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UKCCSRC Introduction (Capture)

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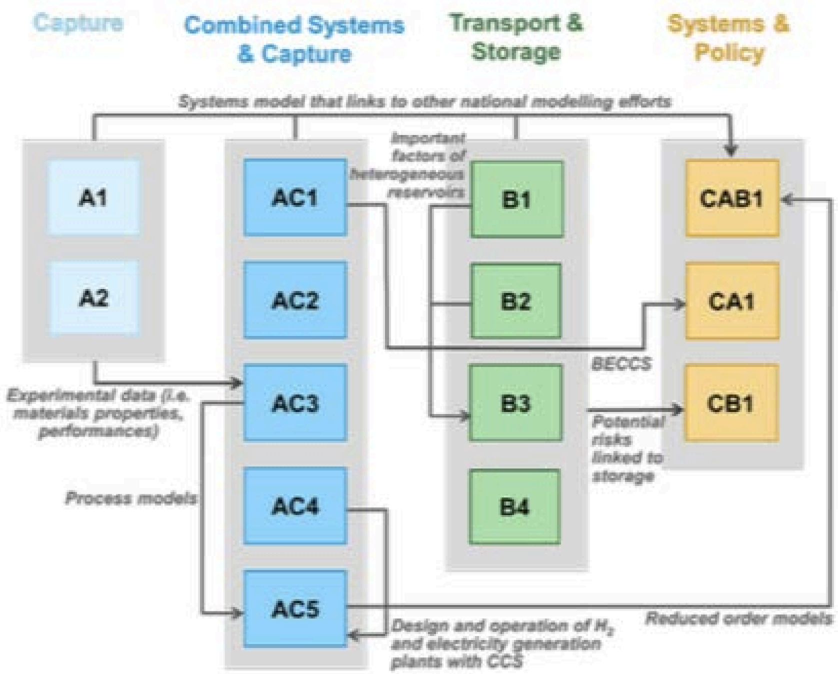
Welcome to the Capture Theme

Developing new materials (Imperial, Nottingham)

Working to scale these materials up (Imperial, Cranfield, Nottingham)

Using the results from tests to design and validate new processes (Imperial, Cambridge, Sheffield).



WP	WP description	Related WPs
A1	Materials development	AC3, CAB1
A2	Pilot testing	AC3, CAB1
AC1	BECCS	AC3, CA1, CAB1
AC2	Cycles using GT with sCO_2 or direct oxy-fired CCGT-CCS	AC3, CAB1
AC3	Detailed models	A1, A2, AC1, AC2, AC5, CAB1
AC4	Integration options for H_2 and clean power synergies	AC5, CAB1
AC5	Reduced order models	AC3, AC4, CAB1
B1	Pressure propagation and control	B3, CAB1, CB1
B2	CO_2 migration and storage	B3, CAB1, CB1
B3	CO_2 modelling software assessment	B1, B2, CAB1, CB1
B4	Scoping/development of a proposed CO2GeoLab	CAB1, CB1
CAB1	Cross cutting value of CCS	A, B
CA1	BECCS within the energy system	AC1
CB1	Social licence to operate	B

Progress

A1: Novel materials have been designed and tested at lab scale

A2: Scale-up is ongoing.

AC1: BECCS – experimental runs in progress at PACT. Trace element emissions have been compared for the oxyfuel and air-fired cases.

AC2: GT with sCO_2 or direct oxy-fired CCGT-CCS – models built and interesting divergence of results based on thermodynamic model.

AC3: Modelling, based on kinetics obtained has been started, including transfer of kinetics from IC.

AC4: Different integration possibilities have been explored in the field of hydrogen / clean power, resulting in significant uplift in efficiency.

AC5: Reduced order models of a number of processes developed and implemented.

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So – What's New ?

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1. Based on the work conducted so far on UKCCSRC, two ongoing PhDs – one looking at iron and steel production integrated with hydrogen production (experimental) and one looking at further development of the material synthesis methods.
2. A second PhD has been looking at integration of chemical looping and hydrogen production to produce directly reduced iron (nearly completed). The student has also been looking at the integration of energy storage with the above technologies.

Come see me at my poster, if it has arrived here.

Bahzad, H. et al. Iron-Based Chemical-Looping Technology for Decarbonising Iron and Steel Production Int. J. Greenhouse Gas Control. (Accepted).

Bahzhad, H. et al. Development and techno-economic analyses of a novel hydrogen production process via chemical looping. International Journal of Hydrogen Energy. 44 (39) 21251-21263. (2019).

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A few highlights from the Iron and Steel / CLC work...

1. CLWS process was simulated using ASPEN-PLUS V.9 simulator.

2. Using the sensitivity-analysis in ASPEN-PLUS, the ratio of natural gas to hematite flow was obtained at which pure iron was produced.

3. Reaction kinetics were determined for some of the major reactors experimentally.

4. The process was optimized based on the heat-integration analysis using the pinch-point method.

5. The process evaluated thermodynamically and economically and benchmarked with steam methane process "SMR" to discuss is viability.
6. The overall aim is to produce a process that can swing between H_2, DRI and power production according to market price.

