CO_2 capture from IGCC by low-temperature syngas separation and partial condensation of CO_2

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Presentation outline

- Brief introduction to the DECARBit project
- Vapour-liquid equilibria in H_2–CO_2 systems
  - Gives the expected CO_2 capture ratio for phase separation
- Principal process-level design for low-temperature syngas separation and CO_2 capture
- Main results from process simulations
- Conclusions

The DECARBit project (2008–2011)

- Assess and research new techniques for **pre-combustion CO_2 capture**
- Develop advanced oxygen production techniques
- Continue the development efforts in FP6 projects in the pre-combustion area for key enabling technologies
- Underpin the cost reduction objective
- Establish collaborative schemes with emerging large-scale CCS initiatives in Europe
- Perform an assessment of the advanced pre-combustion capture techniques to the benefit of other energy intensive industries

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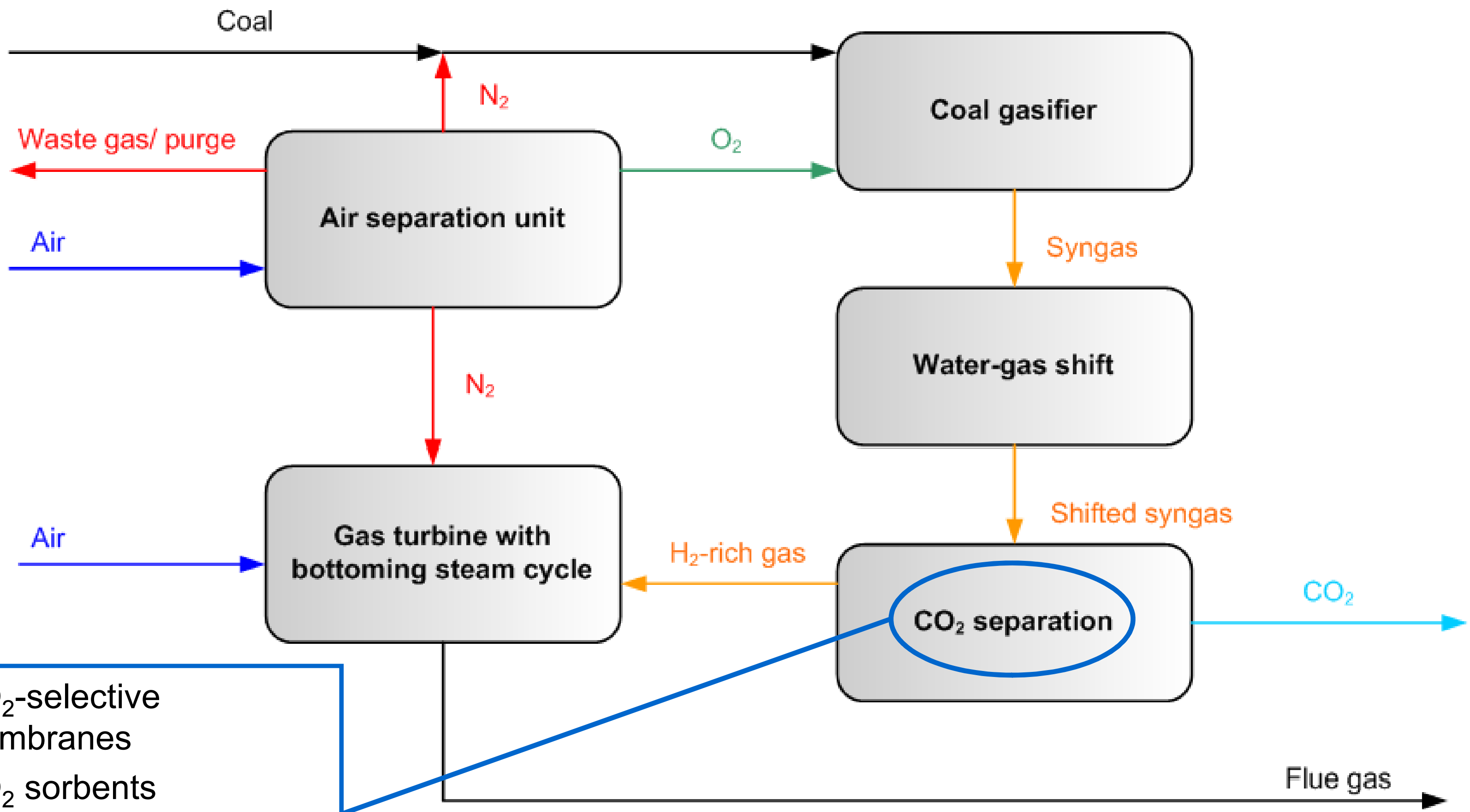
SEVENTH FRAMEWORK PROGRAMME

The DECARBit project (2008–2011)

