



# Knowledge Sharing: ARENA Solar Fuels Roadmap Project

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CSIRO ENERGY TECHNOLOGY  
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# Aims of presentation

- Brief overview of project
- Highlights of outcomes thus far
- Summary and outlook

This project is supported by the Australian Government through the Australian Renewable Energy Agency.

**ARENA**



**Australian Government**

**Australian Renewable  
Energy Agency**

# ARENA Concentrating Solar Fuels Project:

## Project snapshot

Duration: 3 years commencing July 2012, concludes July 2015

Budget: \$3.5M (ARENA\$1.6M)

Two Streams:

1. Low temperature reformer (\$2.5M)
2. Solar fuels roadmap (\$1.0M)

### Stream 1: Low temperature reformer:

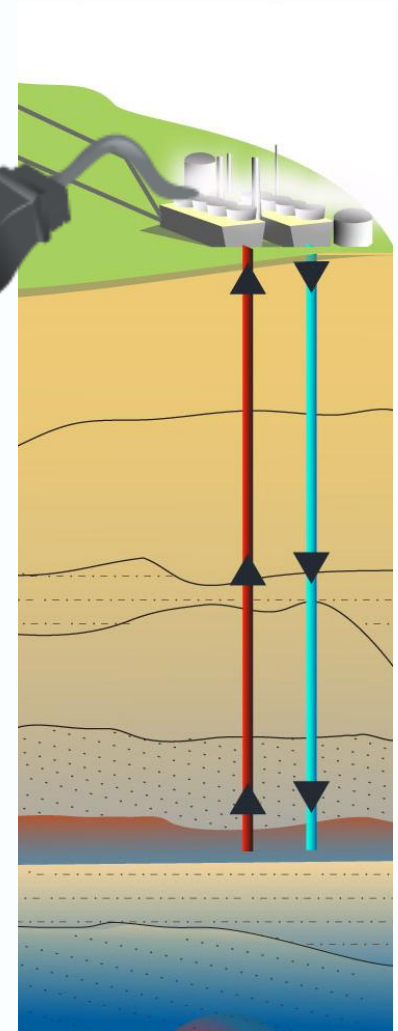
- Design, construction and demonstration of low temperature (membrane based) reactor for steam methane reforming
- $\text{CH}_4 + \text{H}_2\text{O}(\text{g}) \leftrightarrow \text{CO} + 3\text{H}_2$
- Low temperature operation  $\rightarrow$  integration with conventional TES
- Requires new catalysts – low temperature, bifunctional

