Racing Ahead: Ultra-Low-Carbon Technologies Are Quickly Advancing in CCUS and Hydrogen

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8 RIVERS

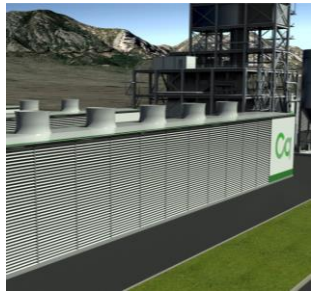
Speaker Background

- 15+ years in Energy Sector focusing on Research, Development and Demonstration (RD&D) projects
- Worked for UK Government for 11 years funding more than £50m of cutting-edge CCUS innovation projects
- Now work for 8 Rivers helping to commercialiase their portfolio of technologies that include

Zero-Emissions Power from Gas

Zero-Emissions Power from Solid Fuels

Zero-Emissions Hydrogen and Ammonia

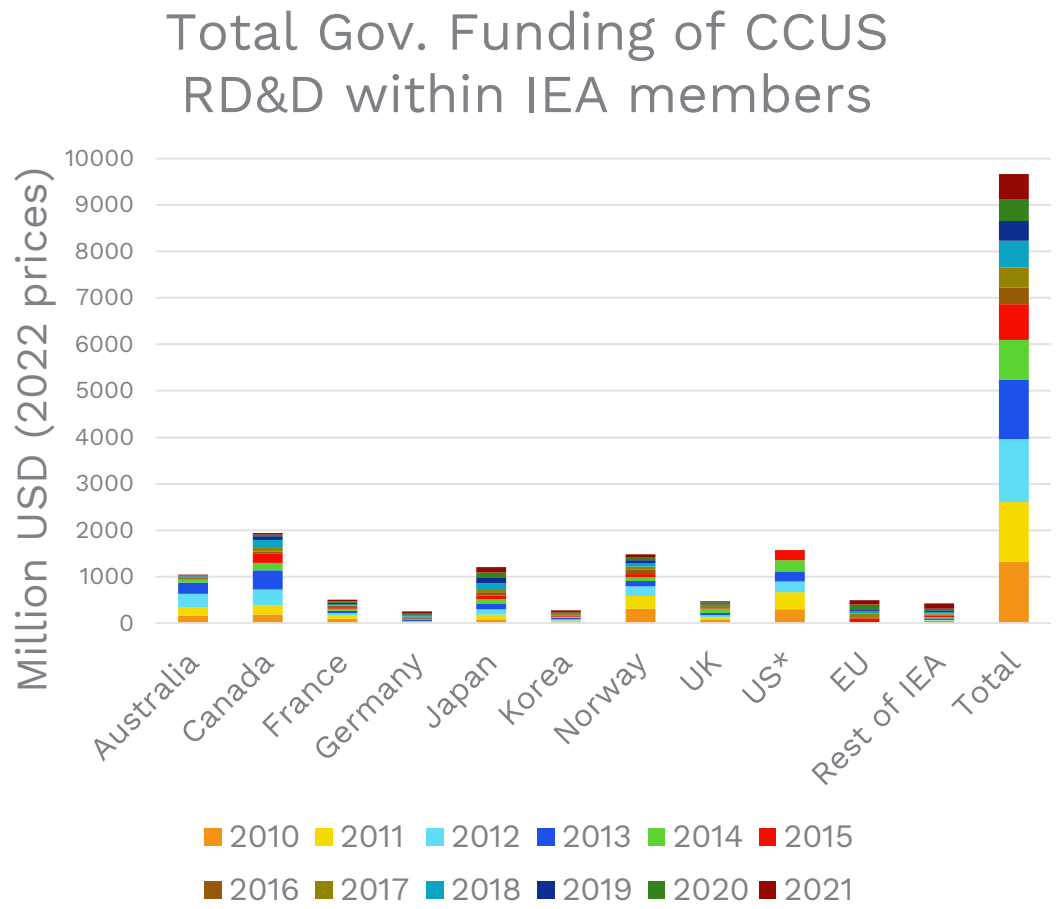


Direct Air Capture of CO_2 (DAC)

H_2S Sour Gas to Sweet Gas

Post-Combustion Capture of CO_2

Significant technology development funding in CCUS and Hydrogen



IEA RD&D database, * USA data 2010-2015

- Graph shows Government funding of CCUS RD&D by IEA members between 2010 and 2021
- US has provided data to the IEA since 1974, but stopped this provision after 2015
- If recent data included from US. More than $10bn has been invested into CCUS RD&D between 2010-2021
- When private funding is included the number is significantly larger
- Similar case for RD&D funding into low carbon hydrogen production