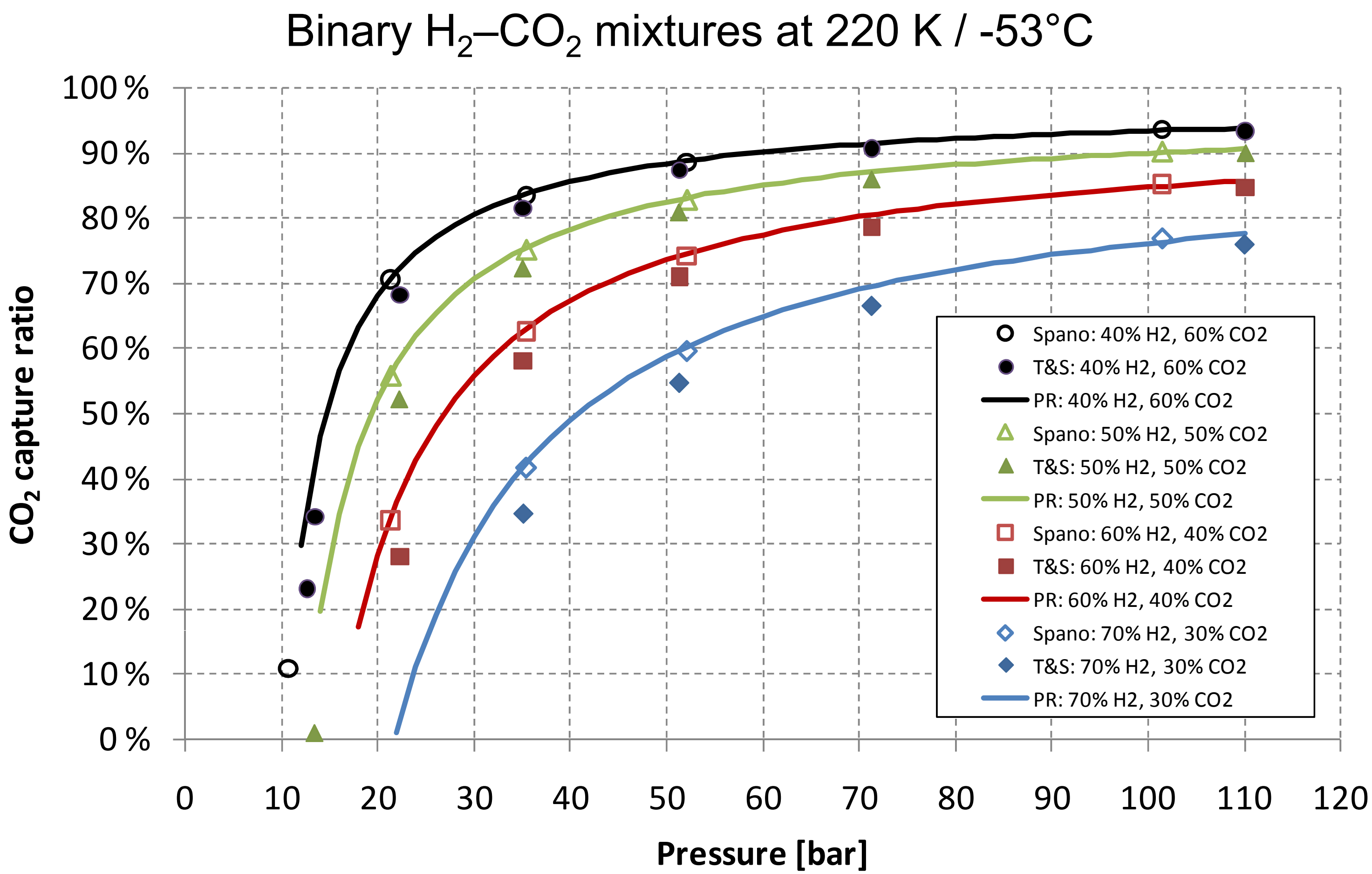


- CO_2-selective membranes
- CO_2 sorbents
- Novel solvent systems
- **Low-temperature syngas separation**

The DECARBit project (2008–2011)

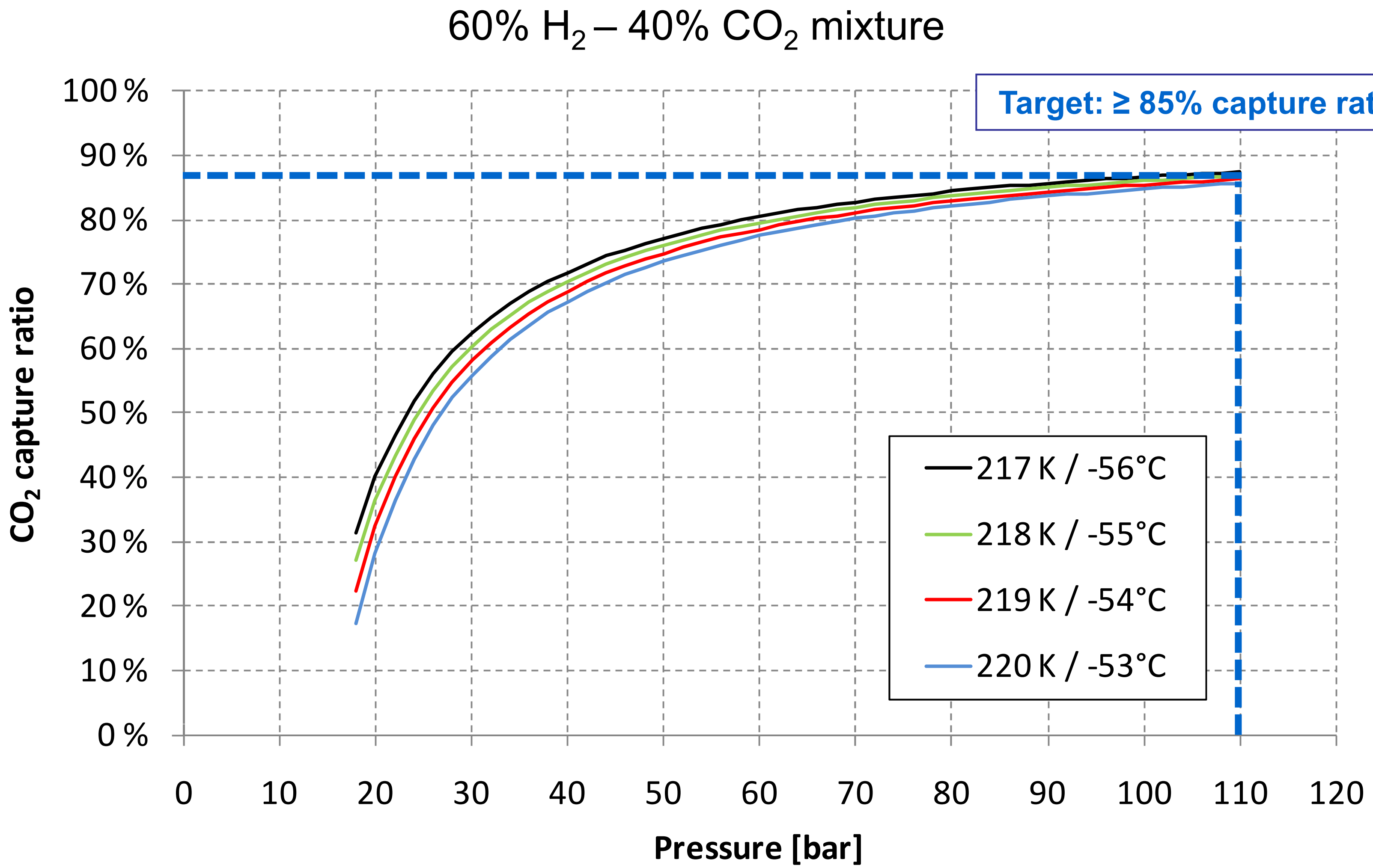
	Unit	Syngas after H_2S removal, sweet shift and H_2O removal
Temperature	°C	30
Pressure	bar	35.0
Flowrate	kg/s	114
Composition	mol-%	
H_2		54.14
CO		1.73
CO_2		38.39
N_2		4.79
Ar		0.94
H_2O		ppm levels
H_2S		ppm levels
Other		0.02