# Stream 2: Solar Fuels Road Map

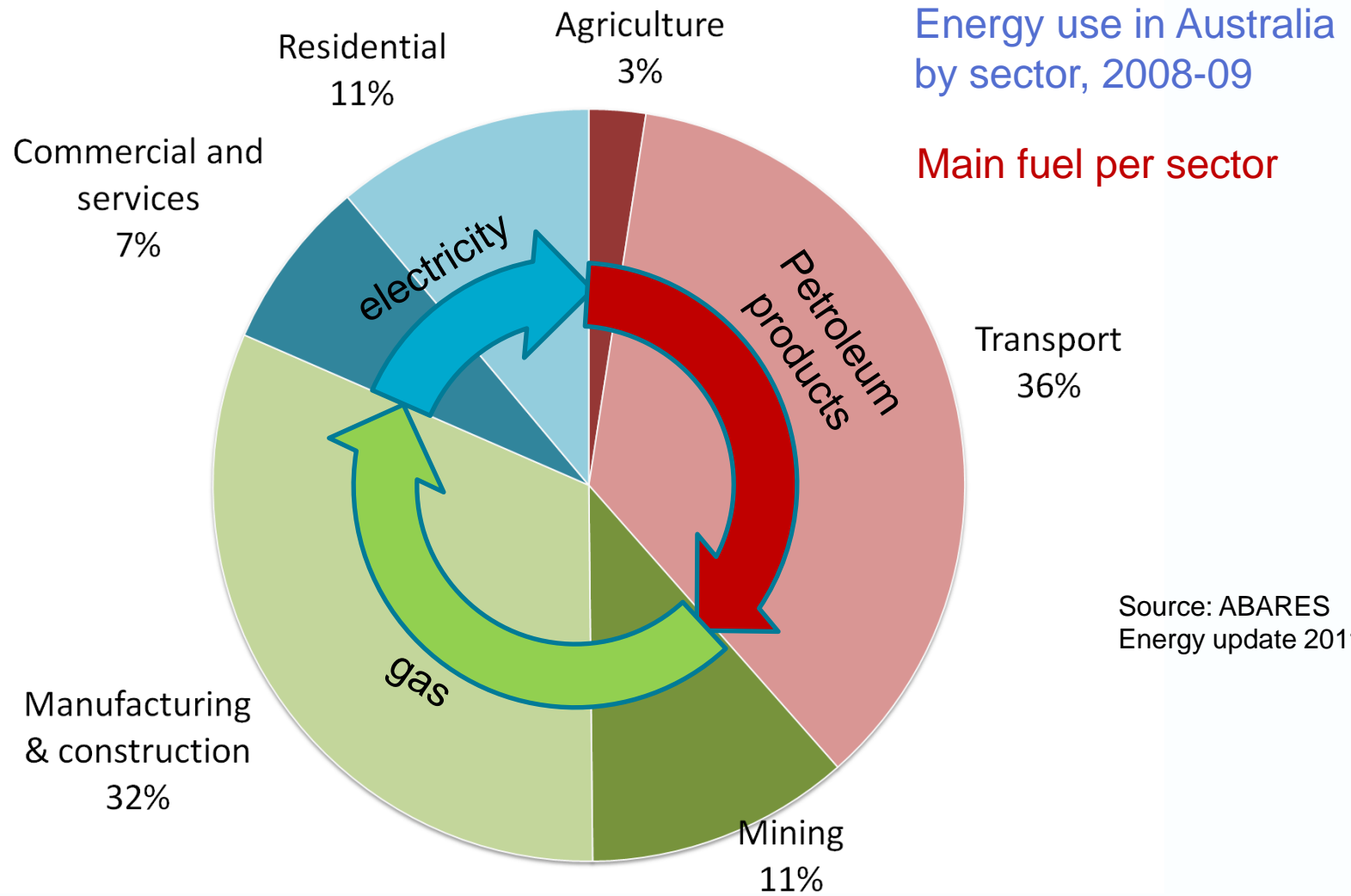
- Credible, industry validated road map to establish a solar fuels industry in Australia
  - Developed with international experts and local stakeholders
- Identify key issues and what a staged development looks like
  - Current status, potential and challenges/barriers
  - Examine markets and product opportunities
  - Map out research, development and demonstration priorities to move technologies forward along TRL/CRL scales
- Public dissemination of the message
- Strong engagement with leading international institutes/experts
  - Partners from Germany, US, Japan, Switzerland, Canada
  - Leveraging considerable experience & expertise



# Renewable energy = electricity?



# Renewable technology blind spot





# Solar Fuels Opportunity

Australia is facing a large difference between liquid transport fuel consumption and domestic production

