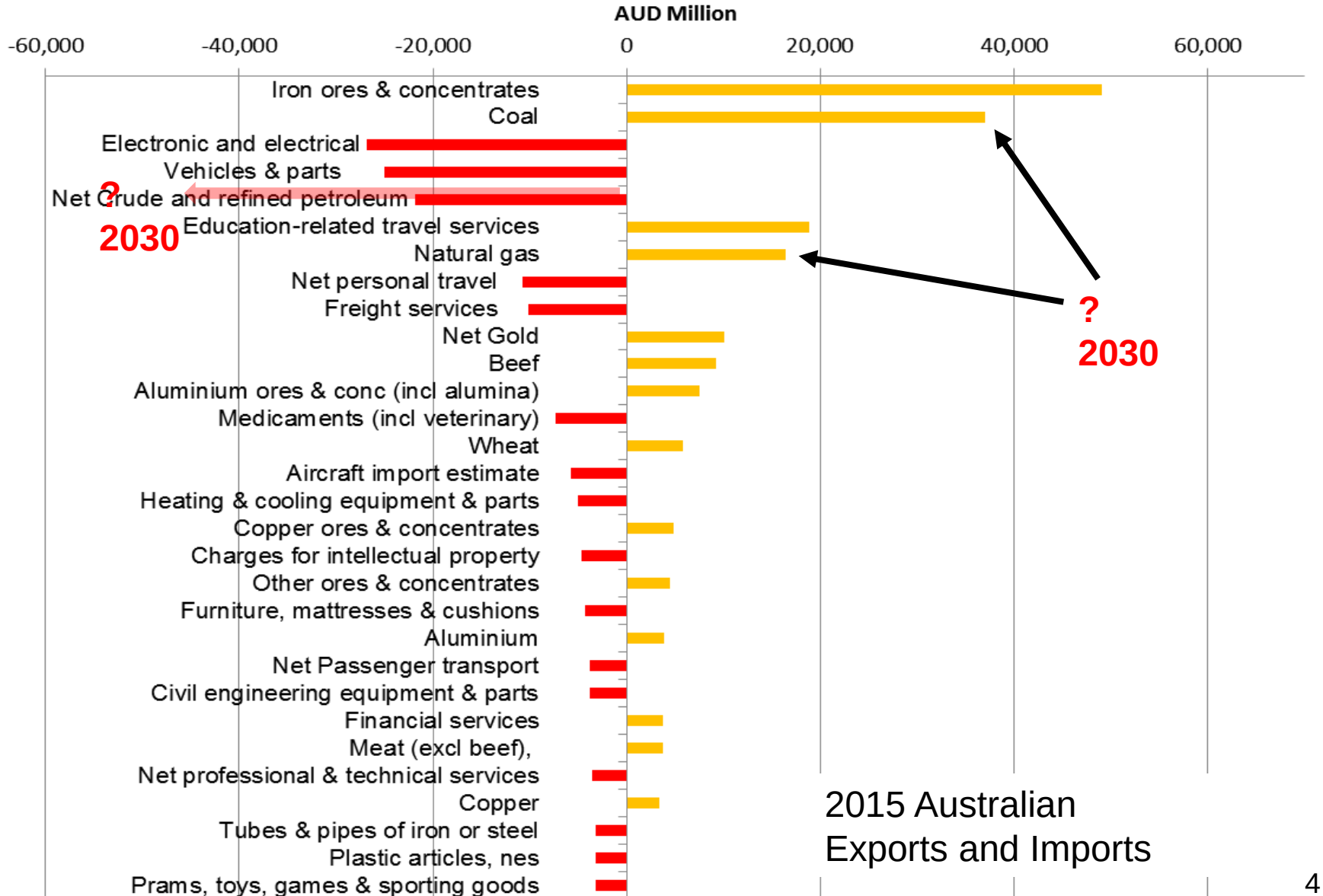
1. About IT Power Group
2. Australia's exports in a low carbon world
3. Concentrating solar for ammonia production
4. Conclusion

1 - IT Power Group

- Established in the UK in 1981
- Key country offices
  - UK
  - India
  - Australia
  - China
- Specialist sustainable energy engineering consulting
  - renewable energy and efficiency consulting
  - climate change policies and carbon trading market analysis
  - business consulting and due diligence
- Solar Thermal across group lead by Keith Lovegrove (MD ITP Thermal Pty Ltd)
- More than 1,500 sustainable energy projects in 150 countries.



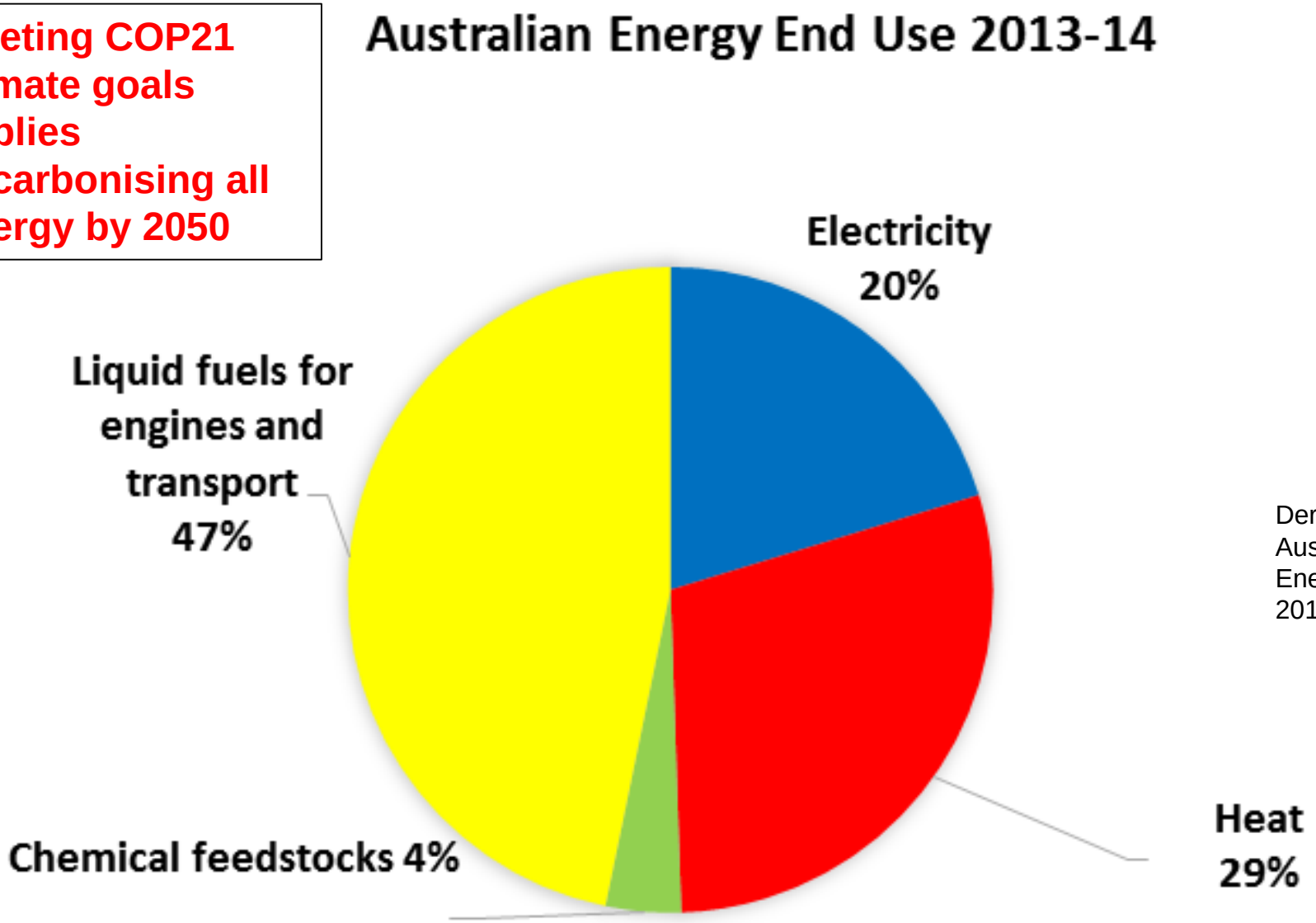
2 - Australia needs innovative new exports in a low carbon world



