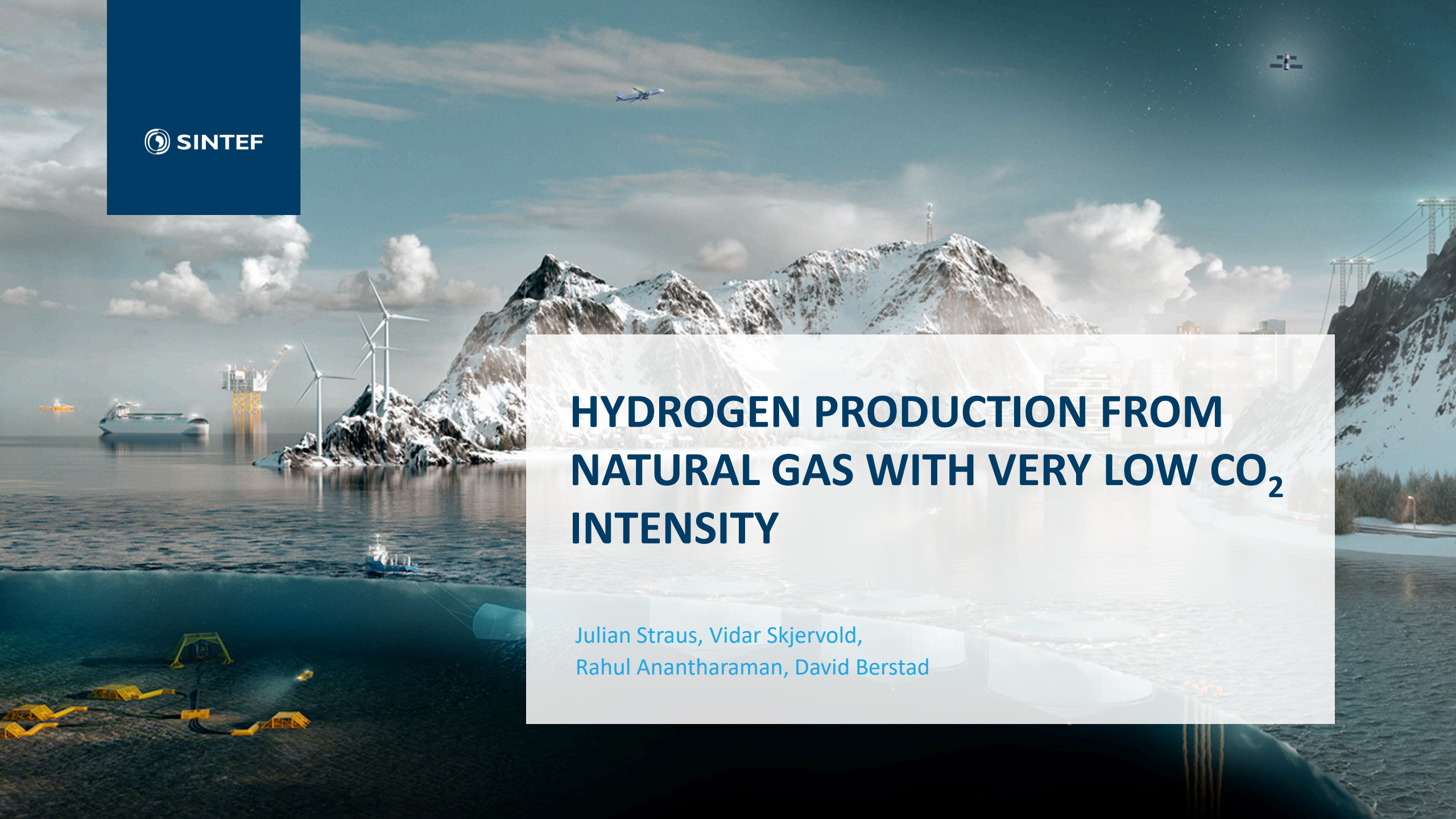


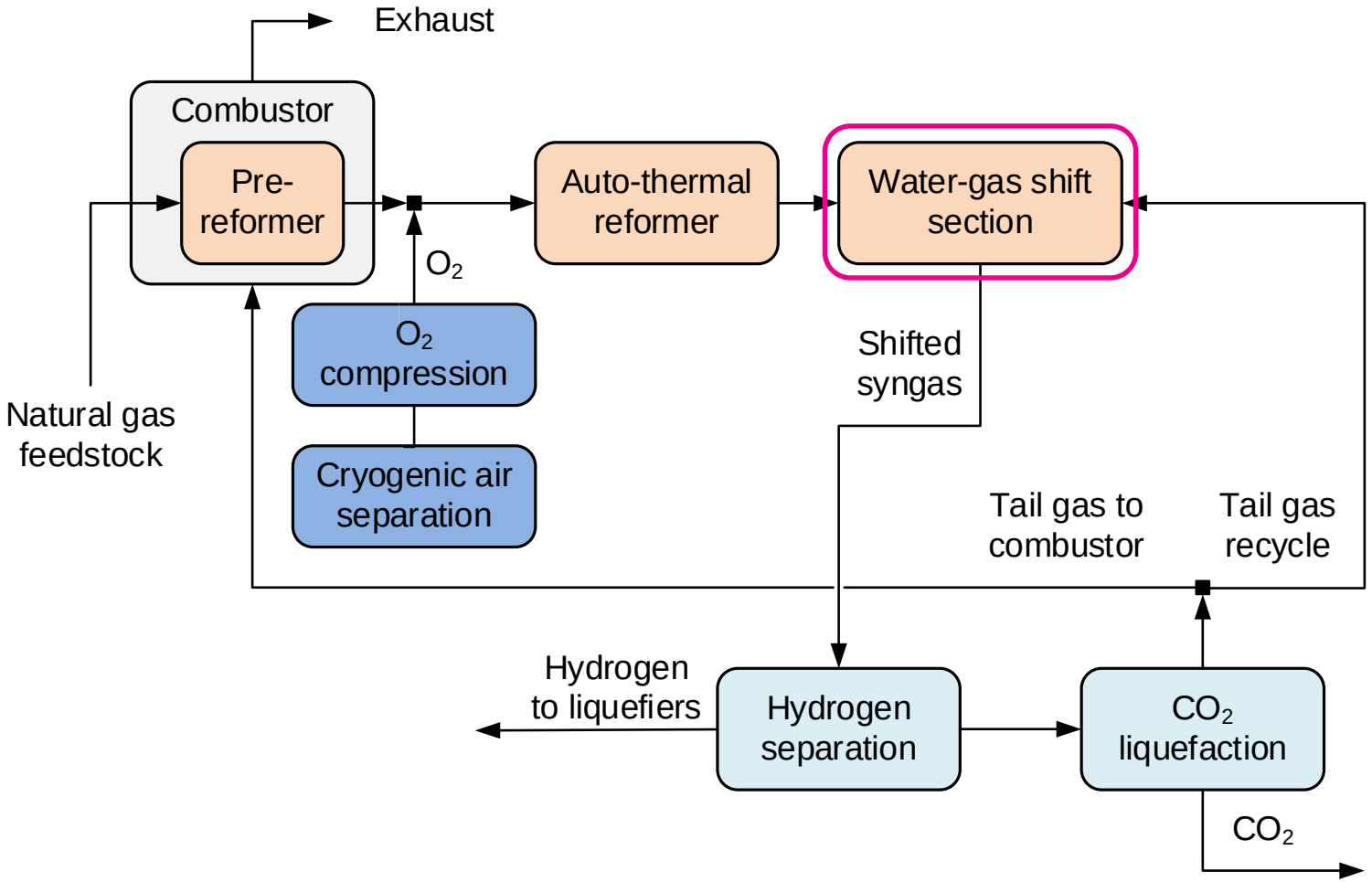
HYDROGEN PRODUCTION FROM NATURAL GAS WITH VERY LOW CO_2 INTENSITY

Julian Straus, Vidar Skjervold,
Rahul Anantharaman, David Berstad

Overview

- Natural gas reforming – process description
- Recap: Improved process configuration
- CO_2 liquefaction as separation technology
- Analysis of operation conditions
- Comparison to aMDEA + PSA process
- Conclusion