Projected deficit to increase from \$13b in 2010 to \$70b by 2030

Australia has world class solar and natural gas resources

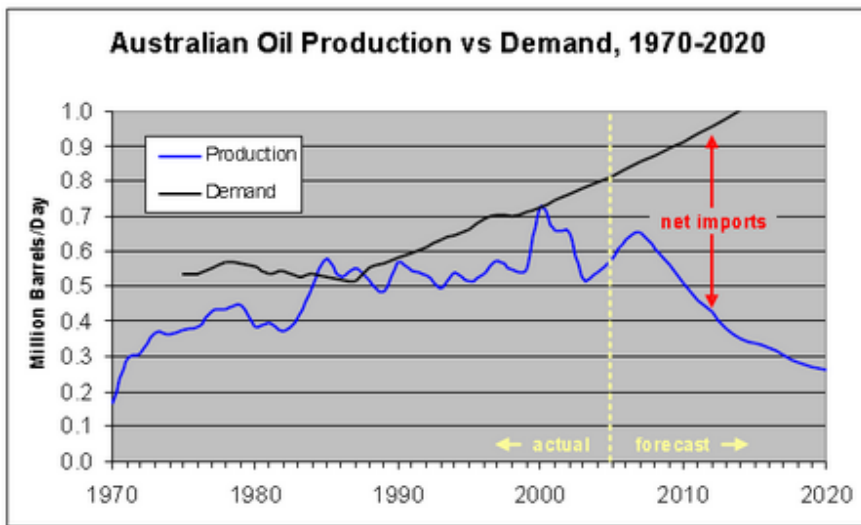
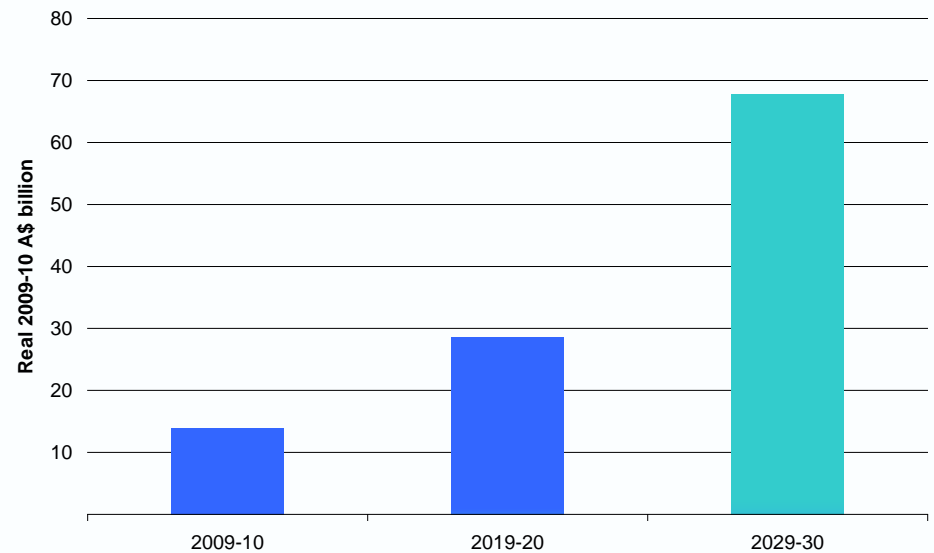
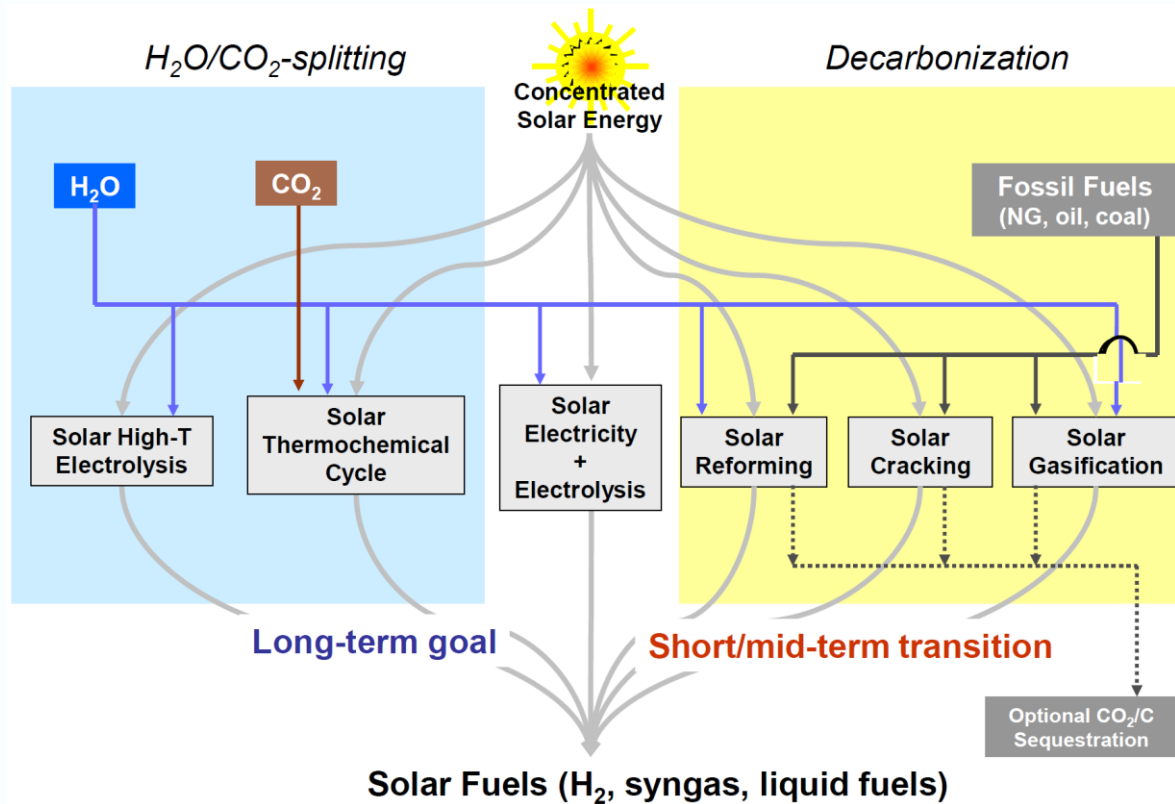


Figure 6. Australian Oil Production (Geoscience Australia, actual and P50 forecast) vs Demand (ABARE), 1970-2030.



