Feasibility of a Novel Low Temperature Carbon Capture Process, A3C

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6 September 2018

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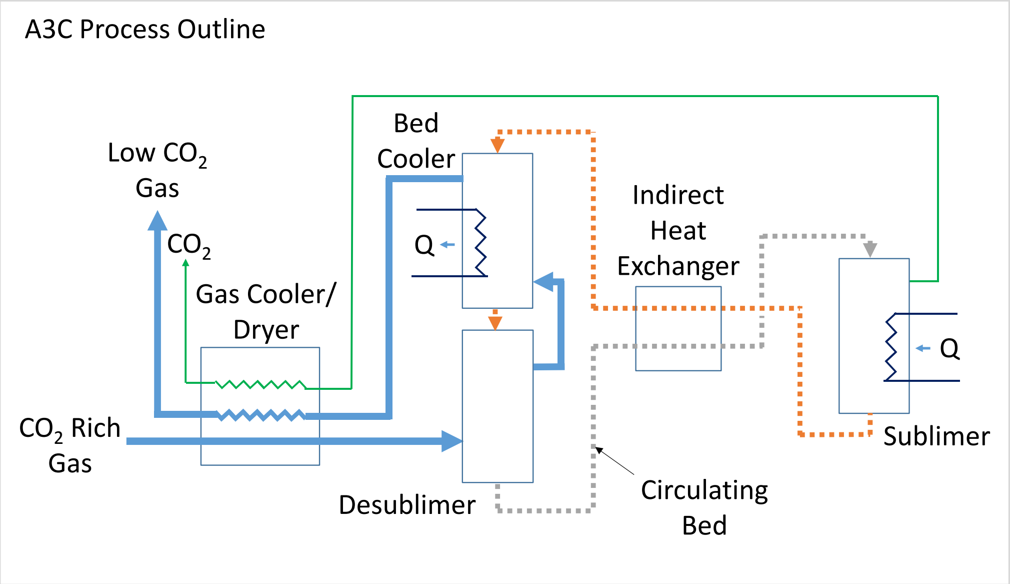
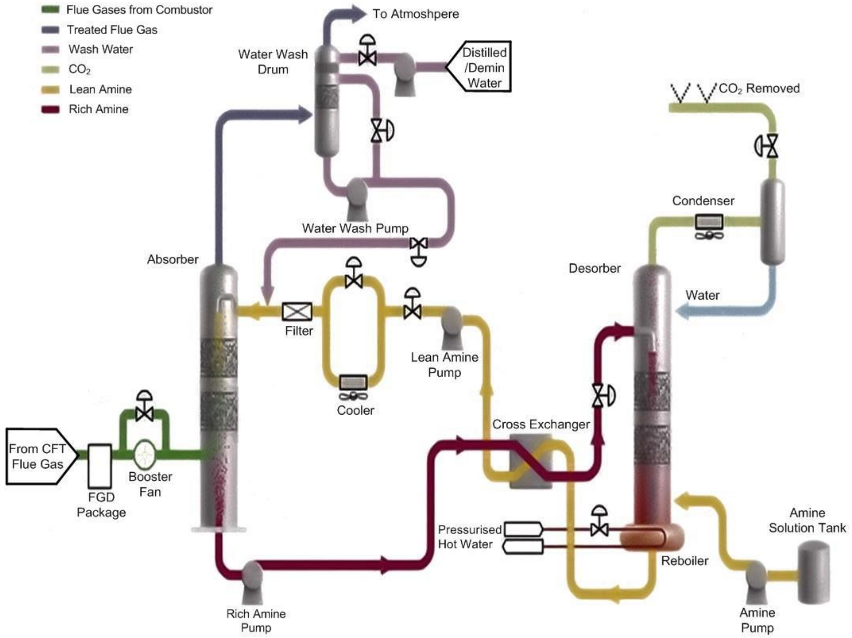
Content

1. A3C (advanced cryogenic carbon capture) process
2. Objectives of this work
3. Description of process and modelling
4. Post-combustion application
5. Economic comparison
6. Conclusions