Natural gas reforming



- Hydrogen separation technologies:
  - Pressure swing adsorption (PSA)
  - Palladium membrane (Pd)
- Focus on:
  - Recap of last results

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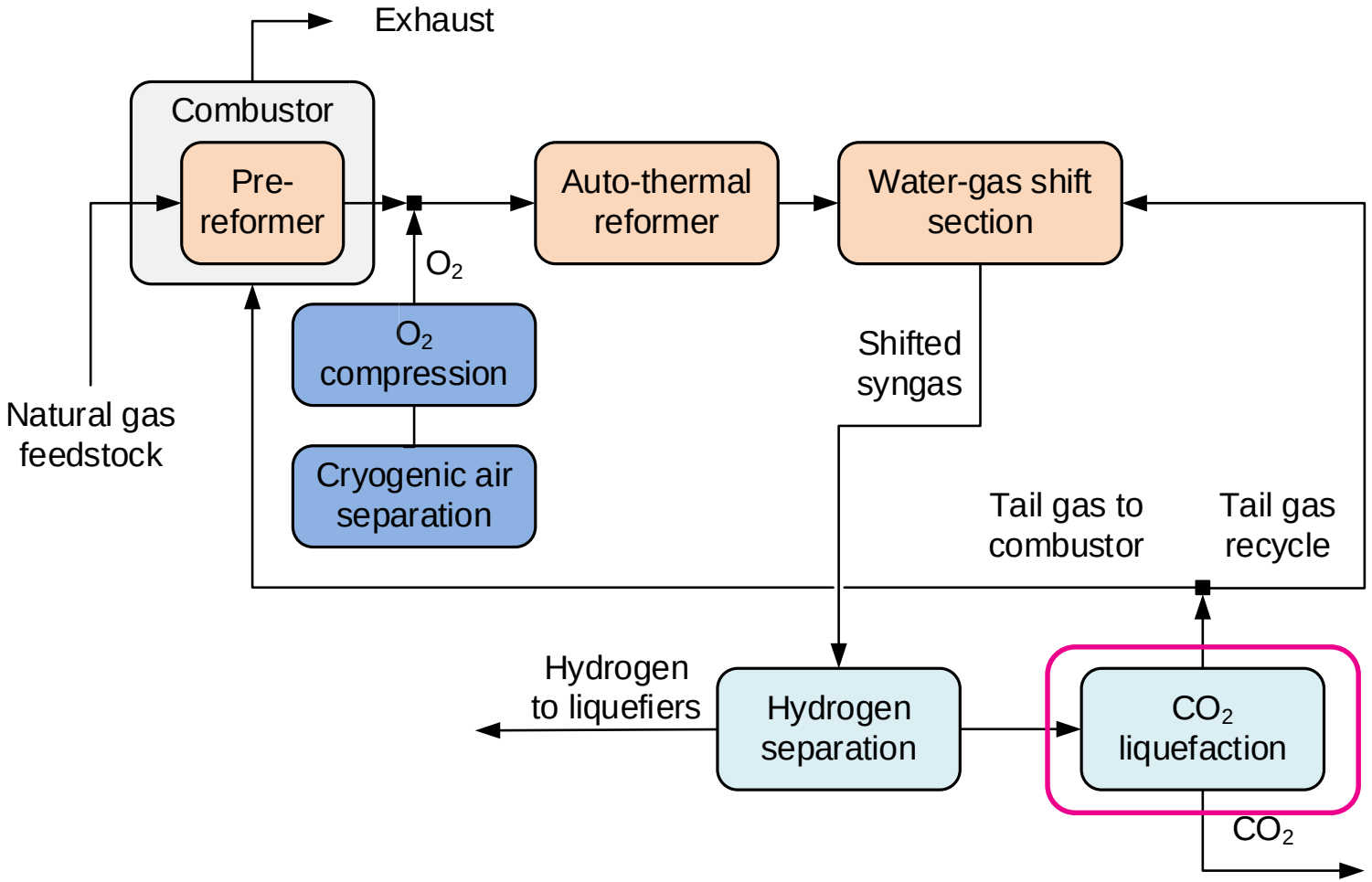
Natural gas reforming