H_2–CO_2 vapour-liquid equilibria

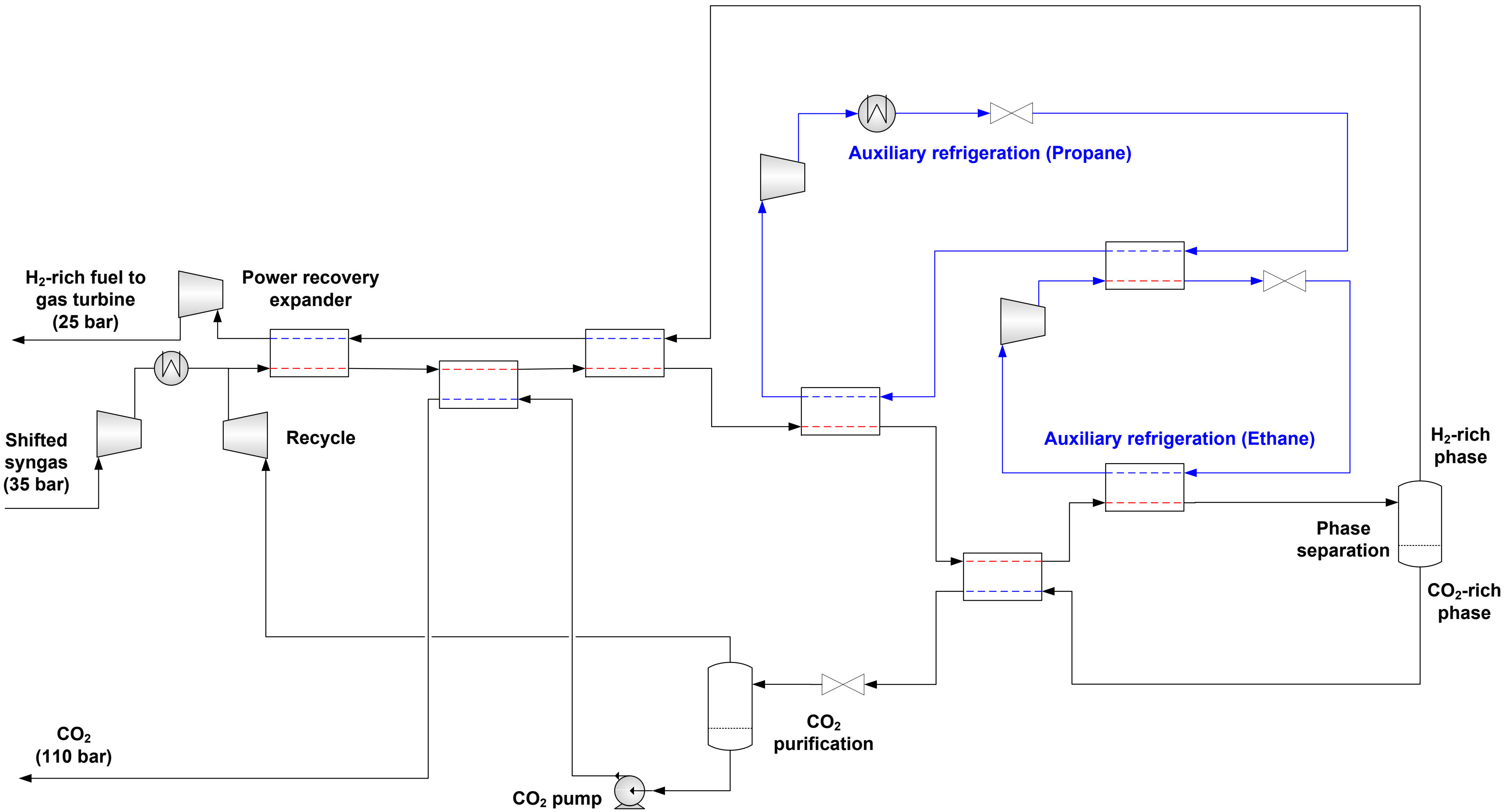


Spano J, Heck C, Barrick P. Liquid-vapor equilibria of the hydrogen–carbon dioxide system. J. Chem. Eng. Data. 13(2), 169–171 (1968).
Tsang C, Streett W. Phase equilibria in the H_2/CO_2 system at temperatures from 220 to 290 K and pressures to 172 MPa, Chem. Eng. Sci. 36, 993–1000 (1981).

