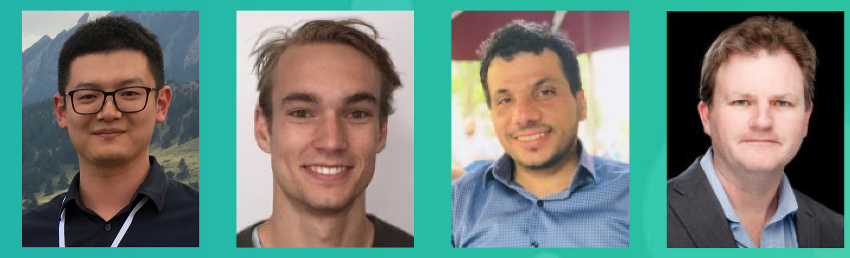
Bridging Blue and Green Hydrogen



Dr. Fuyu Jiao* Dr. Keelan O'Neill Dr. Saif Al Ghafri Prof. Mike Johns

*presenter (fuyu.jiao@uwa.edu.au)

FUTURE ENERGY EXPORTS Cooperative Research Centre

Introduction

The production of blue hydrogen is frequently considered as a transitional hydrogen production option as part of establishing a hydrogen economy, and is conventionally executed via steam methane reforming (SMR) coupled with CO_2 sequestration. An alternative to SMR is the use of autothermal reforming (ATR)[1,2], this effectively involves the co-injection of oxygen and steam as reactants, eliminating the requirement for supplementary reactor heating. Synergy between electrolysis and ATR with the inclusion of Carbon Capture and Storage (CCS), represents the combined production of so-called green and blue hydrogen. The objectives of this project are: i). Assessment of different levels of renewable energy availability; ii). A cost estimation for the combined production plant and production of hydrogen; iii). Considerations of technical challenges; iv). Identify options for synergy, cost and CO_2 footprint reduction.

Methods & Results

A base model of this combined hydrogen production system based on ATR of natural gas is developed using Aspen HYSYS to optimise reaction temperatures and oxygen-steam-methane feed ratios as a function of reactor performance.