- Hydrogen separation technologies:
  - Pressure swing adsorption (PSA)
  - Palladium membrane (Pd)
- Focus on:
  - Recap of last results
  - Improvements for CO_2 liquefaction while maintaining similar CO_2 capture rate

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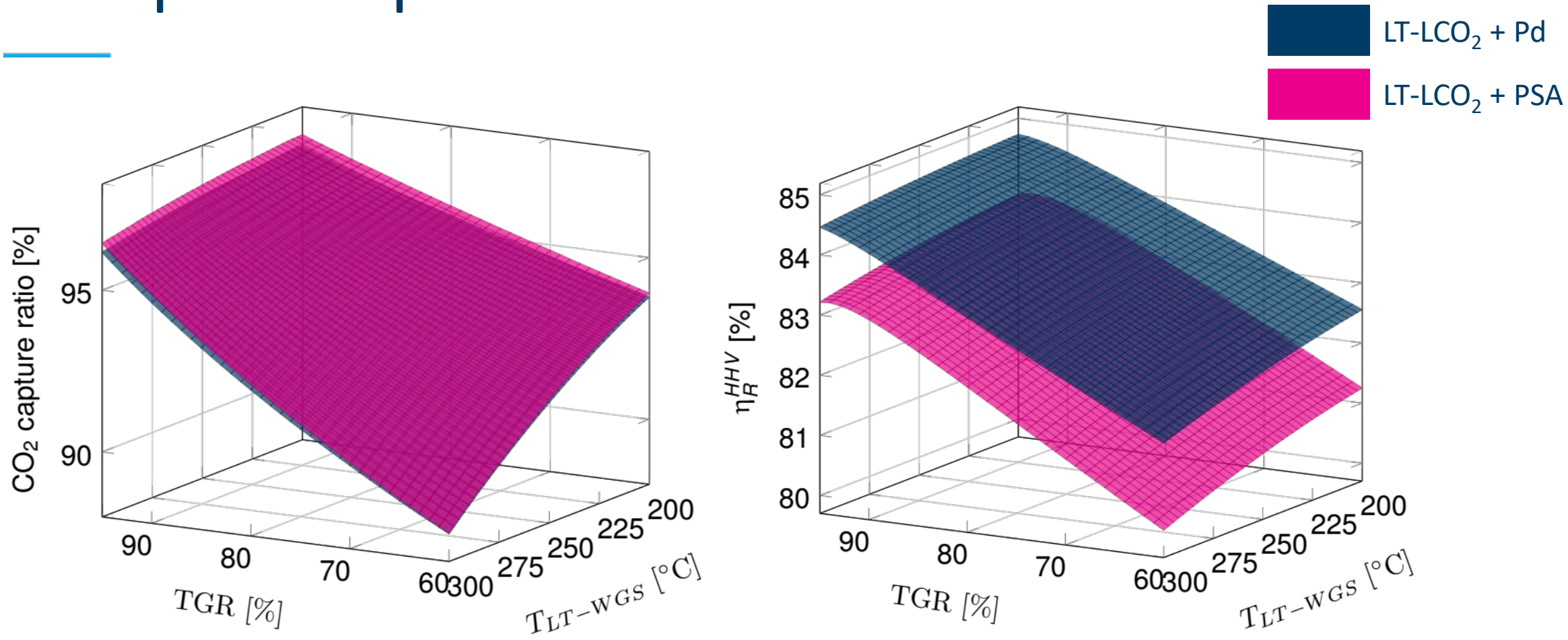
Recap: New process conditions