Vapour-liquid equilibria

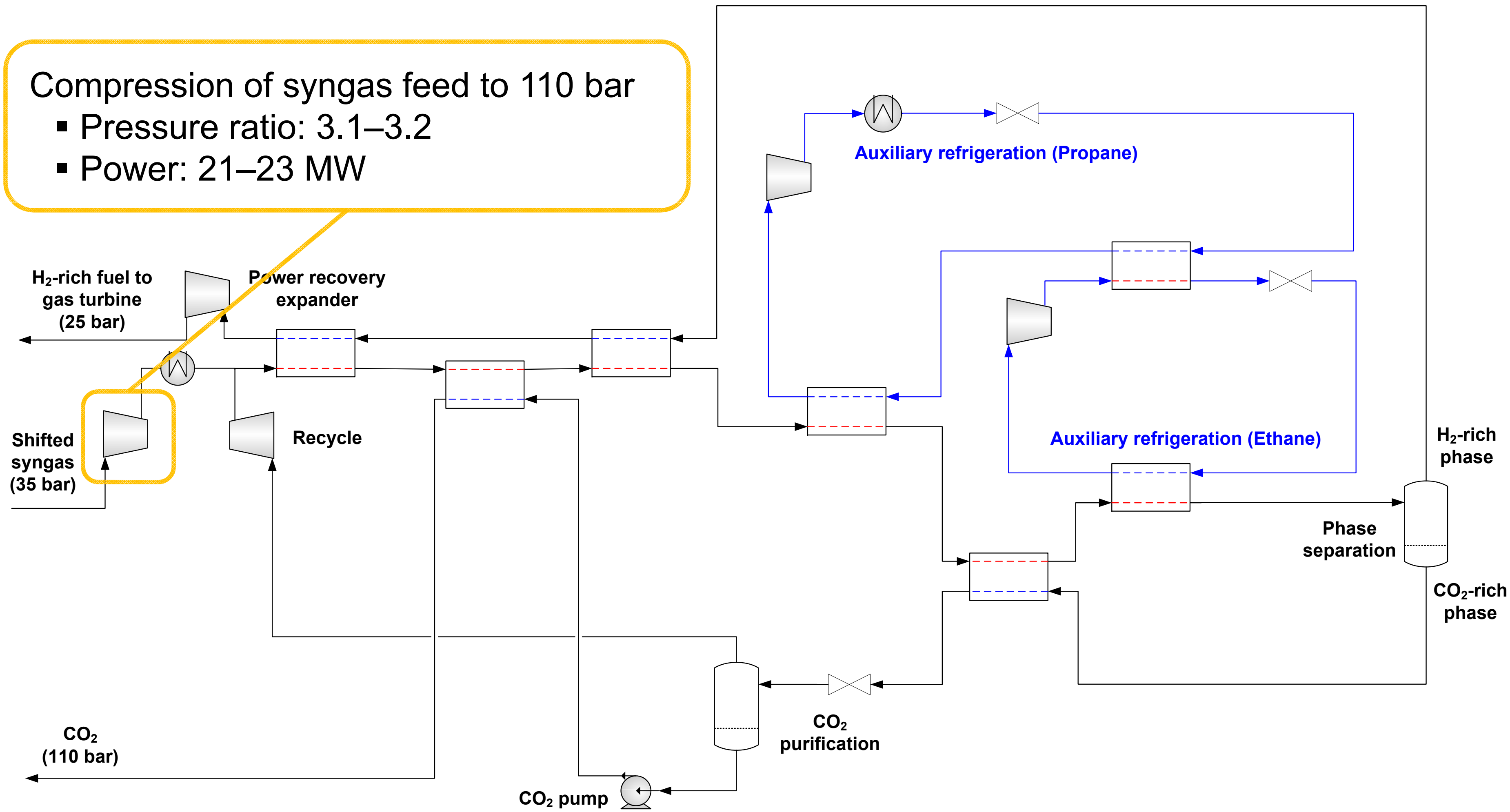


Process flow diagram



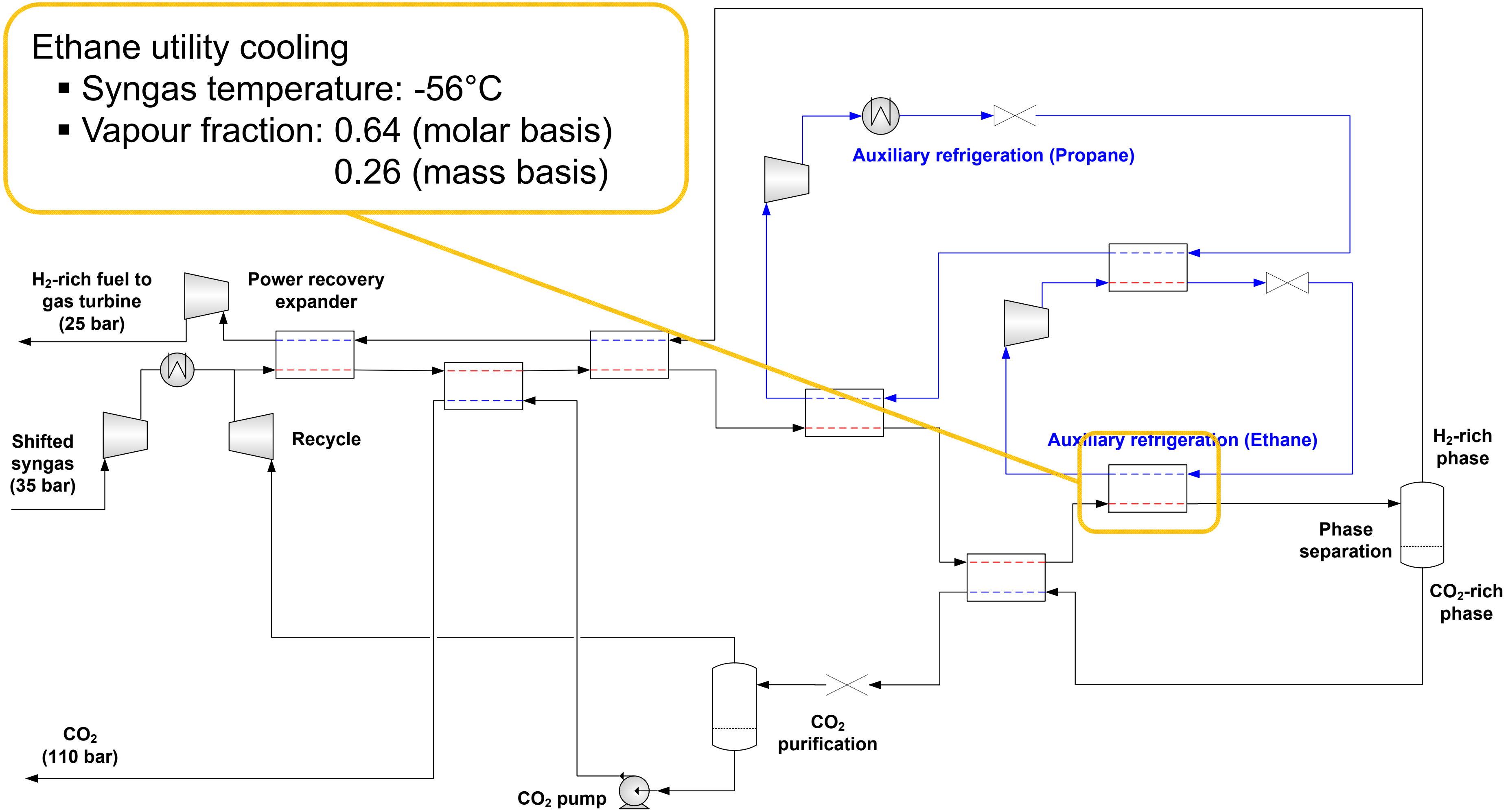
Process flow diagram

Compression of syngas feed to 110 bar
- Pressure ratio: 3.1–3.2