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Economic Evaluation

CAPEX, OPEX and H_2 production cost for CLWSFe process

Parameter	CLWSFe	SMR
Purchased Equipment cost	M$78.6	M$134.8
Total investment cost = 5.03 x Purchased cost	M$364.3	M$678.1
Total operating cost exc. the effect of selling iron	M$432.4	M$207.7
Total operating cost inc. the effect of selling iron	M$219.5	M$207.7
Hydrogen produced	0.2 Mt/yr	0.2Mt/yr
Iron produced	0.7 Mt/yr	-
Fe Selling price	0.3 $/kg Fe	N/A
Interest rate	10%	10%
Plant lifetime	25 years	25 years
Total annual cost exc. selling iron	M$472.6	M$332.7
Total annual cost inc. selling iron	M$259.6	M$332.7
H_2 production cost exc. selling iron	**2.10 $/kg H_2**	**1.64 $/kg H_2**
H_2 production cost inc. selling iron	**1.16 $/kg H_2**	**1.64 $/kg H_2**

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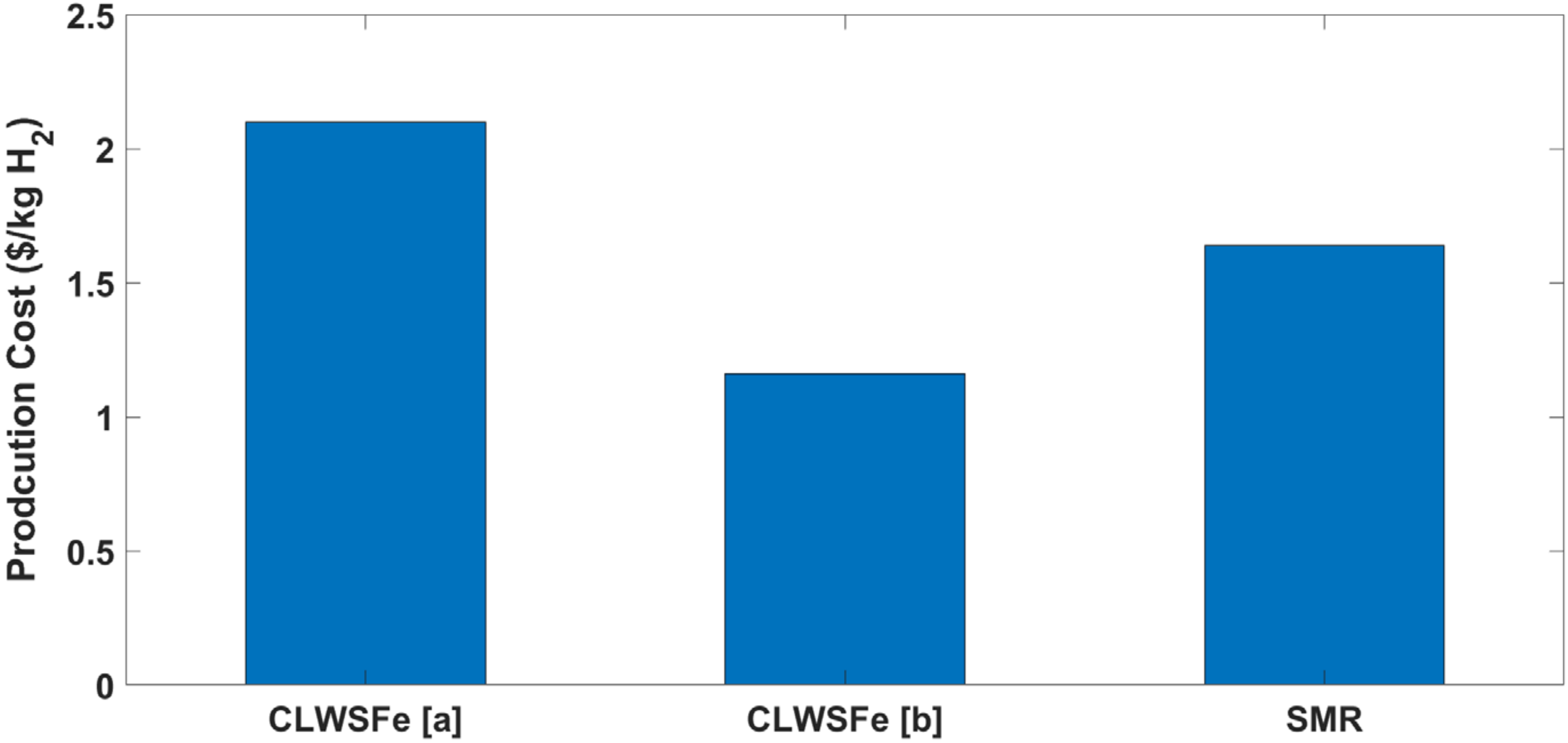

Production cost for: CLWSFe inc.selling iron [a], CLWSFe exc. Selling iron [b] and SMR

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Conclusions

- The thermodynamic evaluation shows that the **effective efficiency** for CLWSFe process **improved** by **12%** compared with SMR process.

- The **hydrogen efficiency** for the CLWSFe process is **6.7% lower** than the SMR process, however CLWSFe process has the advantage of saleable **iron** as **co-product**.

- CLWSFe process is considered as an **inherent CO_2 capture** process, therefore less equipment is required compared with SMR, hence **lower** total investment and **hydrogen production cost**.

- CLWSFe is a **promising novel technology** for the production of **H_2** with inherent CO_2 capture and co-production of a **saleable DRI product**