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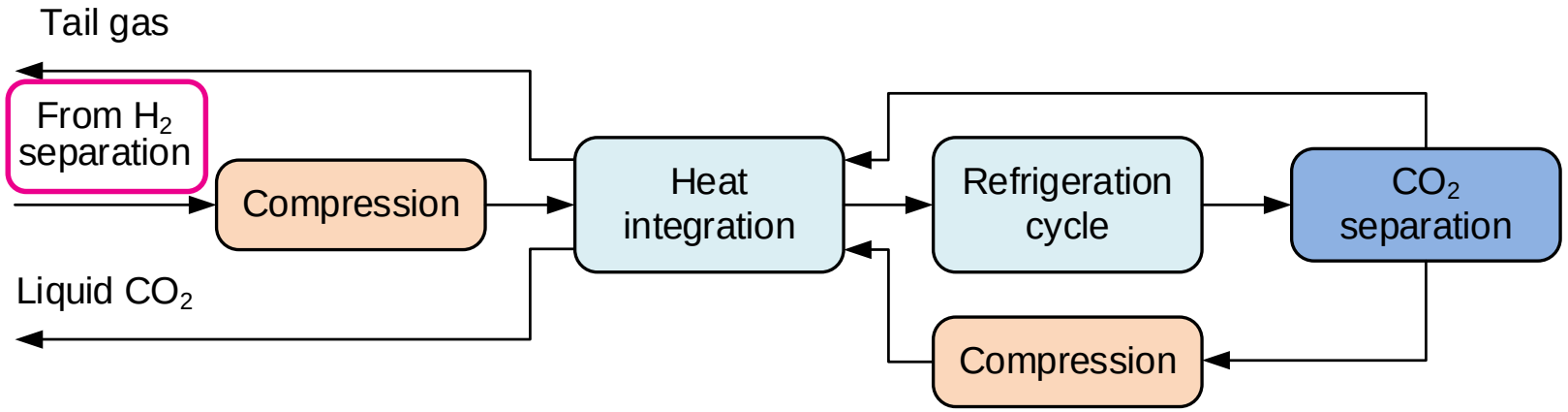
CO_2 liquefaction



- Process for simultaneous separation and liquefaction of CO_2
- Costs of separation characterized by
  - Feed stream composition

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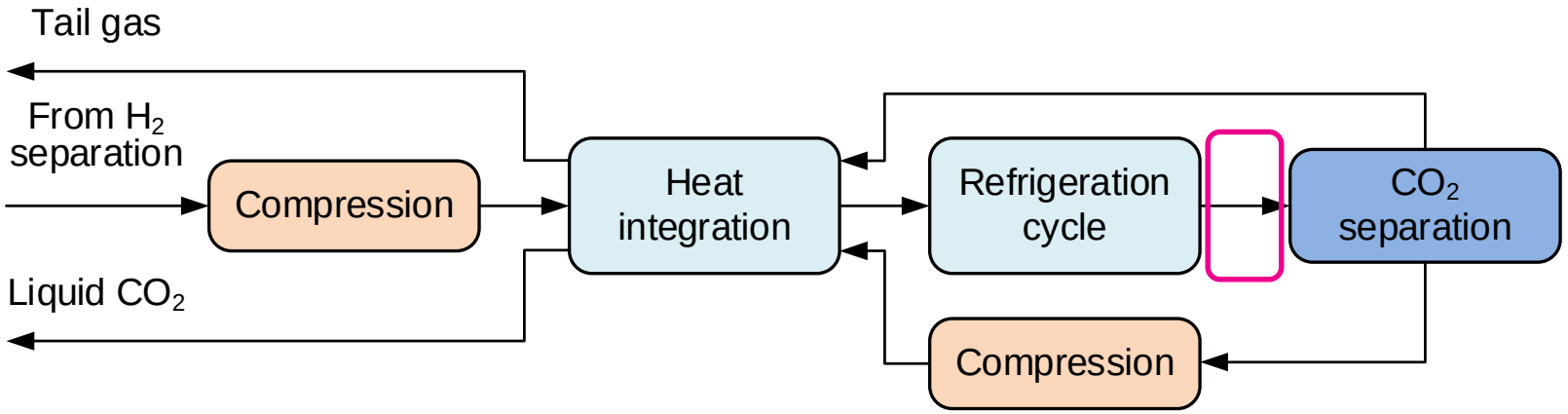
CO_2 liquefaction