2015 Australian Exports and Imports

‘Energy' doesn’t just mean Electricity

Meeting COP21 climate goals implies decarbonising all energy by 2050



Derived from Australian Energy Statistics 2015

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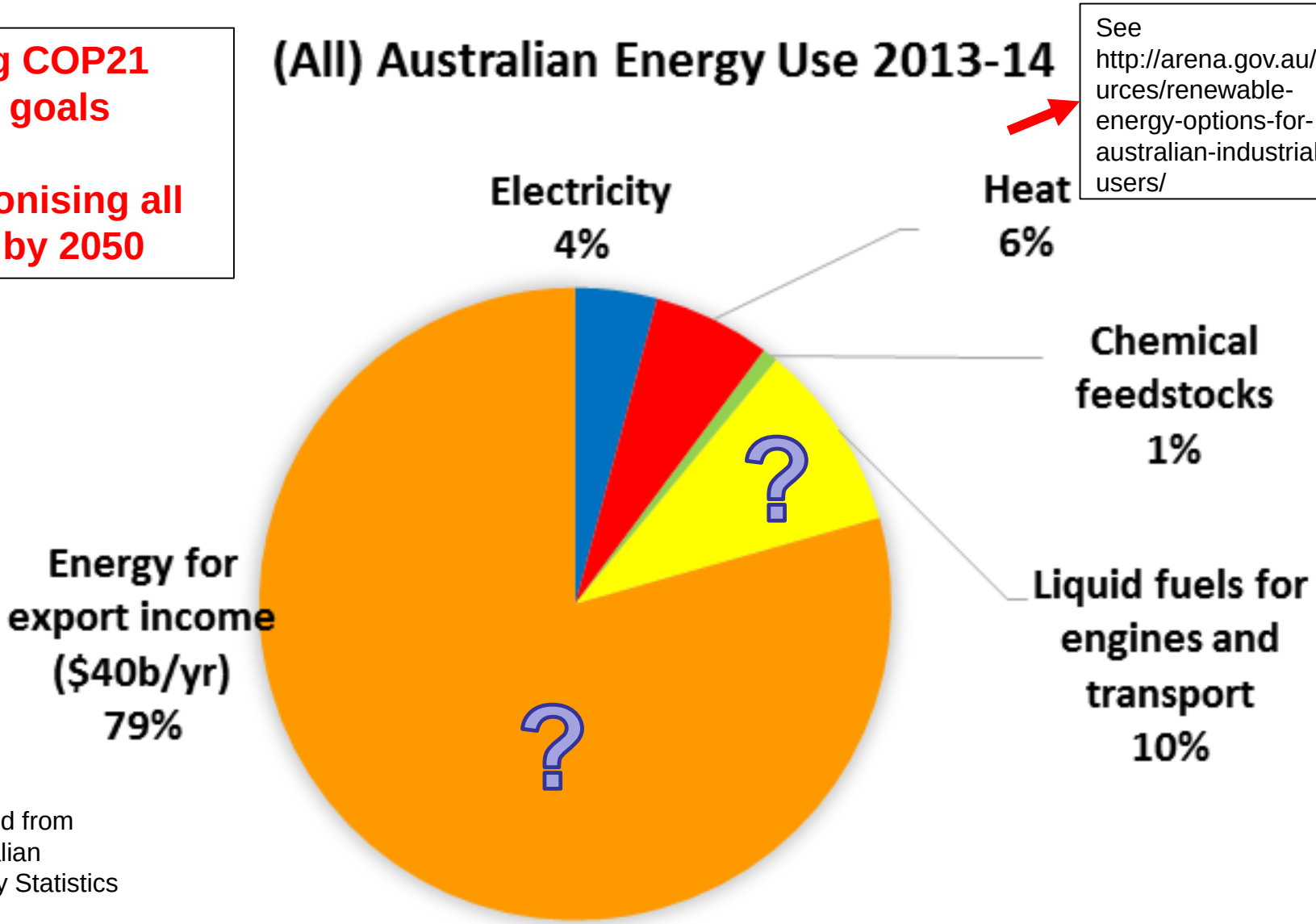
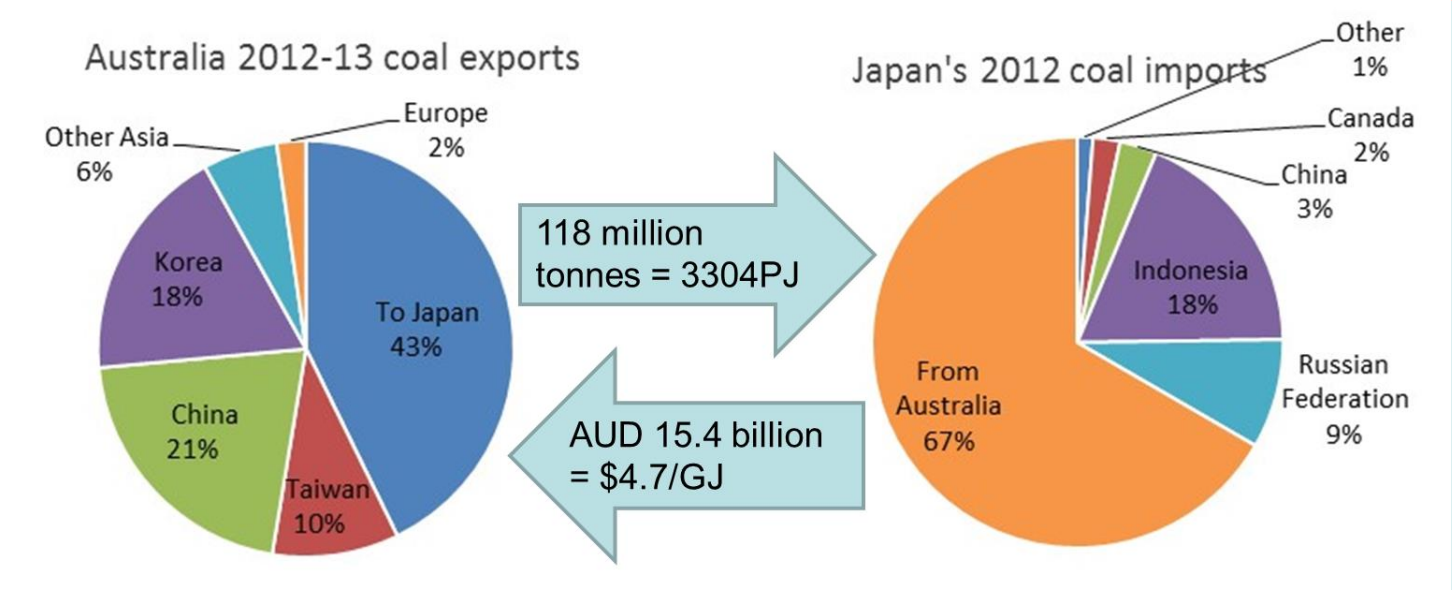
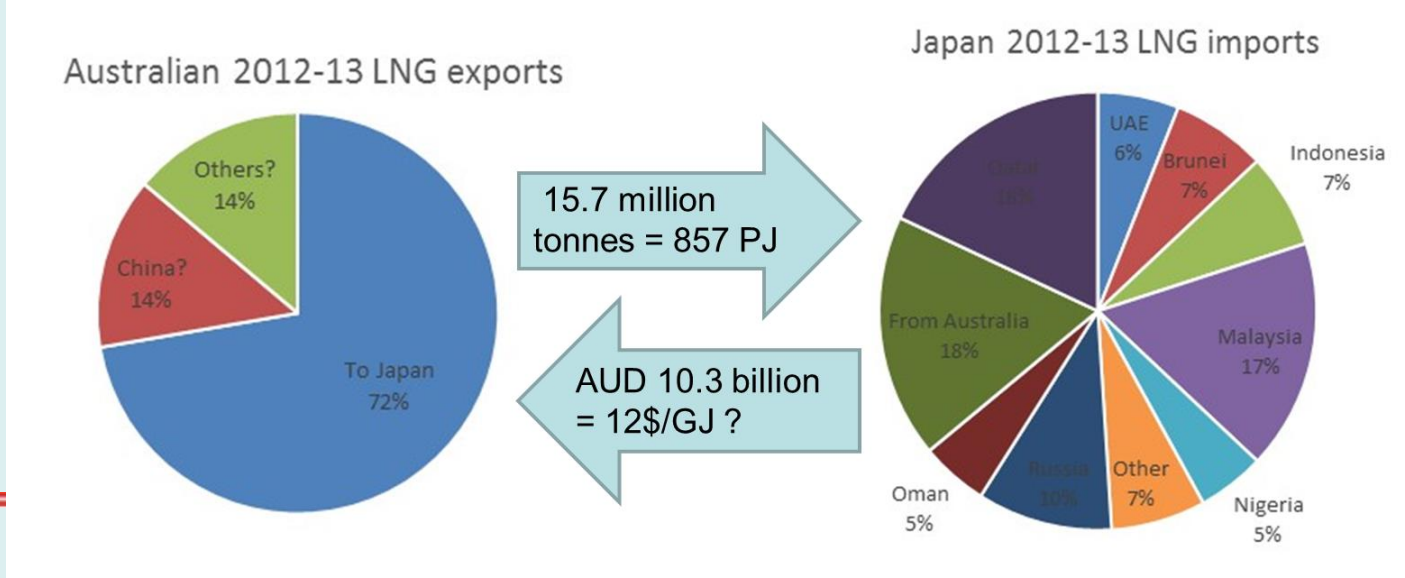