A3C Process



Amine plant (PACT facilities)

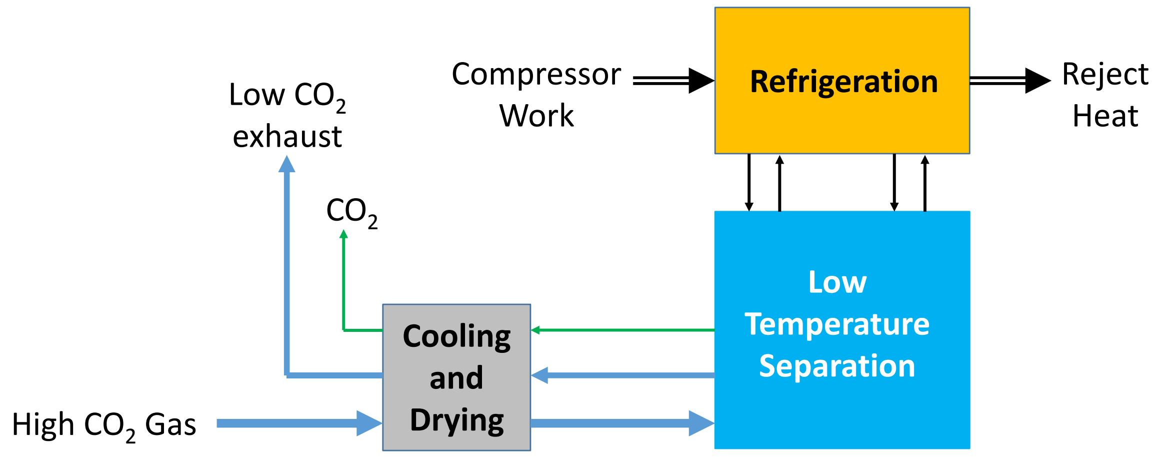


Agbonghae et al. 2014. *Energy Procedia.* 63: 1064-1073

Objectives

- Representation of A3C process using Aspen Plus software
- Selection of post-combustion application
- Benchmark A3C process against amine-based carbon capture
- Feasibility of A3C process as a competitive CCS option

A3C Process Structure



Why A3C?