- Process for simultaneous separation and liquefaction of CO_2
- Costs of separation characterized by
  - Feed stream composition
  - Separation conditions (*p* and *T*)

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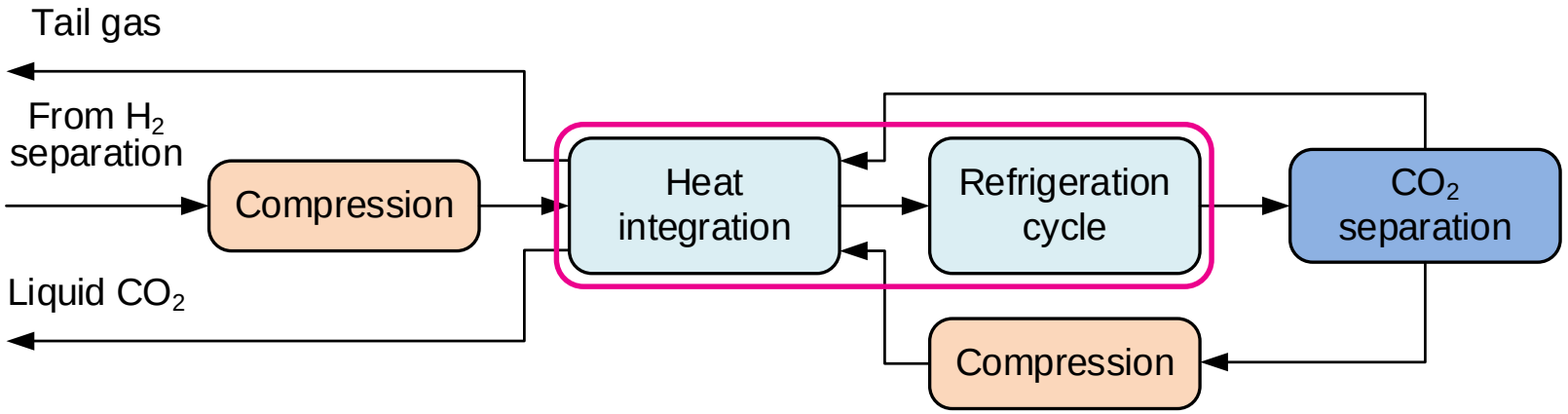
CO_2 liquefaction



- Process for simultaneous separation and liquefaction of CO_2
- Costs of separation characterized by
  - Feed stream composition
  - Separation conditions (*p* and *T*)
  - Heat integration
  - Refrigeration cycle performance