Derived from Australian Energy Statistics 2015

Australia and Japan (asia) have a large energy trade

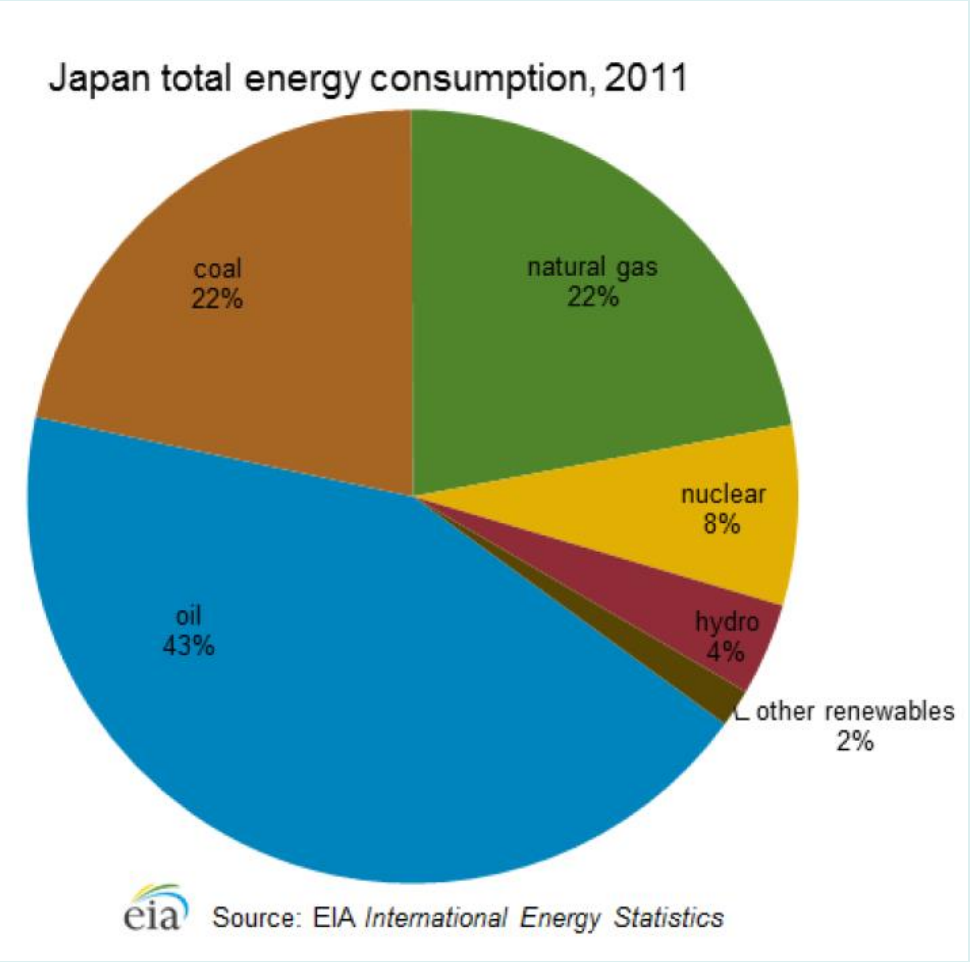




Japan and Australia compared

	Japan	Australia
Population	128 million	22 million
Electricity Installed cap.	285GW	49GW
Land area	0.38 million sq km	7.7 million sq km
Primary energy	22,000 PJ/a	5,800 PJ/a
Direct Normal Irradiation	Around 1100kWh/m^2/year (10.5MJ/M^2/day)	Around 2300kWh/m^2 /year (22.7MJ/m^2/day)
Net energy flow	importer	exporter