- Power: 21–23 MW



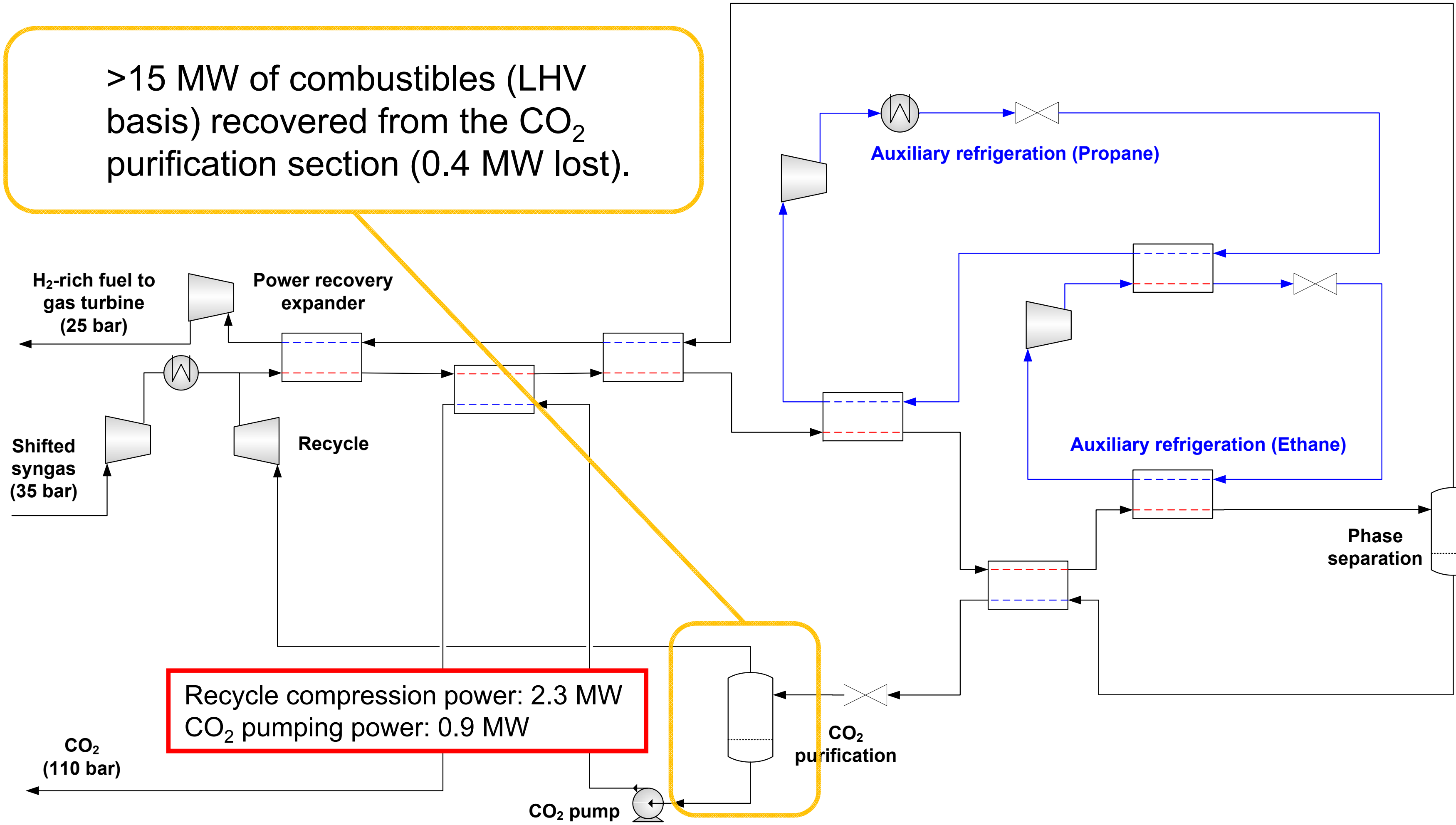
Process flow diagram

Ethane utility cooling
- Syngas temperature: -56°C
- Vapour fraction: 0.64 (molar basis)
  0.26 (mass basis)