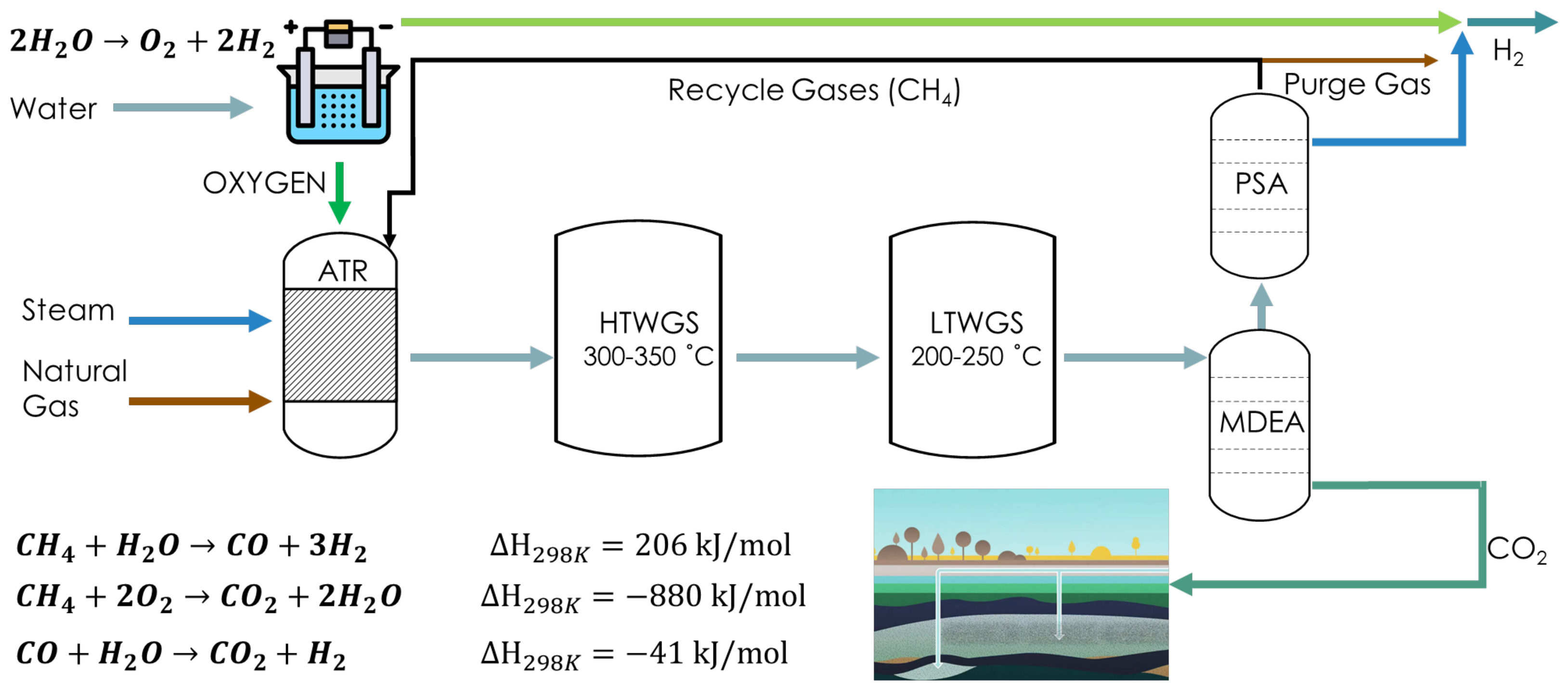
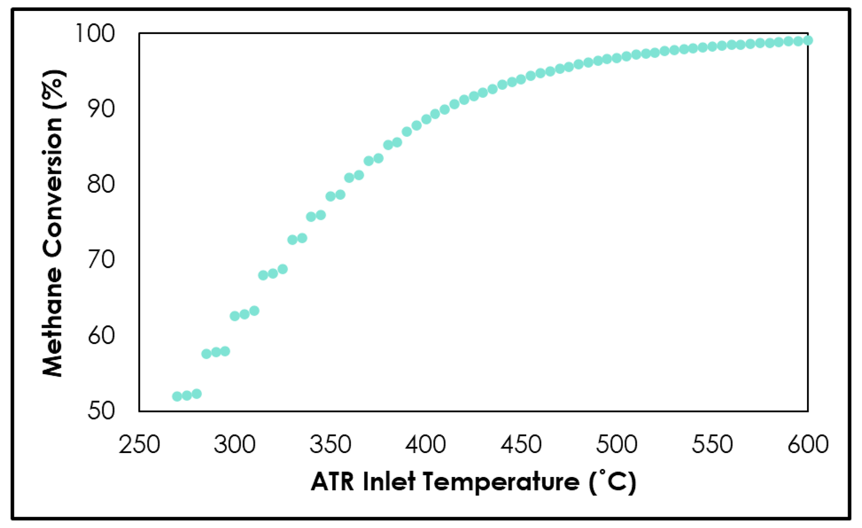


Figure 1 PFD of a hydrogen production plant based on ATR with CCS and electrolysis.[3,4]

Modelling of the ATR process on Aspen HYSYS enabled for the optimum operating conditions to be determined. There are multiple operating variables considered in the simulation to minimise reactor temperature and maximise hydrogen yield.

- The Resulting optimised feed ratios:
  - Steam to Carbon (S/C): 1.2
  - Oxygen to Carbon (O/C): 0.6

Variable	Change	Reactor Temperature
S/C (0.5-1.5)	↑	↓
O/C (0.5-1)	↑	↑



- Inlet Temperature of 400 °C was selected

Figure 2 Key simulation results of the optimal hydrogen production model.