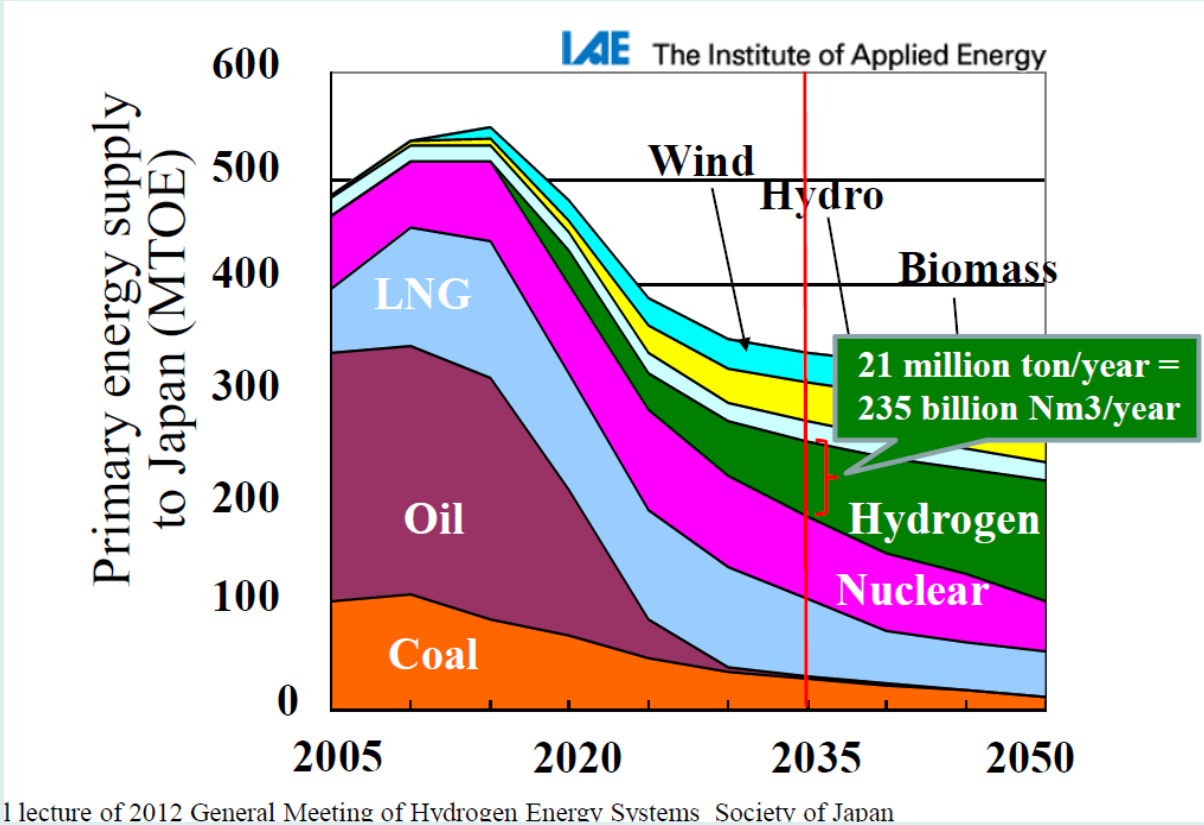
Primary energy sources in Japan



- 22,000PJ/a
- Virtually all energy is imported:
  - *World's largest LNG importer,*
  - *second largest coal importer, and*
  - *third largest net oil importer.*
- Post Fukishima, nuclear dropped to zero by 2013, will it grow again?
- A very large dependence on oil from middle East
- Strong concerns about energy security
- Push for PV, but a long time to any real contribution
- A continuing commitment to reducing GHG emissions

Japanese policy initiatives towards hydrogen

- In FY 2012, invested approximately $240 million in fuel cell and hydrogen energy programs
- plan to sell two million fuel cell electric vehicles by 2025, and install 1,000 hydrogen fueling stations.
- goal of fuel cells powering 2 million homes by 2020.
- Major hydrogen imports expected around 2030



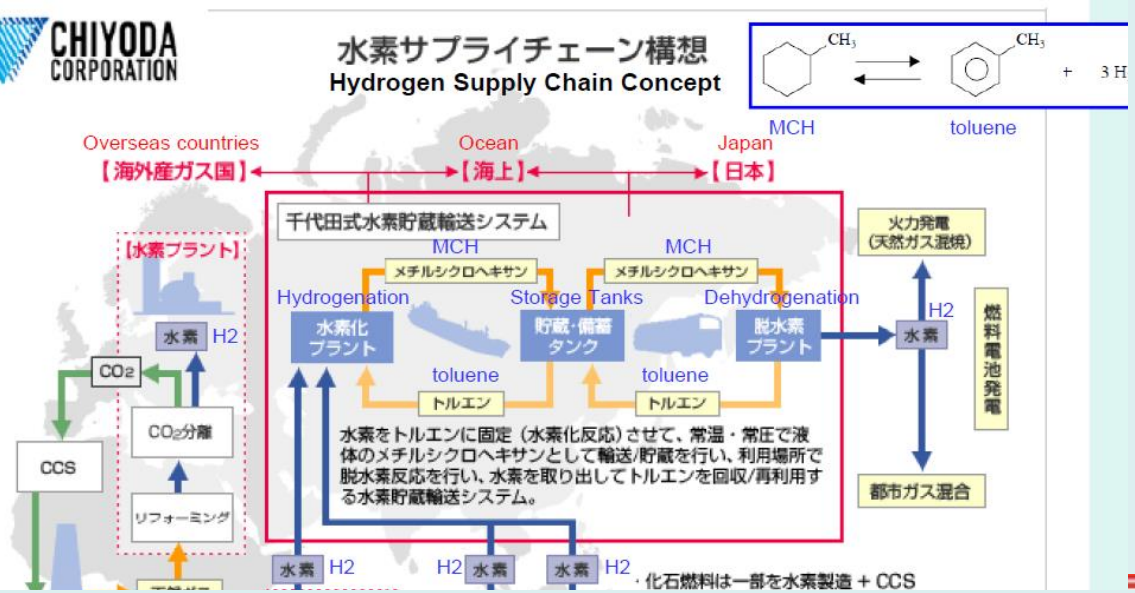
l lecture of 2012 General Meeting of Hydrogen Energy Systems Society of Japan

•**http://www.fchea.org/index.php?id=25**

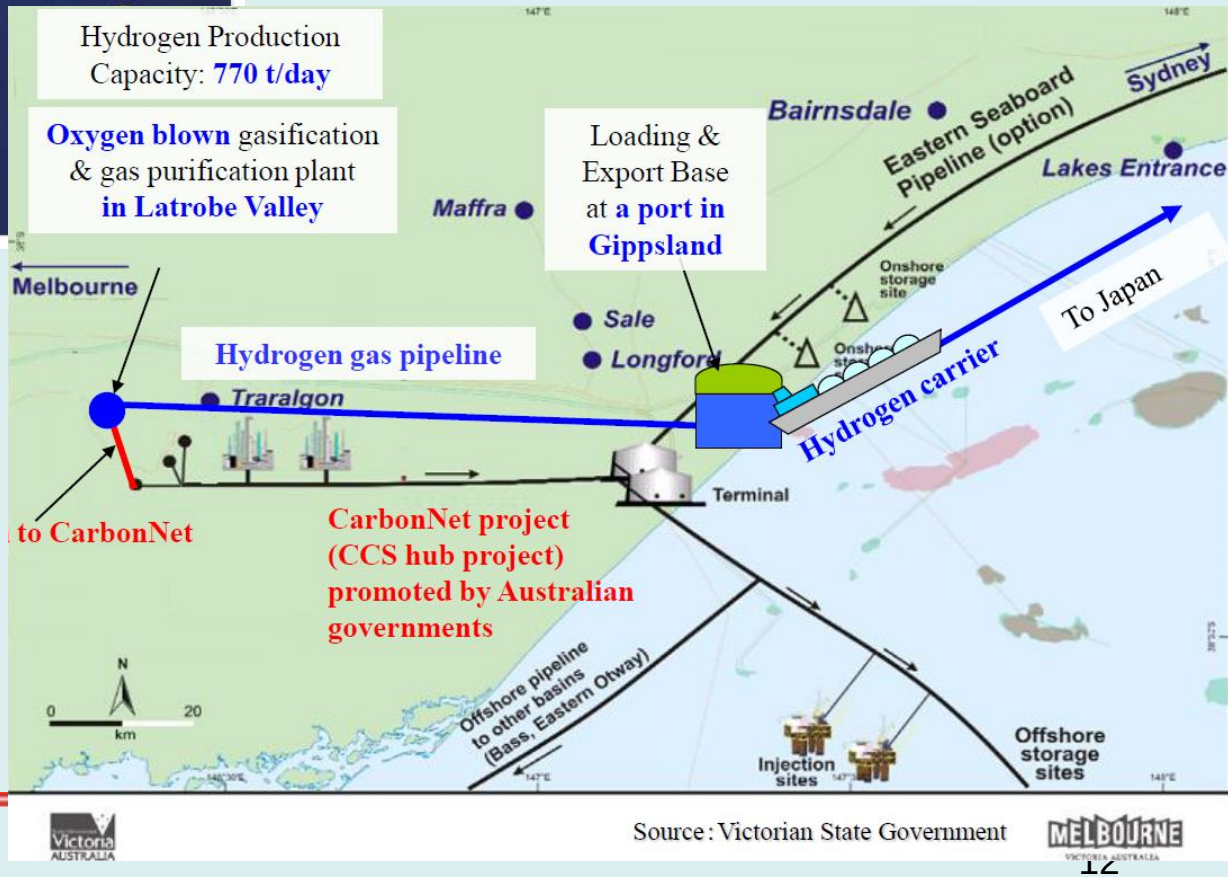
USD 20m “New Energy (Hydrogen) Carrier Project” started April 2013