ADVANTAGES

No need for solvents

High CO_2 purity

No need for product drying stages

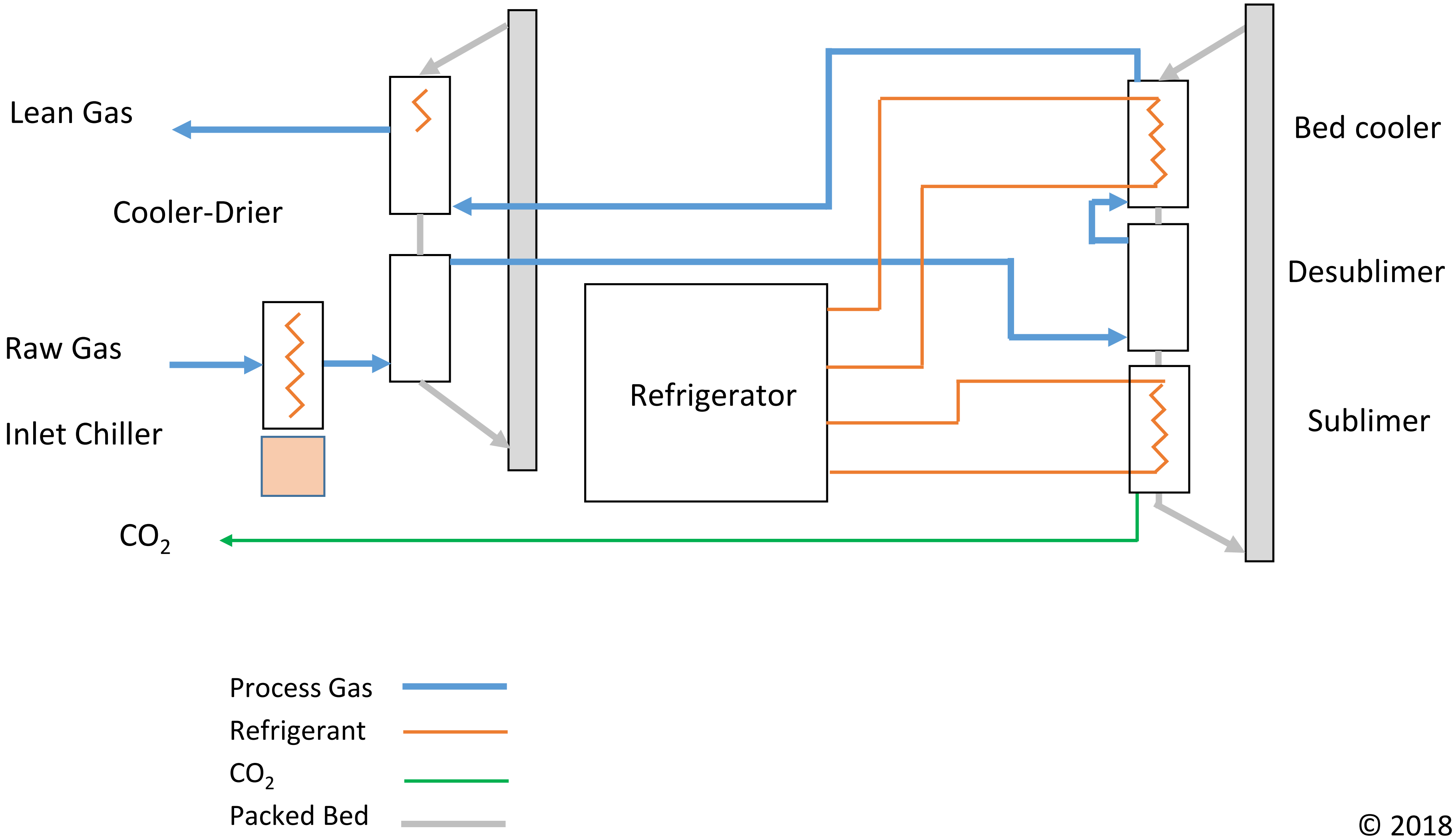
Intense heat transfer at lower cost

DISADVANTAGES

Cooling duty requirements

Energy consumption

A3C Process



Lean Gas
Cooler-Drier
Raw Gas
Inlet Chiller
Refrigerator
Bed cooler
Desublimer
Sublimer
CO_2
Process Gas
Refrigerant
CO_2
Packed Bed

Integrated system modelling – 1st application (utility boiler)