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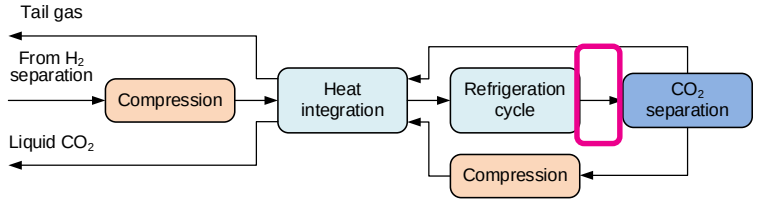
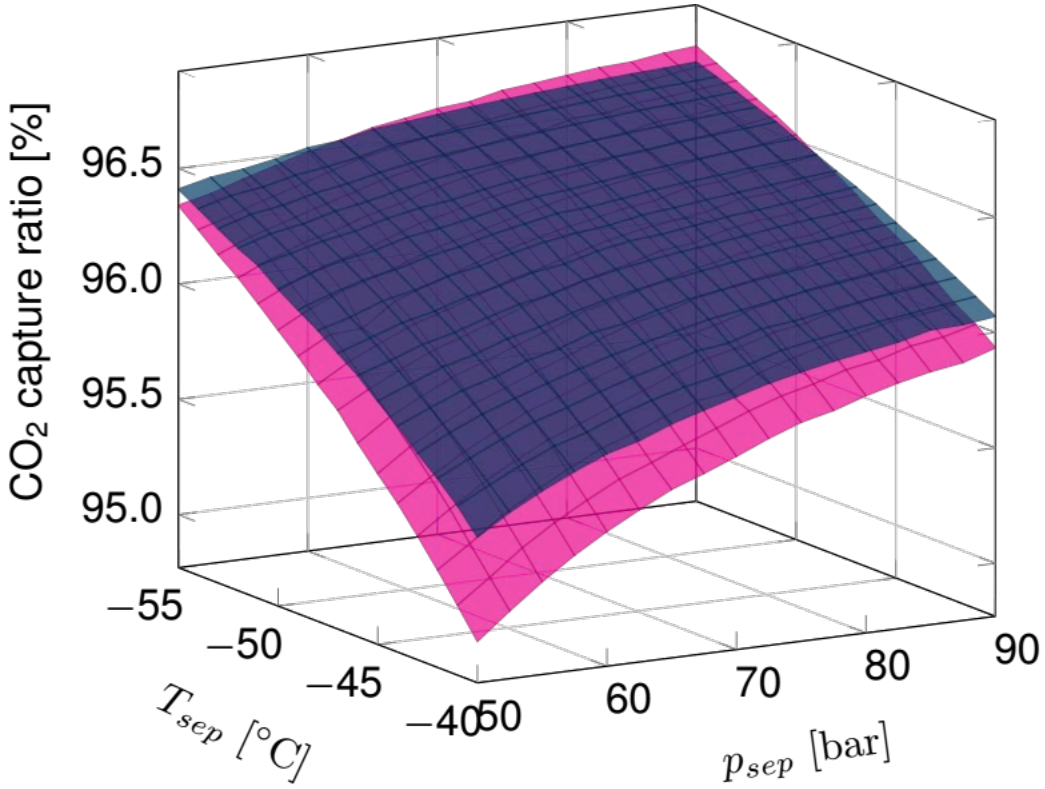
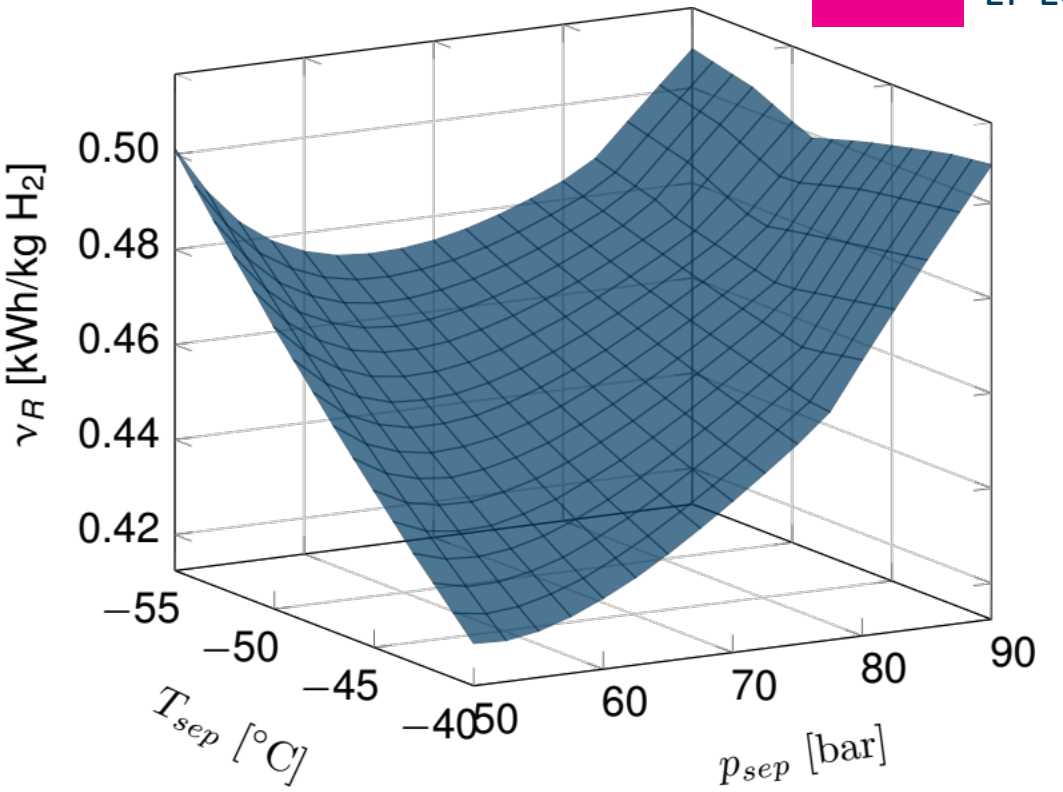
Impact of separation conditions