# Highlights: 1) State of the Art Report

First milestone was a review of solar technologies  
Included public workshop in April 2013 (27 ppl.)



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**Solar Hybrid Fuels (3-A018)**  
Stream 4: Road Map  
Technical Report, Milestone 3

Scoping study, State of the Art and Outcomes of Workshop

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16 September 2013

ARENA, DLR, Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center, Alberta Innovates Technology Futures, Paul Scherrer Institut PSI, itp, ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich, ASU





# Highlights: 2) Preliminary Screening

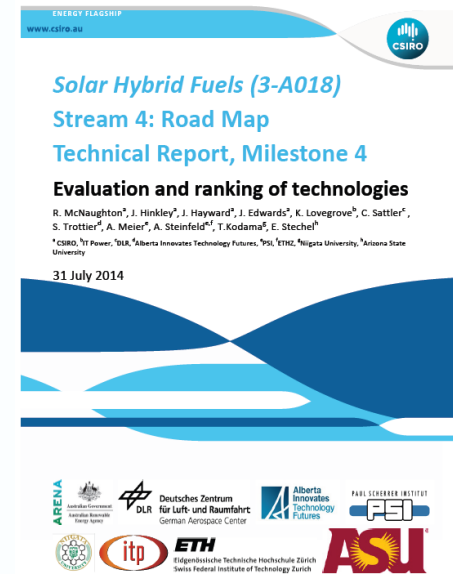
Developed a methodology for evaluating / comparing processes

Industrial perspectives explored at a second workshop

- February 2014, Sydney, 35 attendees
- 3 case studies presented: methane reforming, coal gasification, redox cycles

Feedback:

- Technology is great, but need to focus on business case
- Risk was a key concern – technical readiness, also financial risk (cost of money)
- Social license to operate (coal, methane)
- CO<sub>2</sub> emissions need to be considered carefully



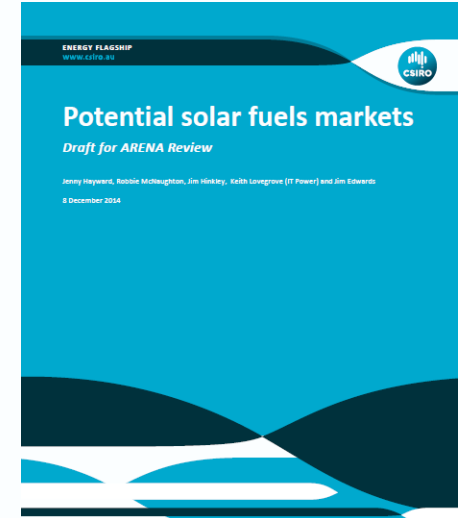
# Highlights: 3) Market evaluation

Products /markets a key theme in milestone reports

- Dedicated report prepared for ARENA (Dec 2015)
  - Japan is a major trade partner and potential market
  - Strong international market for methanol (esp. China)

Explored in greater depth in a workshop in Tokyo

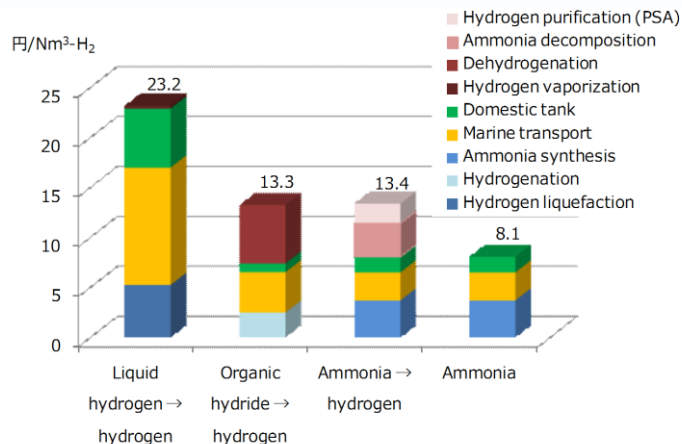
- 10 December 2014, 33 participants
- Senior managers, government, Austrade, industry, research