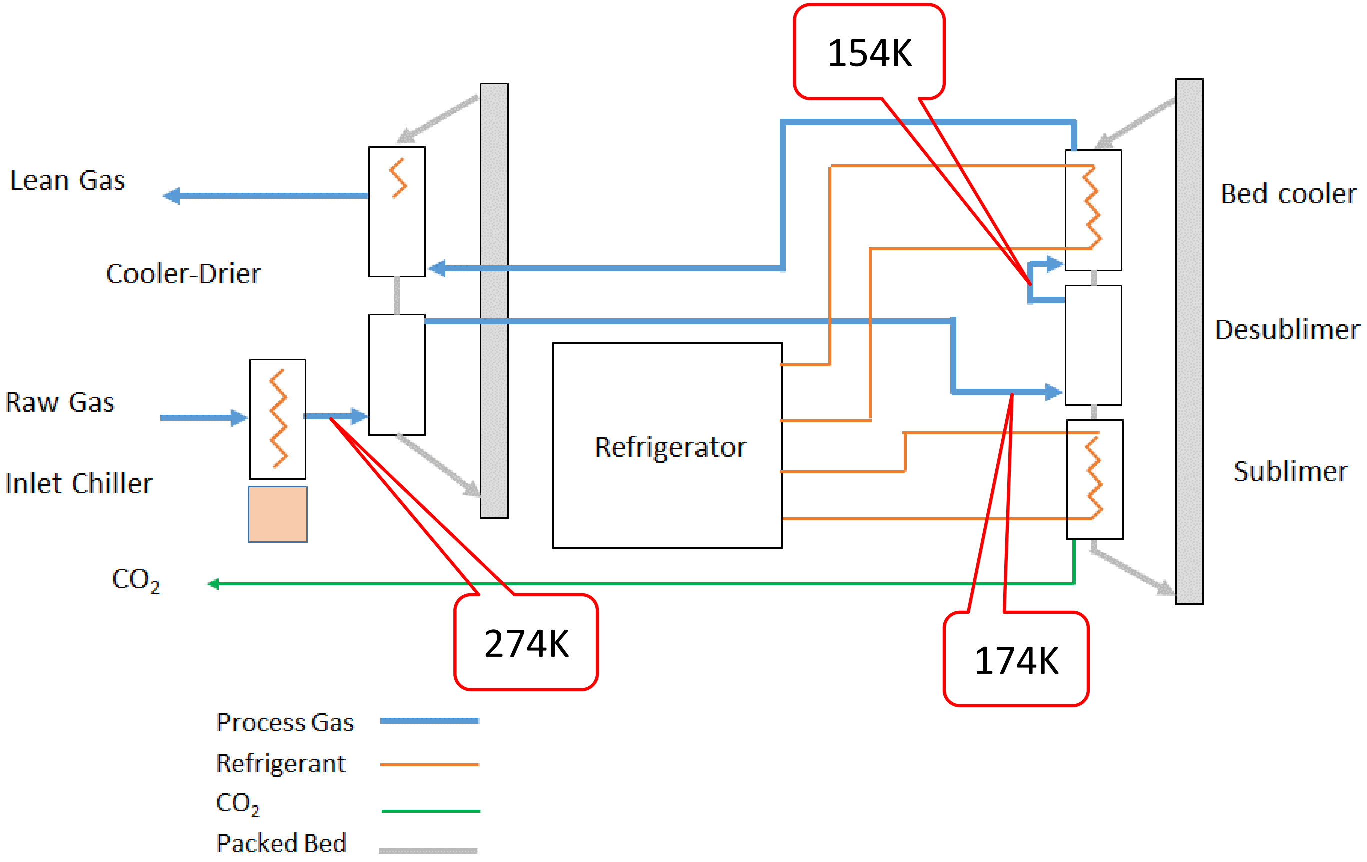
- Initial model
  - Bed material represented by liquid with a low freezing point (dimethyl ether)
- Shell and tube heat exchanger design for the bed – refrigerant exchangers used Aspen EDR to obtain more robust costs
- Refrigeration
  - Highly regenerative cycle – effective COP = ~1
  - Cooling at low temperature
  - Heat rejection at low temperature and ambient
  - Mixed refrigerants evaluated using REFPROP P-h diagrams