...this has led to a very fast-moving technology landscape

World's biggest carbon removals deal ann... ...nced at New York ...ek

Occidental buys carbon air captu... firm for $1.1 billion

Energy veteran Rice's SPAC to take NET Power public in $1.5 bln deal

8RH2 Case Study

- 8 Rivers launched 8RH2 in London on May 2023
- Created from scratch, 8RH2 took under two years to be developed with FEED starting with Fluor this quarter.
- 8RH2 is exemplary of fast-paced innovation that is being brought to market at a quicker pace than previous technology development cycles
- Key to this pace was:
    - The experience and capability 8 Rivers has built-up over 15 years on oxy-fired processes
    - Utilising decades of expertise of the existing ammonia and hydrogen industry

$^8RH_2$ Hydrogen Production

Low-Carbon H_2, Ammonia, and Derivative Product Outcompetes Similar Technologies

What is it?

- $^8RH_2$ is an ultra-low carbon H_2 process that uses available equipment to generate affordable and clean H_2 while capturing >99% of produced CO_2
- Uses proven steam methane reforming and oxy-fired combustion to deliver ultra-low carbon intensity (CI) hydrogen

How does it work?

- $^8RH_2$ combusts natural gas and pure oxygen, generating CO_2 used as a heat transfer medium in a proprietary reformer before sequestering the CO_2

Why is it different?

>99% carbon capture rate
Inherent capture of all CO_2 at pipeline pressure and quality delivers Best-in-Class CI for the sector

Low cost
No back-end capture equipment plus optimized thermal efficiency enables improved conversion rates, minimal power consumption, and lower fuel requirements than competing technology

Low risk
Use of proven equipment and processes minimizes technical and operational risks
Inherent CO_2 capture eliminates need for amines or other capture solvents
Simplified process reduces sensitivity to supply chain bottlenecks

$^{8}RH_2$ Differentiating Technologies

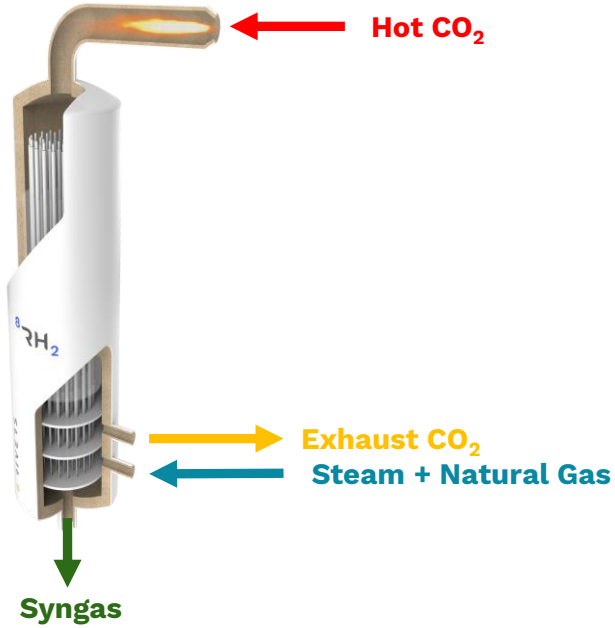
Oxy-Fired Combustor and CO_2 Convective Reformer creates next-generation steam methane reformation