Likely vectors for moving hydrogen internationally
Liquid H_2
Toluene (MCH) cycle
Ammonia

- Kawasaki Heavy Industries favour liquid H_2 – but electricity requirements >> LNG
- Chiyoda corp. working on reversible hydrogenation of Toluene – but small payload in tankers
- **Ammonia is already manufactured and traded on a global scale – gaining increasing attention**



Kawasaki Heavy Industries Australian connection



- Progressing plans for Latrobe valley coal gasification + CCS for hydrogen production in Australia

Europe's Desertec (electric) vision for the future ?

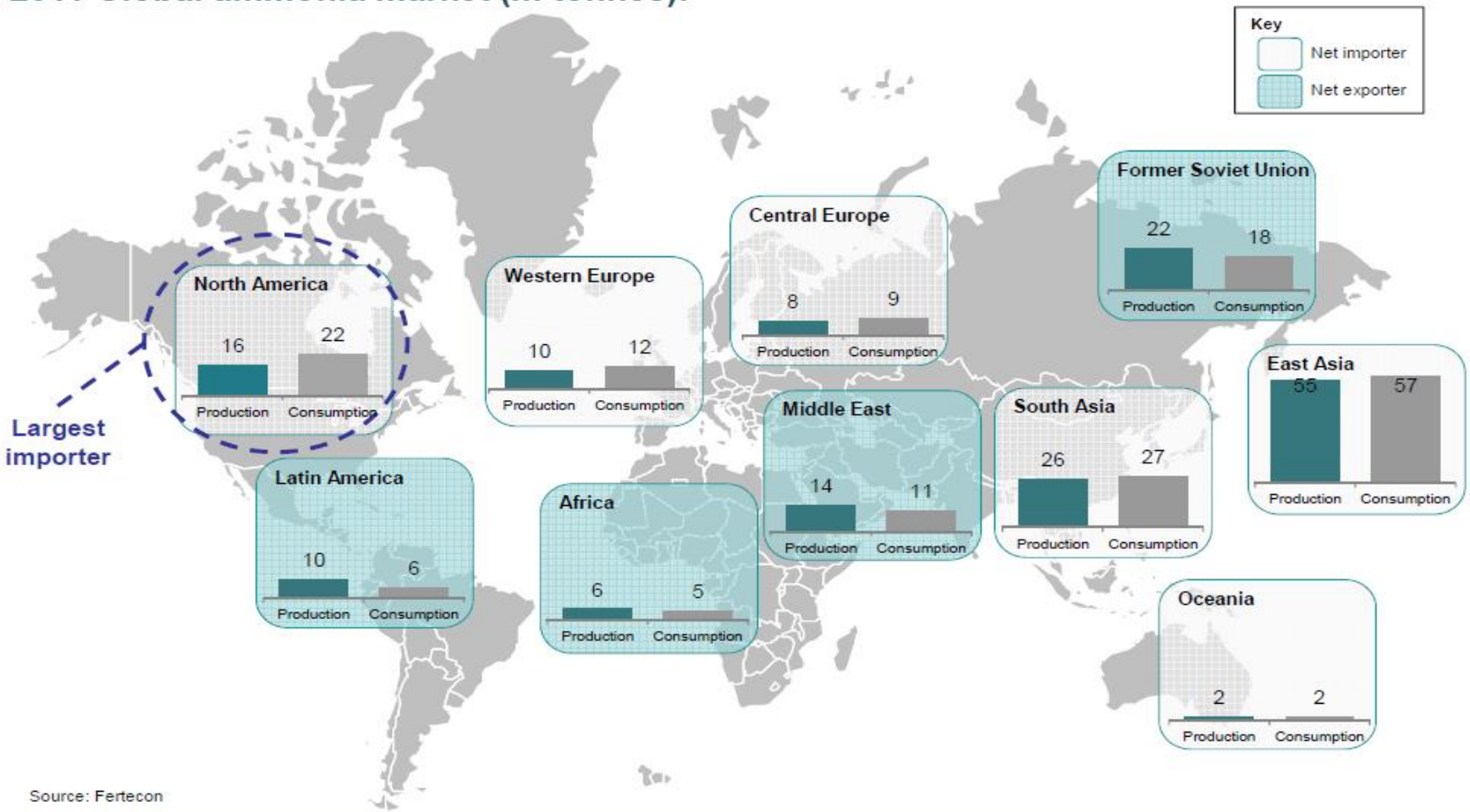
Source: Desertec

- HVDC links across Mediterranean are a few 100kms, readily achievable
- Who would connect Australia 6000km to Japan ??????

Ammonia is already traded globally

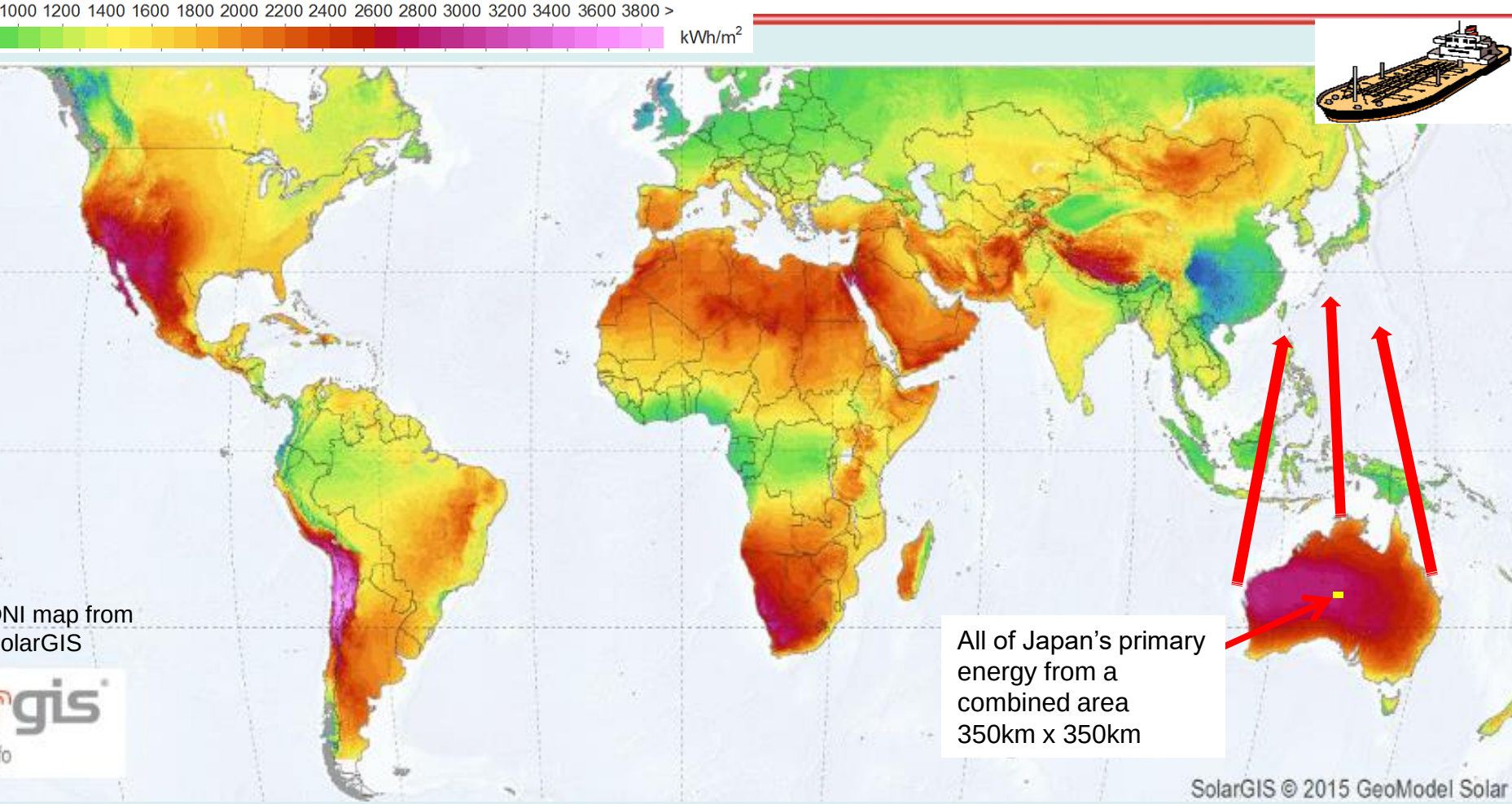
SUPPLY & DEMAND BALANCE FOR FREE AMMONIA