Process modelling – utility boiler

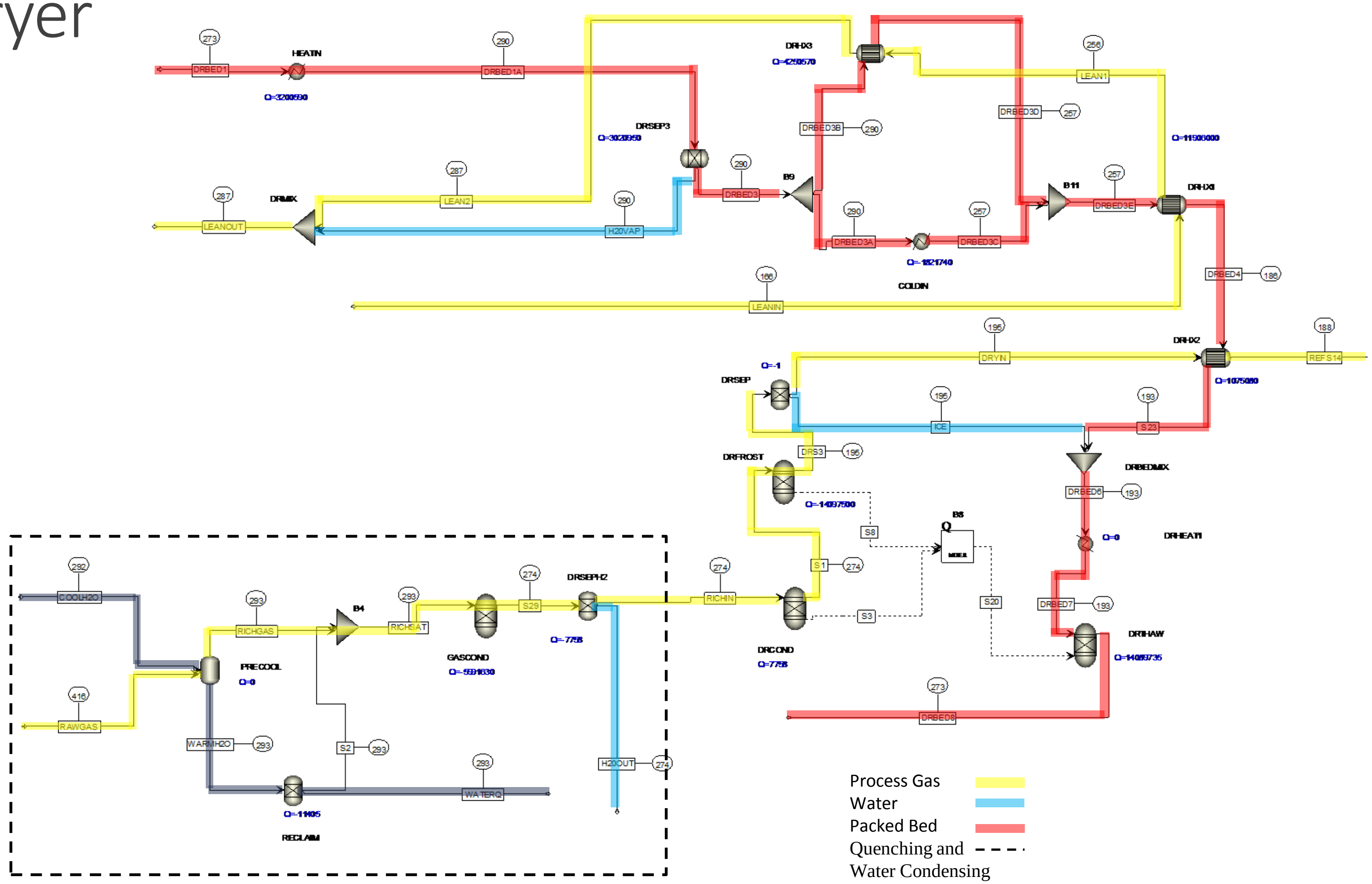
Fuel: Heavy oil
300 MW boiler

Table 1. Feed properties

Parameter	value
Temperature (K)	302
Flow (kg/s)	170
Mole composition (%)	
CO_2	13.33
N_2	78.76
O_2	3.75
H_2O	3.28
Ar	0.01