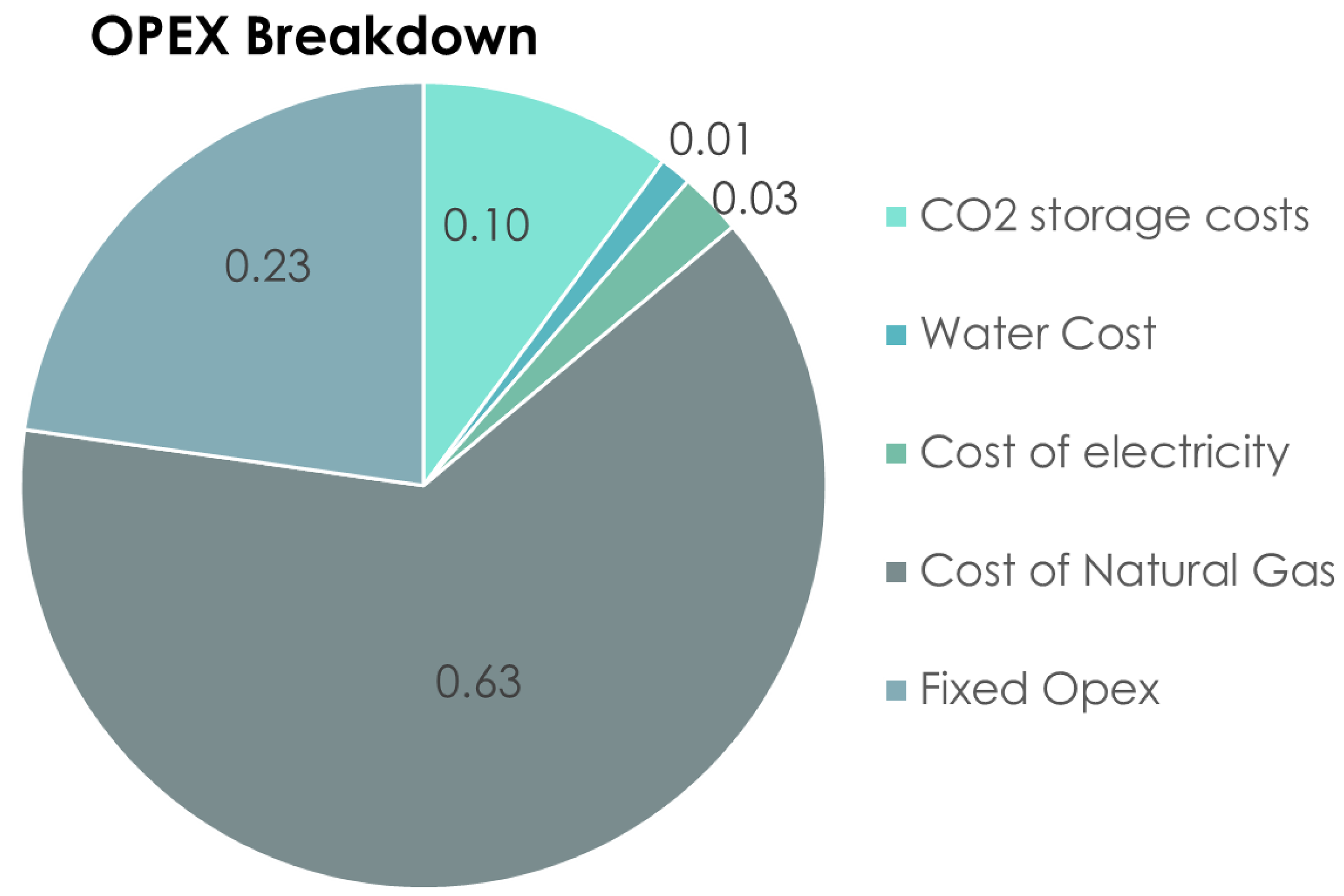


Figure 3 OPEX breakdown of the ATR system.

This combined hydrogen production route is compared to four other hydrogen production routes: i). Steam methane reforming without carbon capture, ii). steam methane reforming with carbon capture, iii). autothermal reforming with carbon capture and iv). electrolysis.