2011 Global ammonia market (m tonnes):



Source: Fertecon

Australia's 'Desertec' – solar ammonia to Japan, Korea and others



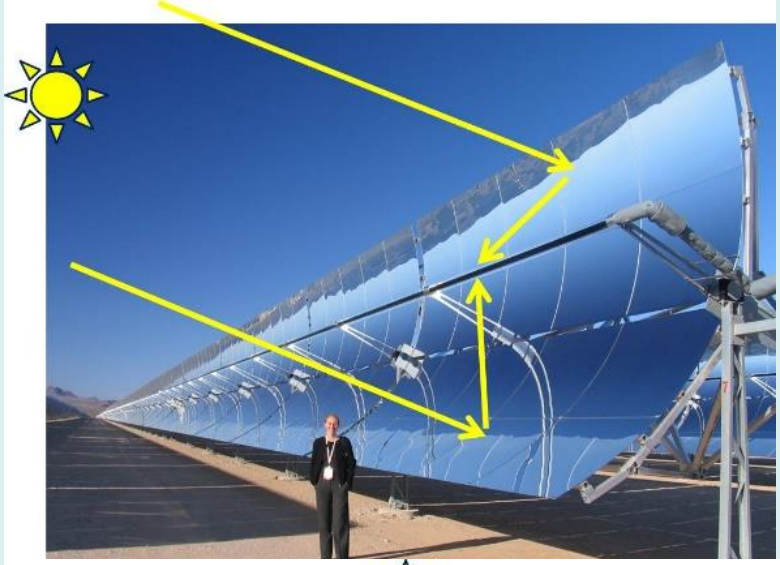
- Australia has >100% more solar intensity and available land
- Energy cost of tanker transport < 5% of ammonia payload

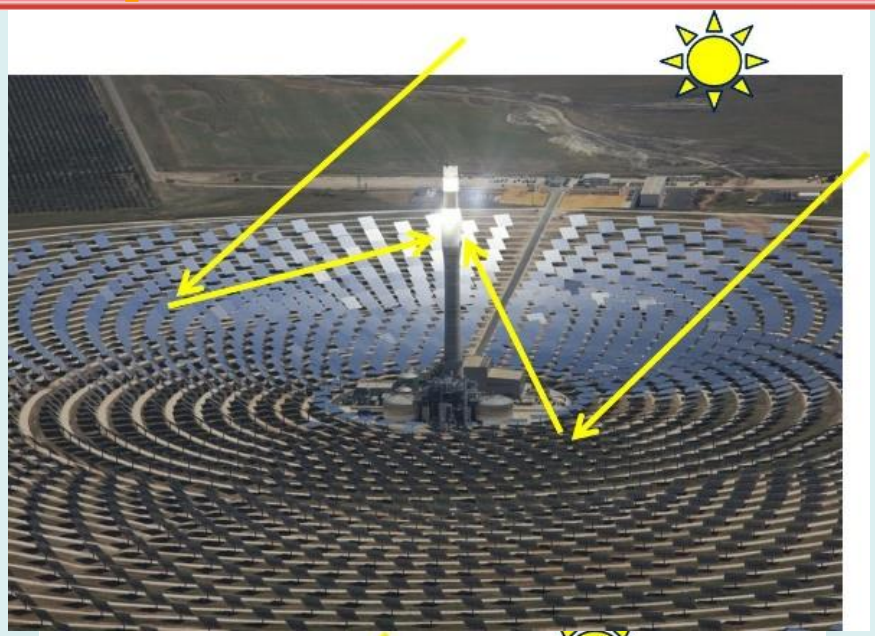
Build on a history of Japanese investment in Australian Oil and gas projects

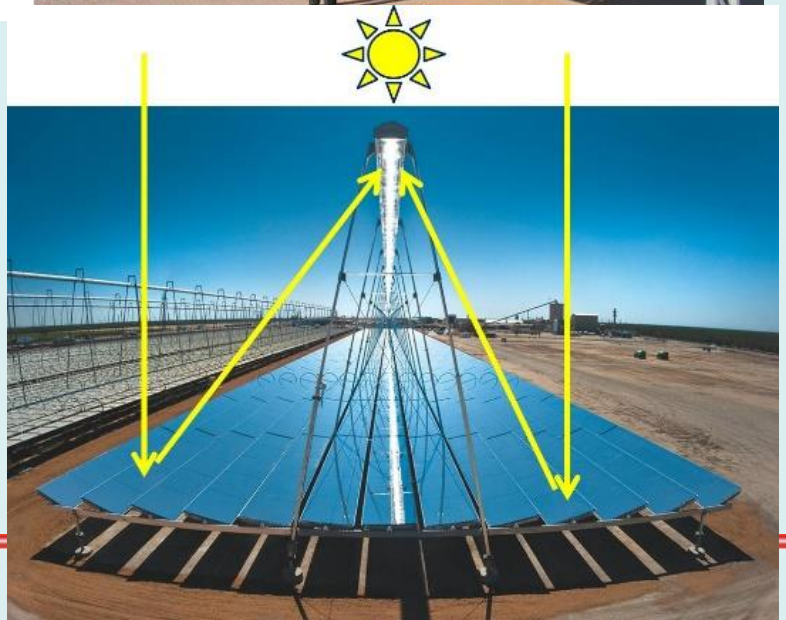
Project	Japanese equity
Ichthys LNG Project, Browse Basin, Western Australia	Inpex, 66% Japanese electric utilities: 2.74%.
Pluto LNG Project	Tokyo Gas 5% and Kansai Electric 5%
Timor Sea Joint Petroleum Development Area	Inpex, Tokyo Gas, and TEPCO, combined 20%
Prelude LNG	Inpex 17.5% acquired from Shell in 2012.
Darwin LNG	pex 11.3%, TEPCO 6%, and Tokyo as 3%
Wheatstone l	panese electric & gas utilities: 9.5%
Browse LNG	tsubishi and Mitsui 14.7% in LNG terminal. % in East Browse and 8% in West Browse.
Van Gogh and Ravensworth oil fields	Inpex: 47.5% of Van Gogh, 28.5% of Ravensworth
Timor Sea Joint Development Area	Inpex: 35% of Kitan oil field
NW Shelf Mutineer and Exeter fields	JX Nippon: 25%