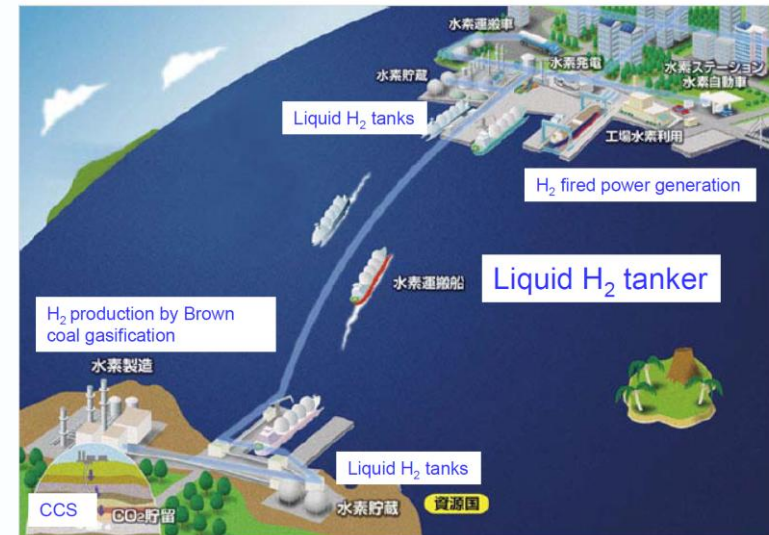
# Japanese perspectives

## Explored the policy drivers and company attitudes / activities

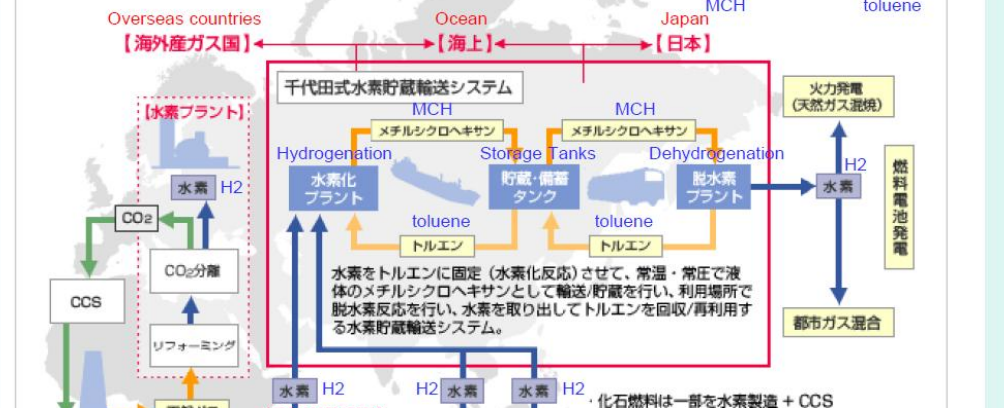
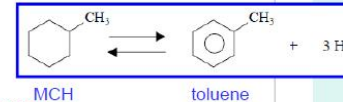
- Japan has a new energy strategy 2014
- Nuclear does not figure prominently
- Transitioning to a hydrogen society
- Looking to establish supply chains
- 2030 Target: 30¥ / Nm3 (~\$30/GJ) delivered to thermal power plant
- Zero emission production



川崎重工グループは、国内で有数の大型水素貯蔵タンクや水素運搬車を製造している技術と経験を活かし、未来社会に向けての新しいエネルギー構想として「CO<sub>2</sub>フリー水素コンセプト」を提案しています。



### 水素サプライチェーン構想 Hydrogen Supply Chain Concept







# Summary and Outlook

Range of solar fuels technologies, various TRL/CRL

- Need a staged and process: bench, lab-scale, pilot, pre-commercial...
- Progressive decarbonisation (hybrids first, fully renewable later)
- Each stage can leverage what has gone before