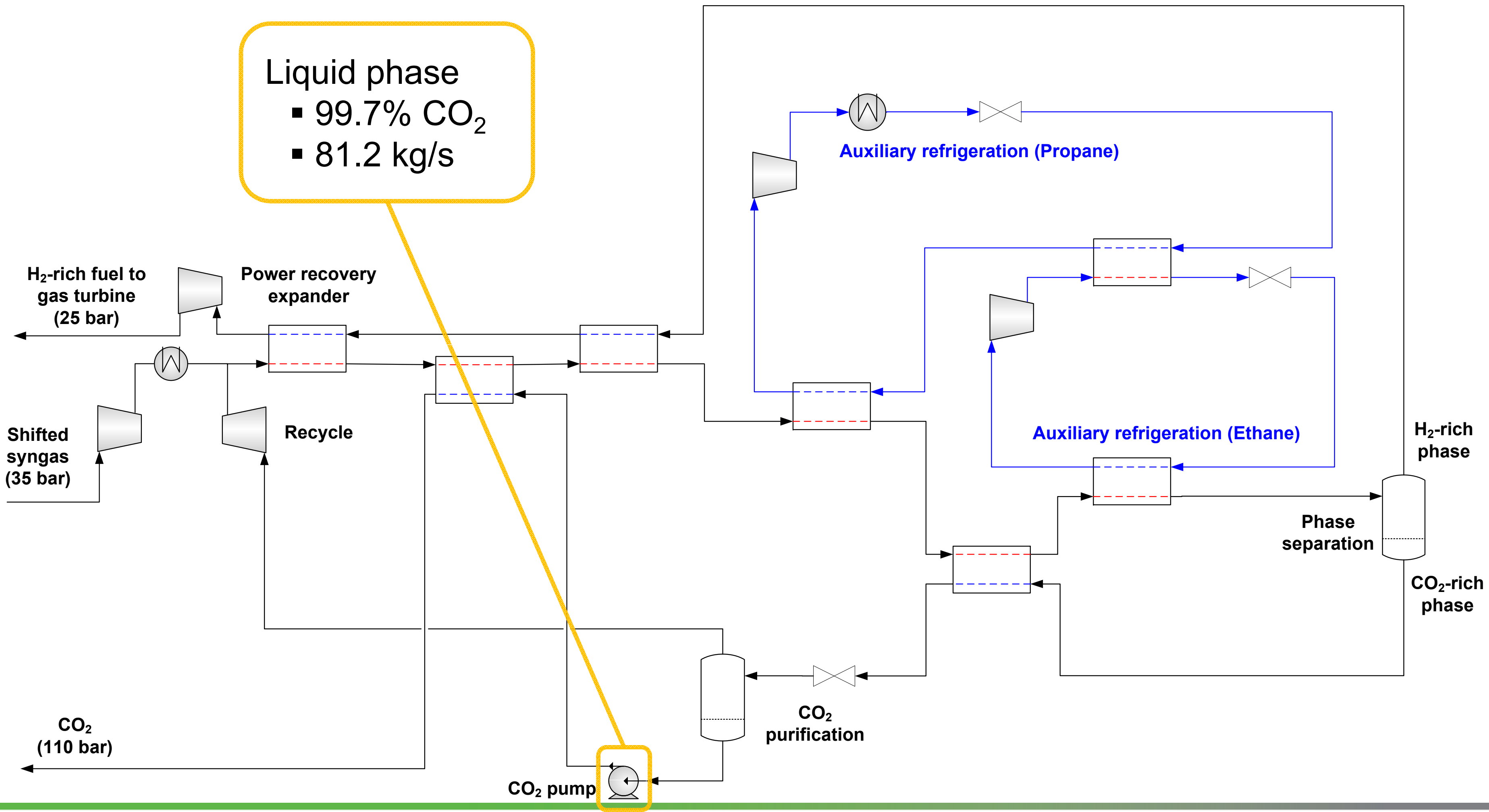
Process flow diagram

>15 MW of combustibles (LHV basis) recovered from the CO_2 purification section (0.4 MW lost).