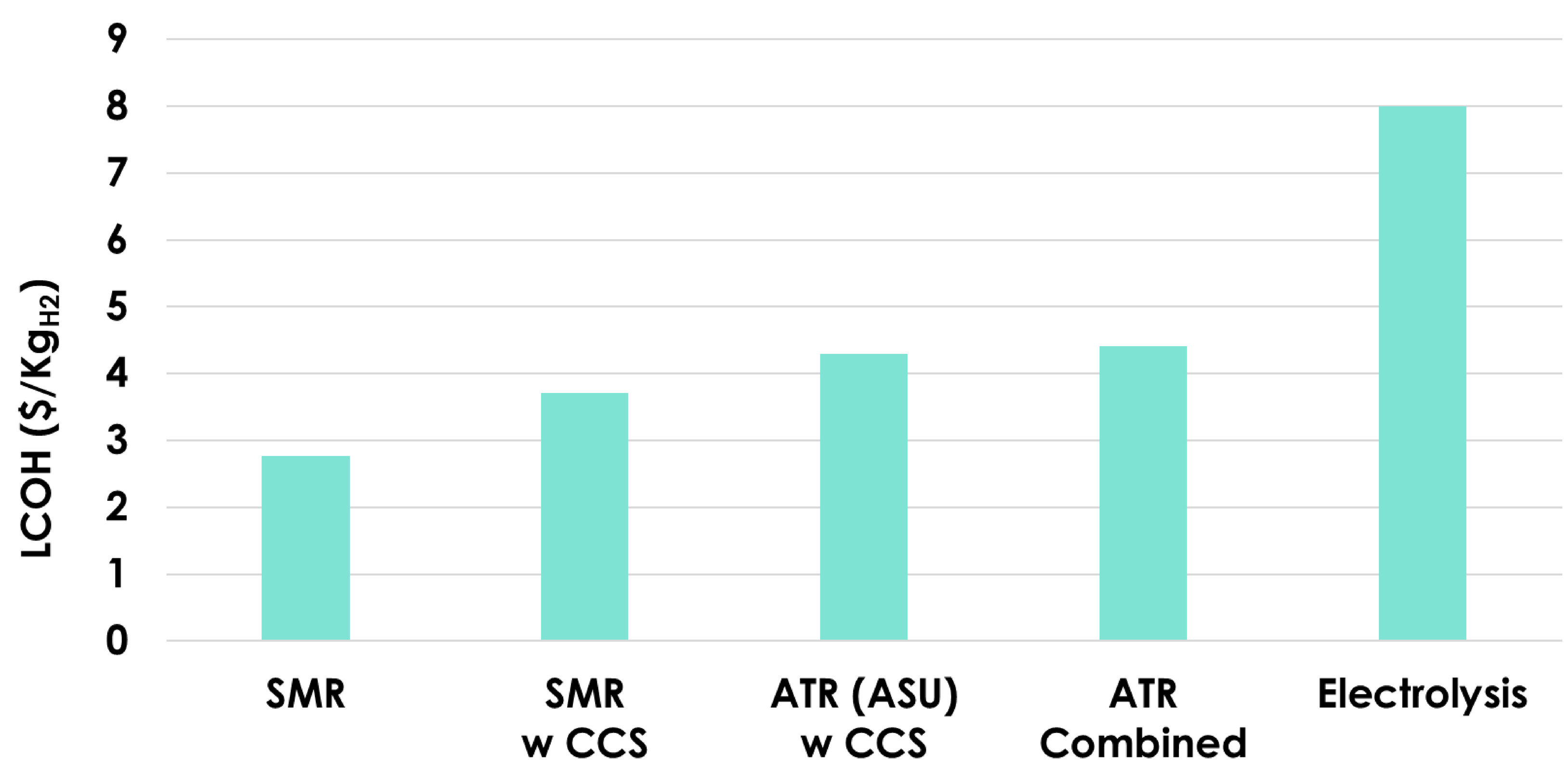


Figure 4 Comparison of levelized cost of hydrogen for various production technologies.