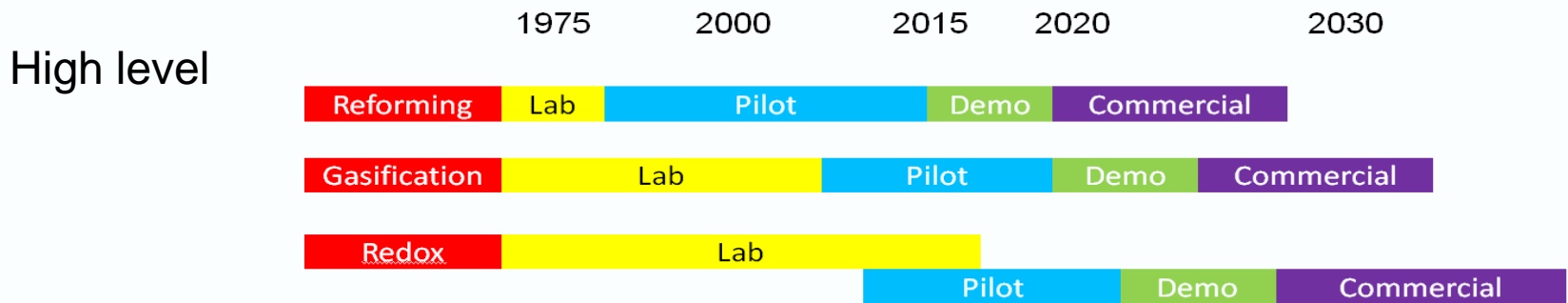
Promising market opportunities:

- Australia: drop in liquid transport fuels
- Japan: hydrogen
- China: methanol

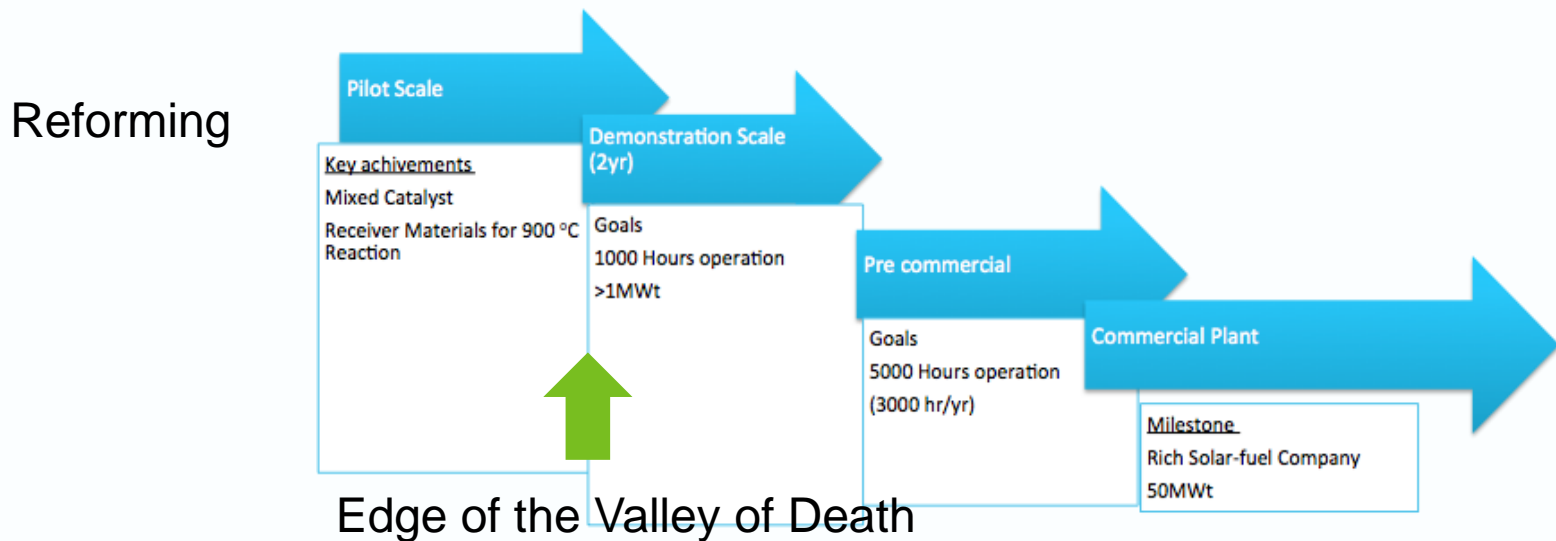
Technology screening and cost analysis suggests methane reforming is most prospective technology

- High TRL, but needs pre-commercial pilot 1-5 MW scale, 2 years operation
- Necessary to demonstrate bankability for pre-commercial demonstration
- Multiple products are possible

# Roadmaps – different resolutions



Note: many different pathways in fact possible for gasification and particularly redox cycles.





# Acknowledgement

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# Thank you

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