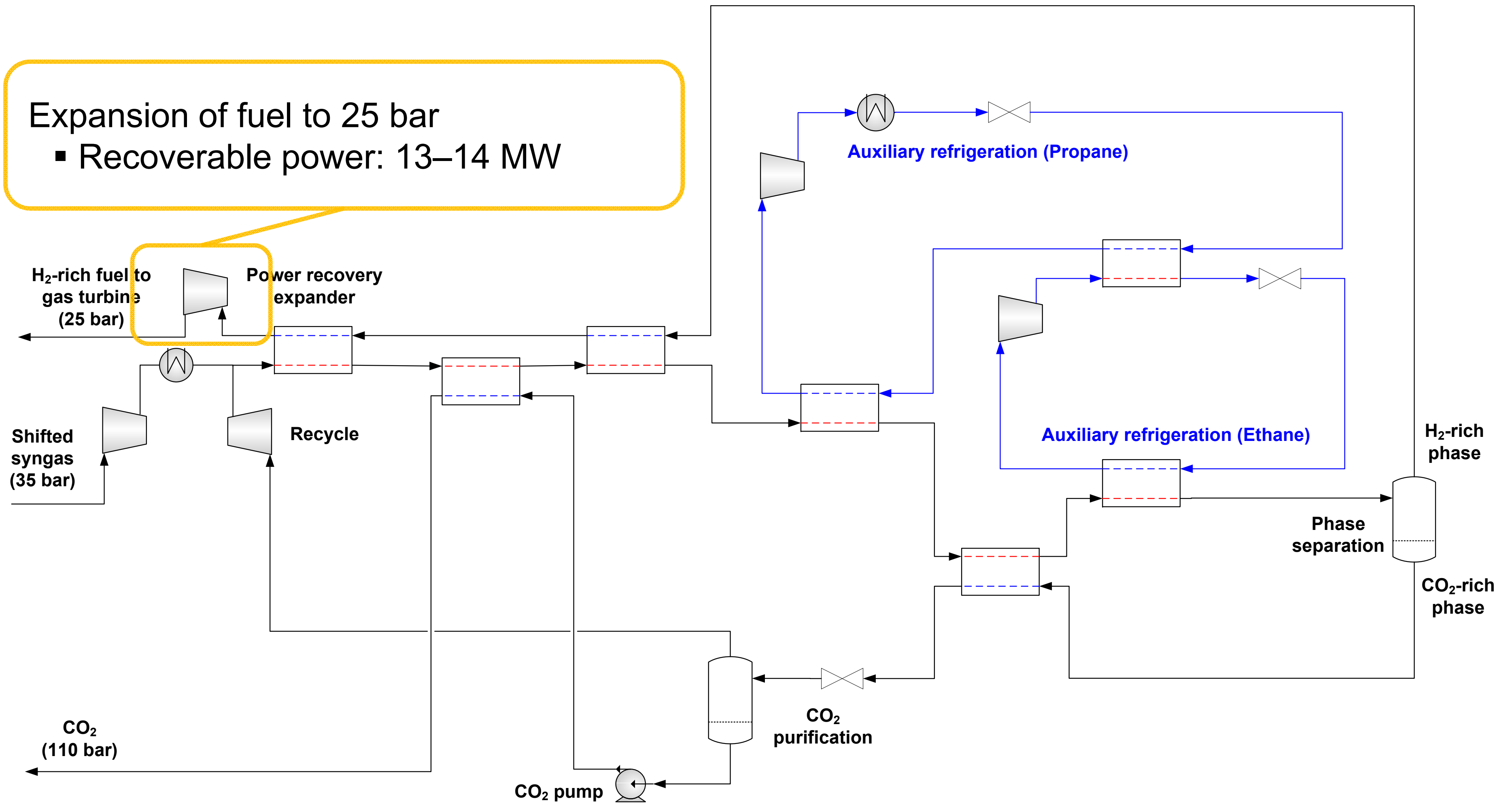
Recycle compression power: 2.3 MW
CO_2 pumping power: 0.9 MW