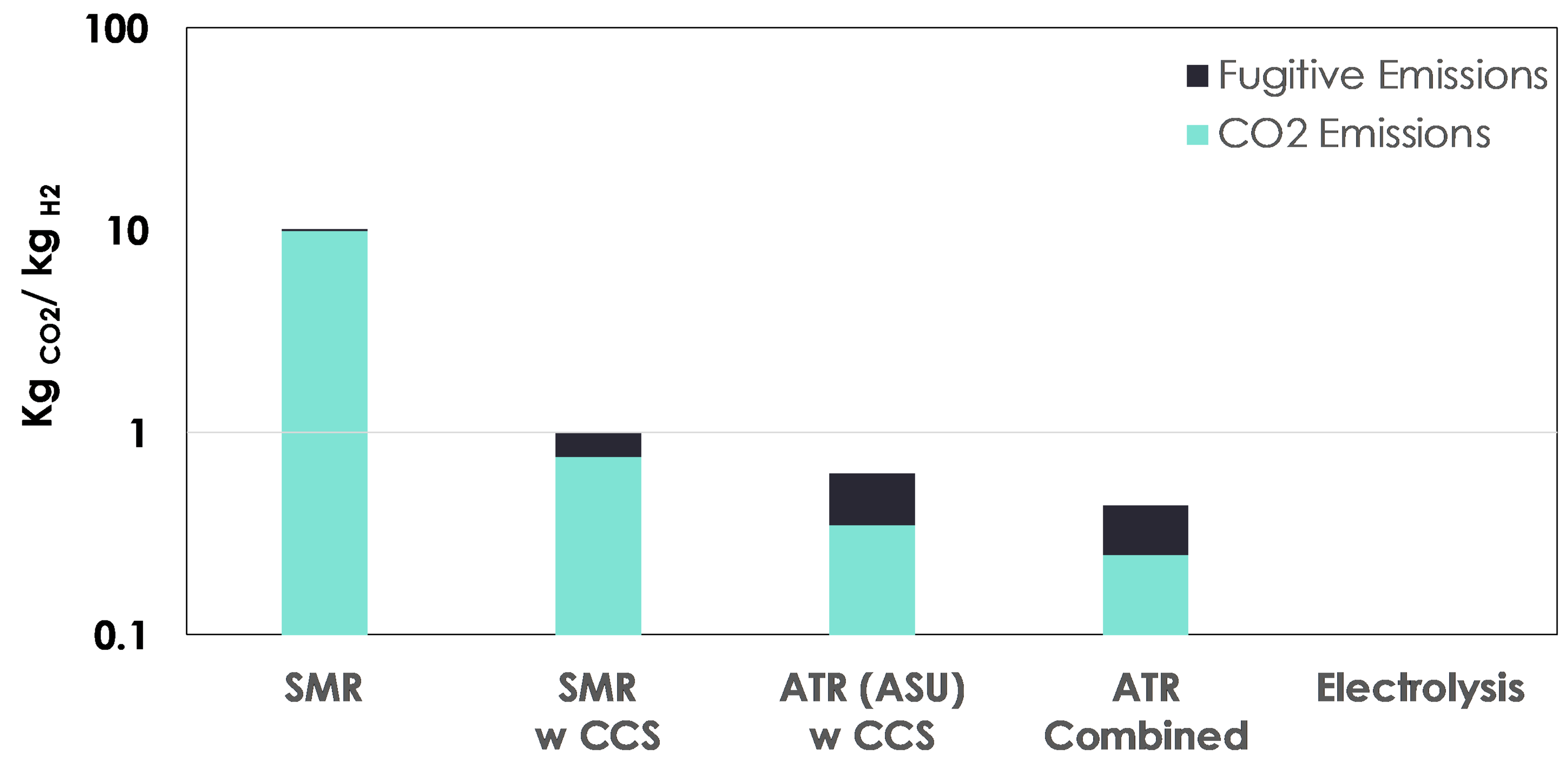


Figure 5 Comparison of CO2 emissions with fugitive emissions for different hydrogen production pathways.

Impact

This work presents a primary analysis on the combination of a green and blue hydrogen pathway. Any progress regards reducing the production cost of hydrogen whilst keeping the associated carbon intensity at manageable levels is directly relevant to Australia's attempts to establish a hydrogen export market. These combined production routes proposed in this project have not been considered in detail before and detailed in the open literature. Utilisation of this project would primarily be via a pilot plant study or a more location-specific evaluation.

References

1. Kim, J., et al., *Process Integration of an Autothermal Reforming Hydrogen Production System with Cryogenic Air Separation and Carbon Dioxide Capture Using Liquefied Natural Gas Cold Energy.* Industrial & Engineering Chemistry Research, 2021. **60**(19): p. 7257-7274.
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4. Khojasteh Salkuyeh, Y., B.A. Saville, and H.L. MacLean, *Techno-economic analysis and life cycle assessment of hydrogen production from natural gas using current and emerging technologies.* International Journal of Hydrogen Energy, 2017. **42**(30): p. 18894-18909.

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