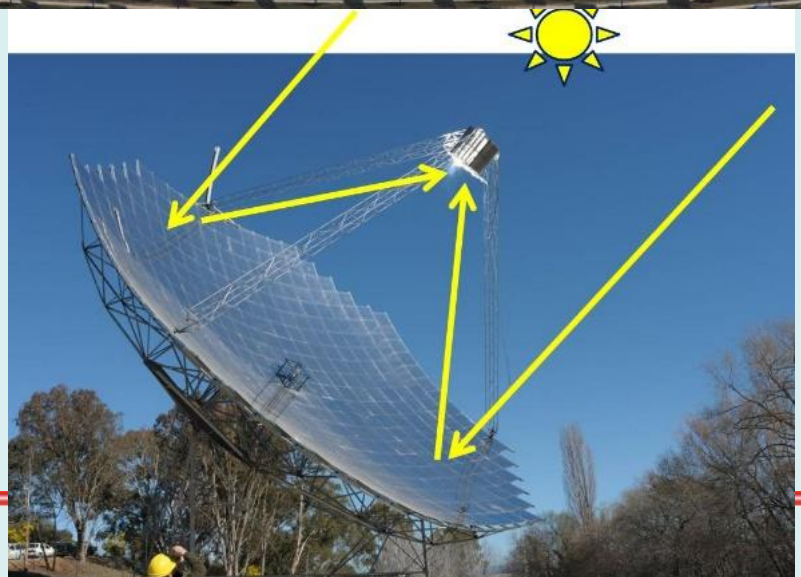
"Japan's limited hydrocarbon reserves and its need to secure energy imports are the incentives the government uses to support upstream Japanese companies in their quest to purchase overseas oil and natural gas equity."(eia)

3 - Concentrating Solar for ammonia production

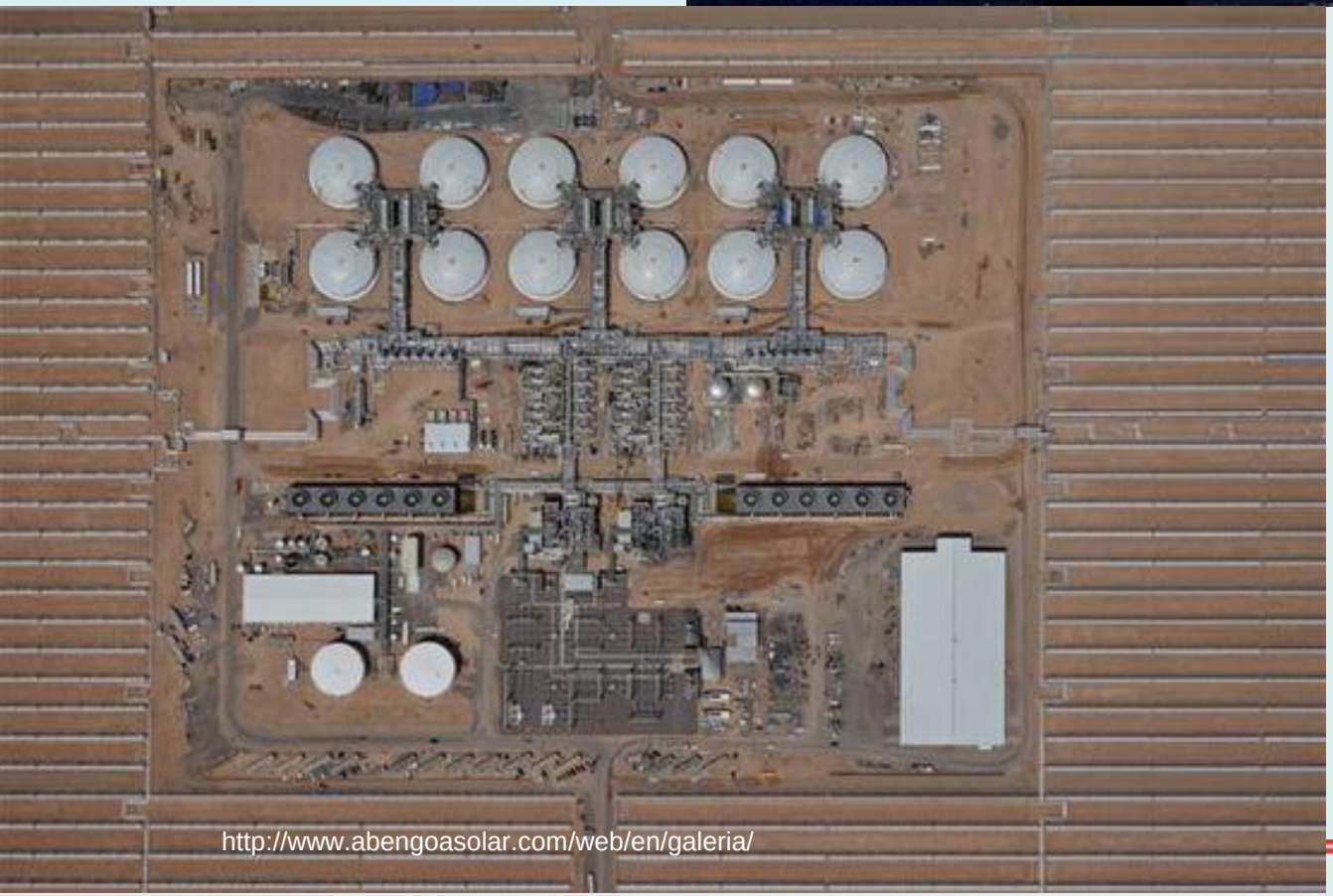








Abengoa's Solana system started operation October 2013



http://www.abengoasolar.com/web/en/galeria/

280 MW trough plant with six hours of thermal storage.
70 miles southwest of Phoenix, Arizona.
Construction began at the end of 2010.
Largest CSP plant with storage so far.

Solar Reserve's Crescent Dunes project

- Nevada, north of Las Vegas
- 110MW$_e$ with 10 hours molten salt energy storage
- Biggest ever tower system
- Final commissioning 2015

Leveraging the technology of solar concentrators for:

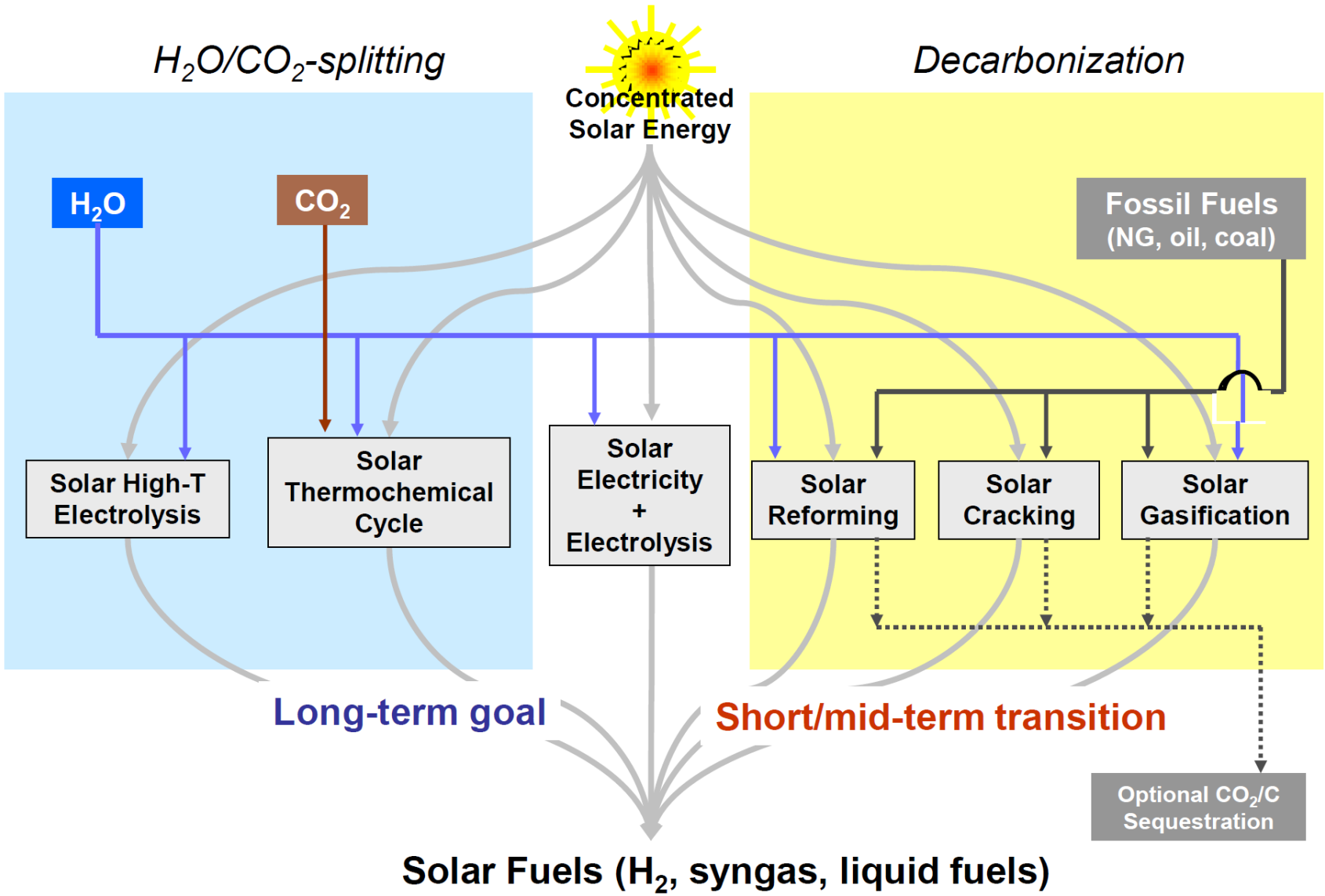


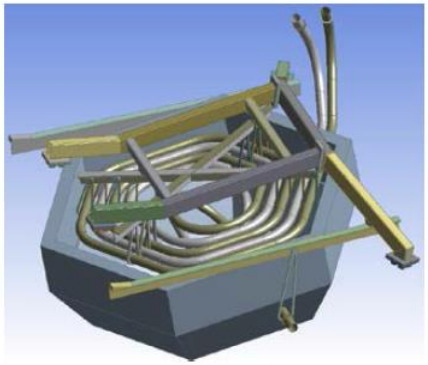
Figure taken from Meier presentation, Newcastle April 2013

Near-Term Solar Production of H_2 and Syngas

Solar pilot plants demonstrated in the power range of 200-500 kW_{th}

Solar steam reforming of natural gas / methane

SOLGAS (200 kW_{th})

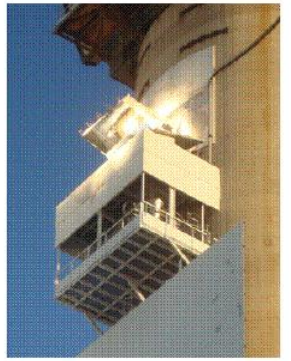


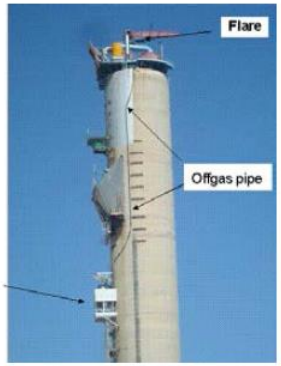
SOLREF (400 kW_{th})

Solar steam gasification of carbonaceous feedstock

SYNPET (500 kW_{th})

SOLSYN (200 KW_{th})





Slide from Tony Meier, Newcastle April 2013

Long-term: Solar Production of H_2, Syngas, and Liquid Fuels

Metal oxide based thermo-chemical processes for H_2 and syngas production demonstrated at the 100 kW_{th} power level

Non-volatile metal oxides

H_2 production using

Ferrite H_2O-splitting cycle

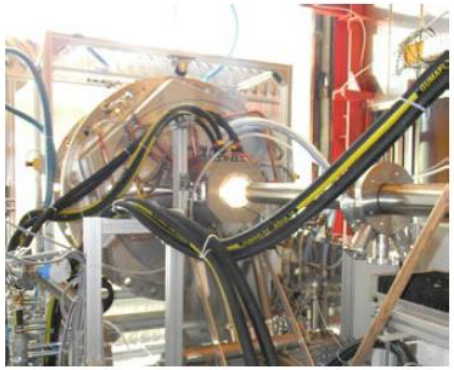
HYDROSOL (100 kW_{th}) at PSA, Spain

Volatile metal oxides

H_2/CO (syngas) production using

Zn/ZnO H_2O/CO_2-splitting cycle

Solar2Zinc (100 kW_{th}) at Odeillo, France



Slide from Tony Meier, Newcastle April 2013

CSIRO lead Concentrating Solar Fuels Road Map for Australia

- 3 year project to develop a credible, industry validated road map
- Identifies key issues and what a staged development looks like
- Current status, potential and challenges/barriers
- Examines markets and product opportunities
- Maps out research, development and demonstration priorities to move technologies towards commercialisation
- Includes PV / Electrolysis assessment as reference case
- Completed end 2015,
- Available at: http://arena.gov.au/resources/concentrating-solar-fuels-roadmap/

Results from Levelised Cost of Fuel calculations (2020 AUD)

Process	Input fuel cost	Solar product gas LCOF	Final fuel (eg NH3) LCOF		Technol. readiness	GHG intens.
Reference: crude oil at $100/bbl	$16/GJ		$20/GJ	$0.56/L	Current technology	High
Solar gasification of brown coal	$1/GJ	$8/GJ	$15/GJ	$0.42/L	Medium	High
Solar reforming of natural gas	$8.4/GJ	$10/GJ	$17/GJ	0.48/L	High	Medium
Solar gasification of biomass	$8/GJ	$9.8/GJ	$17/GJ	$0.48/L	Medium	Zero-Low
Solar water splitting	Zero	$29-35/GJ	$58/GJ	$7/kg H_2	Low	Zero
PV Electrolysis	Zero		$94/GJ	$11/kg	High	Zero

2020 solar field costs estimated at $173/m^2 for heliostats. 6.4% discount rate, 30 year amortisation

Conclusions

- Australia's export income is very dependant on coal and LNG in a carbon constrained world.
- Japan is Australia's number one customer for energy exports.
- Japan has major initiatives on sustainable hydrogen as a fuel.
- Japan's manufacturing base and history of investment in Australia combined with superior Australian solar resources is a good combination.
- The cost of transporting energy dense ammonia fuel is easily justified by the extra level of solar resource in Australia.
- Concentrating solar is a promising approach for producing hydrogen feedstock.
- **Government to government negotiations are needed to establish the framework for international renewable fuels trade.**