Oxy-Fired Combustor

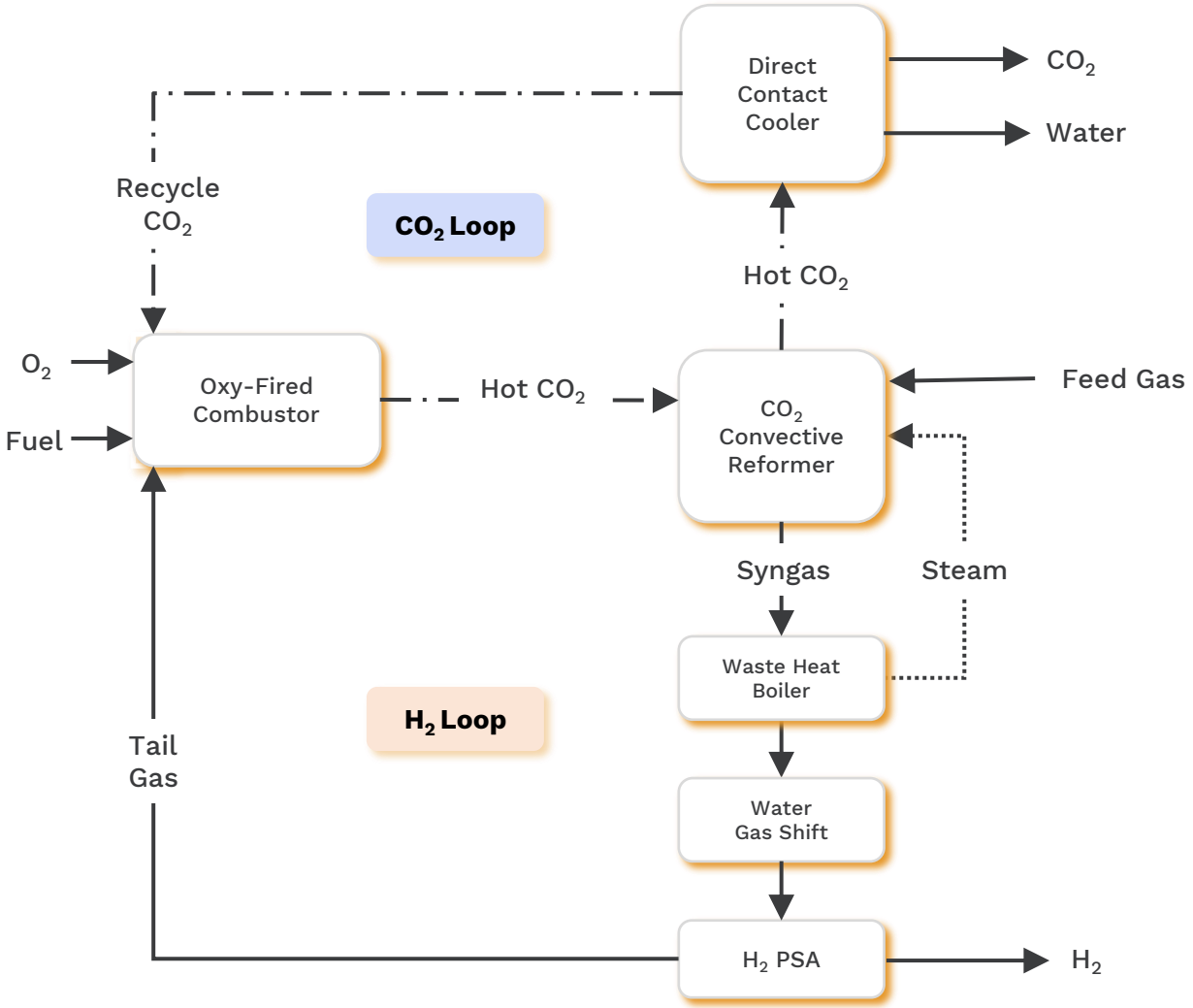
Oxy-fuel combustion replaces air in the typical combustion process with pure oxygen diluted with CO_2. By eliminating the impurities of air, oxy-fired combustion results in an exhaust stream of high-quality CO_2, **eliminating the need for costly back-end carbon capture equipment.**

CO_2 Convective Reformer

Proprietary CO_2 Convective Reformer for hydrogen production reforms natural gas and steam mixture utilizing heat delivered by CO_2 from oxy-combustor.



$^{8}RH_2$ Process Design



8RH2 Takeaways

- 8RH2 will have the lowest levelized cost for producing ultra-low carbon hydrogen in any region because:
  - Its inherent high thermal efficiency
  - <99% of CO2 is captured, leaving minimal CO2 on the table that can be subject to post-regulatory changes
  - It doesn't require expensive back-end capture of CO2
  - It doesn't require hydrogen product to be used to achieve its ultra-low CI
  - Reformer can be shop-built, avoiding the challenges of stick-built reformers
- Colors of hydrogen can be misleading. CI is a much more effective metric
- Be mindful of how much conceptual work (i.e. 3-4 years) will be completed before the first wave of large-scale low CI hydrogen plant are commissioned and ready to be compared
- Consider a wider variety of process designs as part of your conceptual work
- Consider back-to-back pre-FEED studies to ensure you:
  - Select the most economic technology for your project
  - Obtain the greatest competitive pressure from vendors

What does the fast-moving technology landscape mean in practice?

- A significant pipeline of technology innovation will be arriving before 2030
- A lot of this innovation is building on previous work allowing it to come to market at a much quicker and surprising rate
- Industry is reshaping how it interacts with next generation technology
- As an example, EPC focused companies are now getting involved at an earlier RD&D stage than historically they have in the past
- Companies and Governments will have a harder time keeping track of the technologies on the horizon
- Need to consider not only TRL, but how quickly a game-changing innovation can be brought to market
- Keep track of innovation programmes happening in UK and internationally, more on this on next slide
- Encourage your technical teams to attend more conferences and “get out and about” with potential vendors between now and 2030

A few links to Mid/Late Stage UK Programmes

- DESNZ Net Zero Innovation Portfolio (NZIP)
- Innovate UK
- Net Zero Technology Centre (NZTC)
- DESNZ Net Zero Hydrogen Fund
- DESNZ Industrial Energy Transformation Fund (IETF)
- North Sea Transition Deal

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