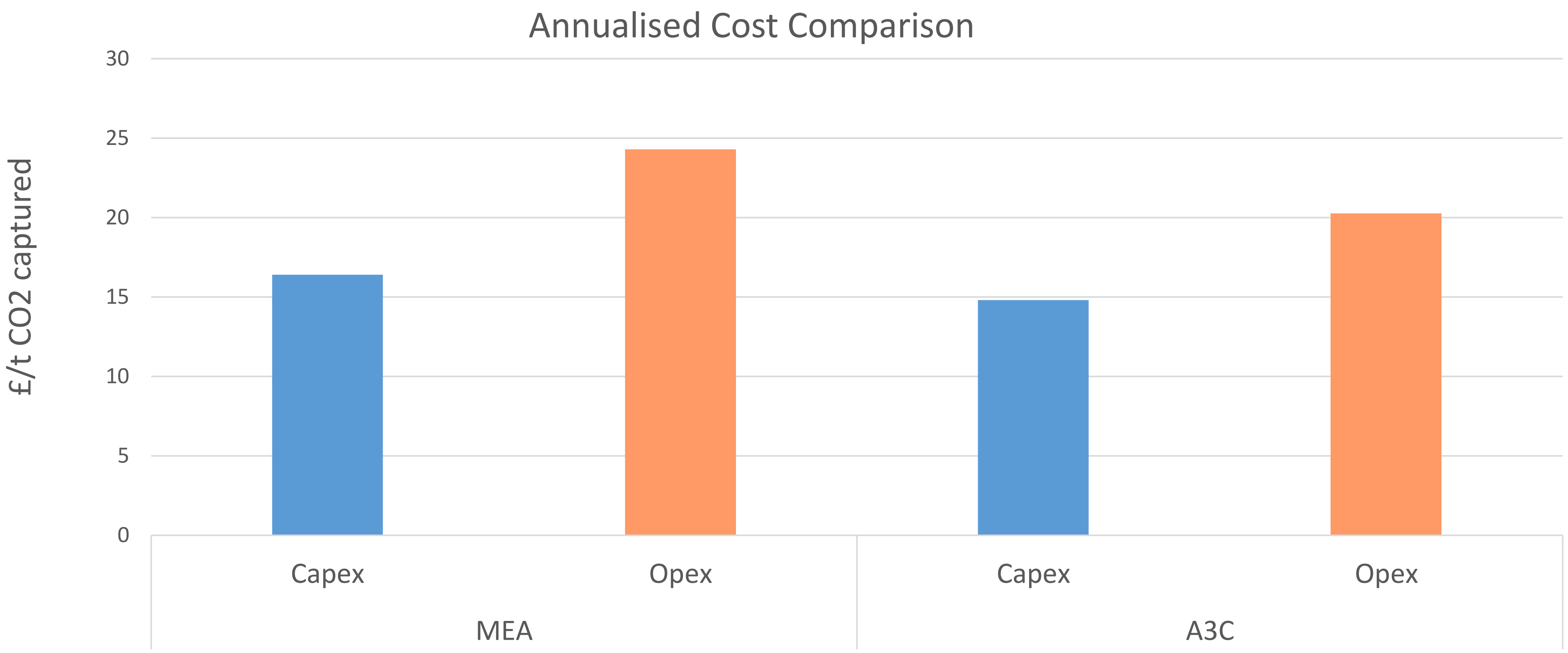
Aspen Plus model - Cooler/Dryer



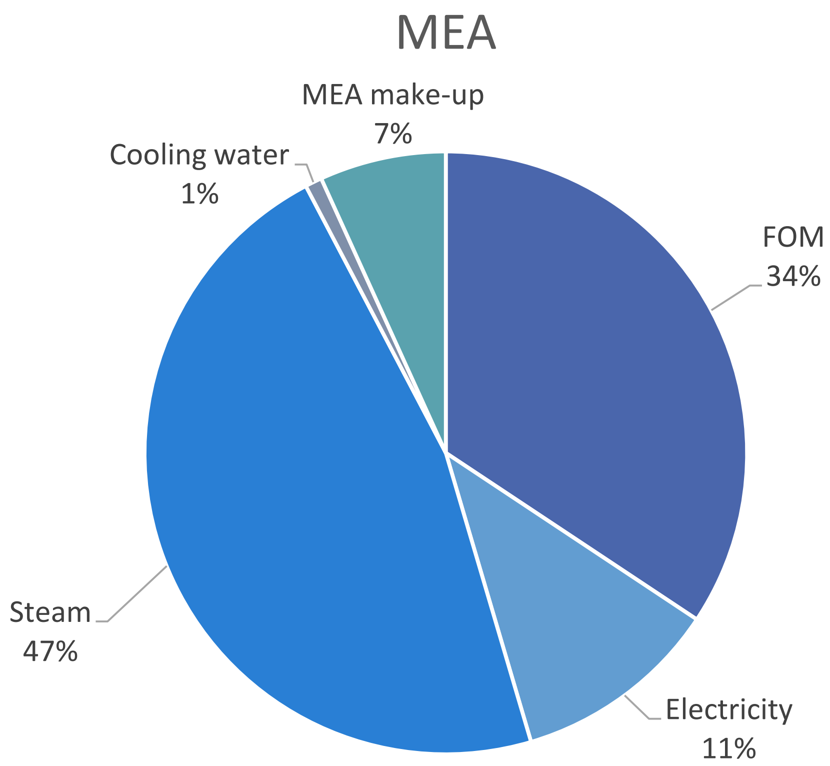
Techno-economic analysis

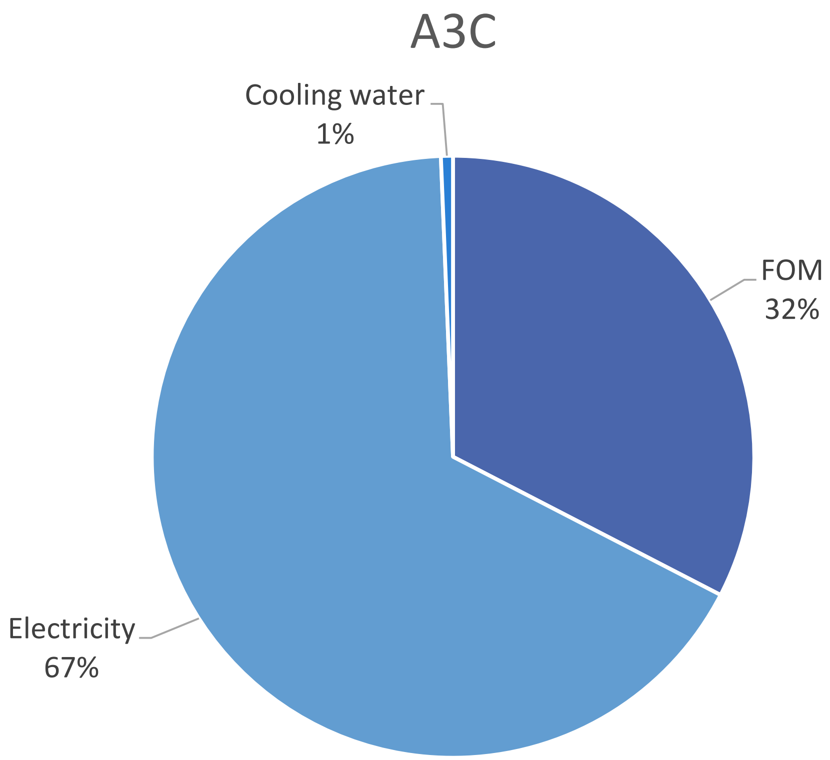
	Units	MEA-based capture	A3C process
CO_2 capture rate	% tonne/day	90 2480	90 2480
CO_2 water content	ppm (mol)	360	0.05
Power duty	MJ/kg CO_2	0.225	1.157
Thermal duty	MJ/kg CO_2	3.97	-
Cooling water	kg/kg CO_2	176.6	101.1
Total equivalent energy (heat & power)	MJ/kg CO_2	1.178	1.157
LCCC	£/t CO_2	40.69	35.06

Techno-economic analysis



OPEX


MEA
MEA make-up
7%
Cooling water
1%
FOM
34%
Steam
47%
Electricity
11%


A3C
Cooling water
1%
FOM
32%
Electricity
67%

Conclusions

- The A3C process has been shown to be feasible for an industrial-scale utility boiler
- Techno-economic evaluation of the process shows a modest advantage over MEA technology.
- A3C is an immature technology and while extensive regenerative energy recovery has been used, there are significant opportunities for further improvement and optimization.

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Thank You

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- University of Chester
  Carolina Font Palma*
  Joseph Howe
- University of Sheffield
  Mohamed Pourkashanian
  Alastair Clements
  Stavros Michailos
- PMW Technology
  Paul Willson
  Georgios Lychnos
- WSP
  Anthony Alderson
- DNV GL
  Andrew Williams
- Costain
  Bryony Livesey

Acknowledgments:

Innovate UK (A3C Carbon Capture Project Ref.132957)

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