Process flow diagram

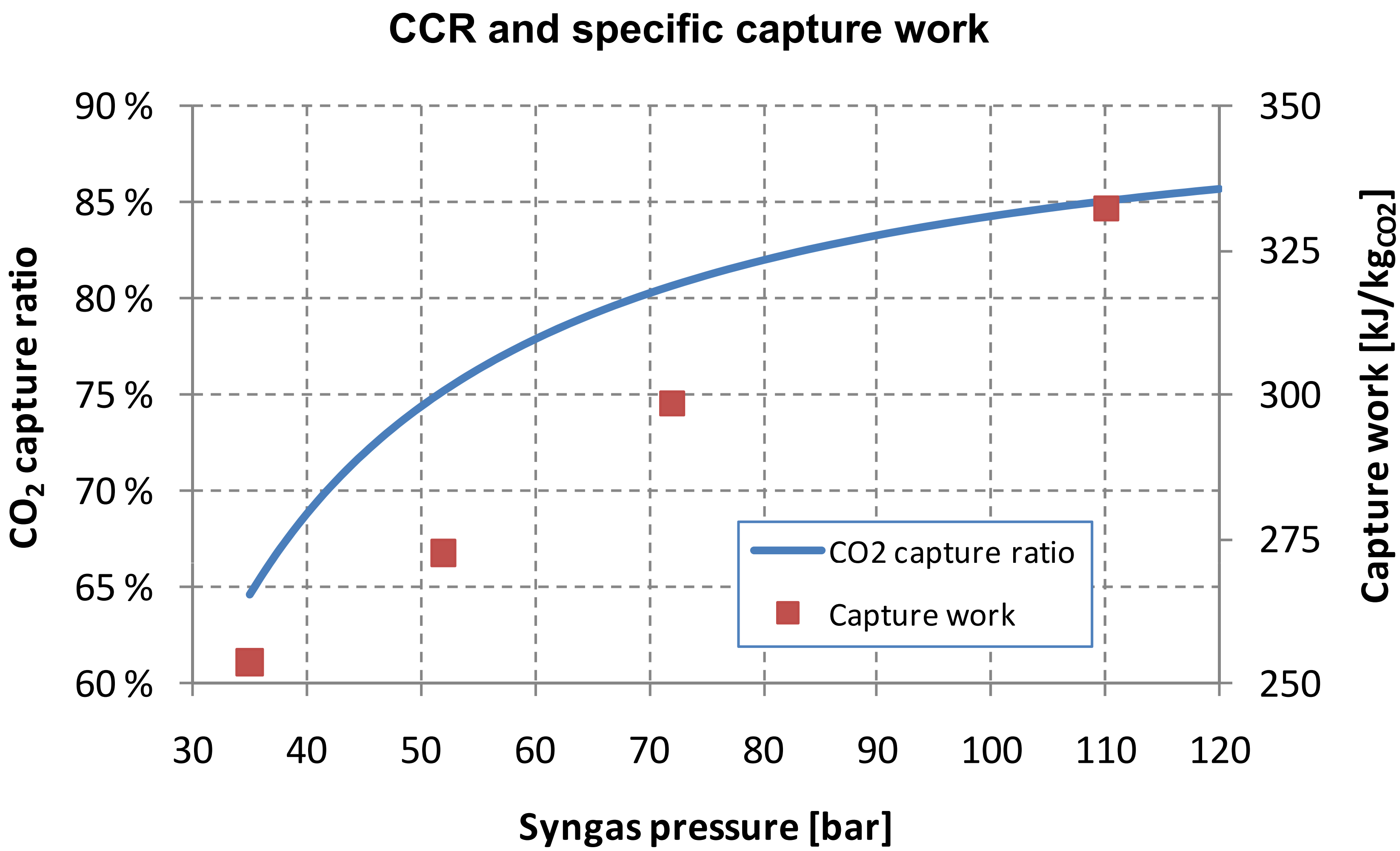


Process flow diagram

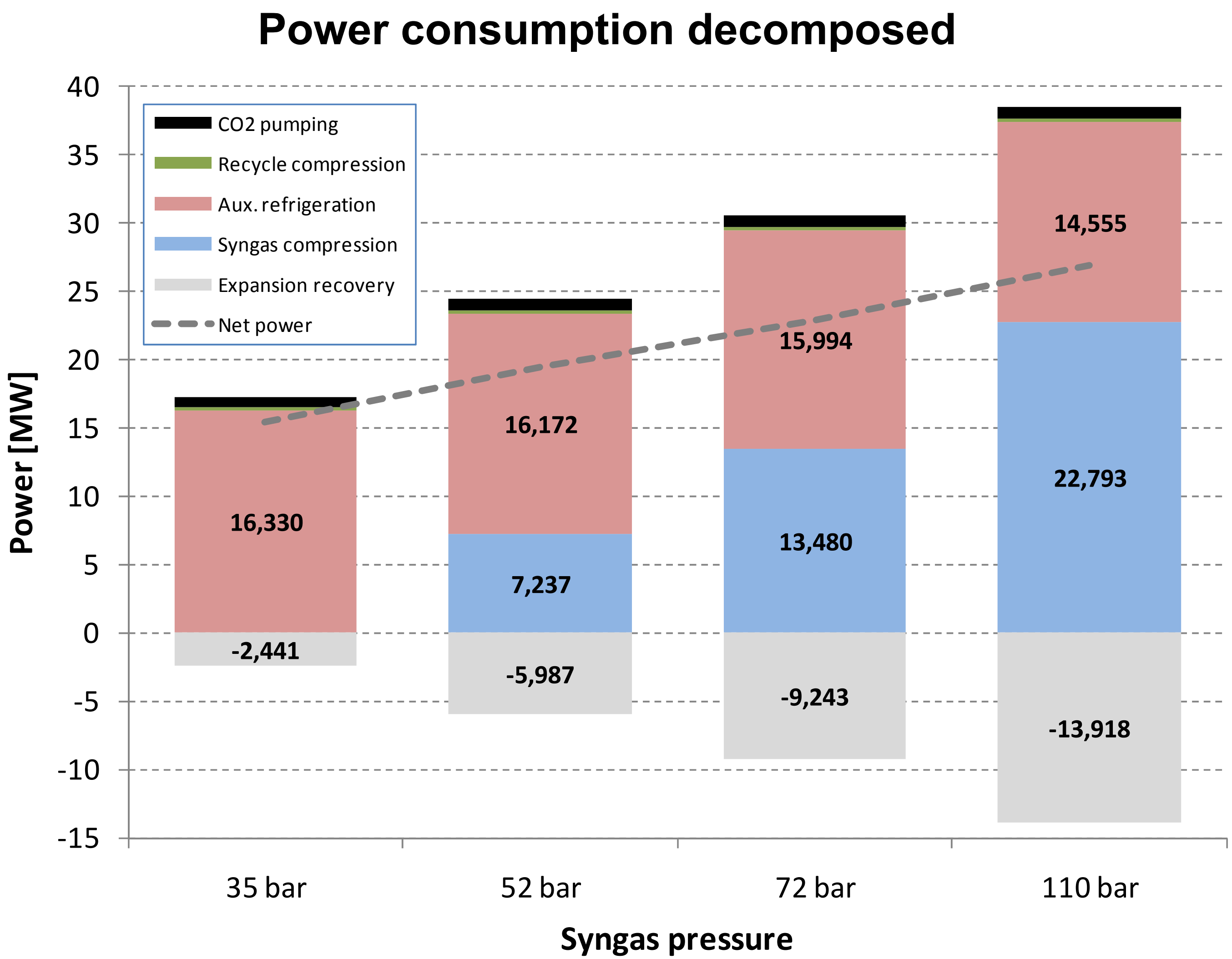
Expansion of fuel to 25 bar
- Recoverable power: 13–14 MW



Main results



Main results



Main results

Simulation parameters

Isentropic efficiency		
Syngas compressor	%	82
Propane compressor	%	82
Ethane compressor	%	82
Recycle compressor	%	80
Power recovery fuel expander	%	85
Liquid CO_2 pump	%	80
Pressure drop		
Heat exchangers	bar	0.2
Inter- and after-coolers	bar	0.5
Temperature approach		
Heat exchanger pinch	°C	3
LMTD in propane–ethane cascade heat exchanger	°C	> 5

Concluding remarks

- A conceptual low-temperature syngas separation process for CO_2 capture from IGCC has been developed and simulated
- 85% capture ratio is achievable for shifted syngas with a CO_2 concentration of 38 mol-%. Specific capture work for the considered system boundaries is around 330 kJ per kg CO_2 captured
- Partial capture is possible without the need of pre-compression
- Refrigeration cycles account for a significant part of the power consumption and must be optimised
- Simulation of the overall IGCC with CO_2 capture is required in order to obtain a justified benchmarking with baseline technologies
  - Syngas conditioning (water removal and desulphurisation) must be included
- Overall performance analysis and techno-economic assessment, equipment sizing and costing will be carried out in the last phase of DECARBit

Acknowledgements

Participating industry partners

Funding industry partners

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