LT-LCO_2 + Pd

LT-LCO_2 + PSA





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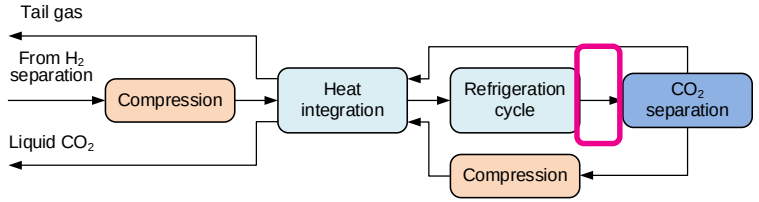
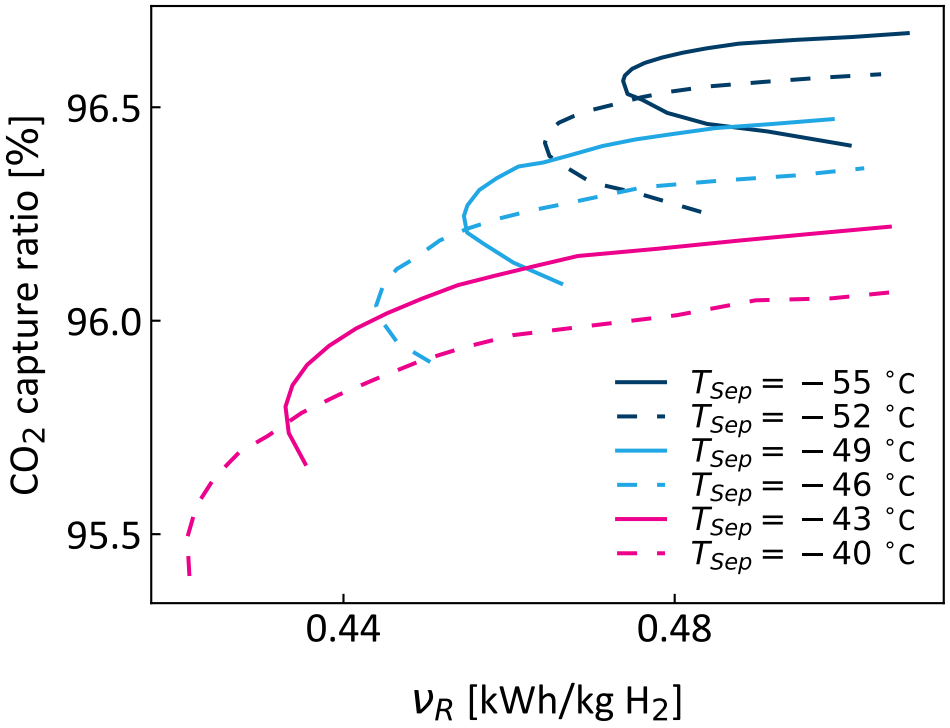
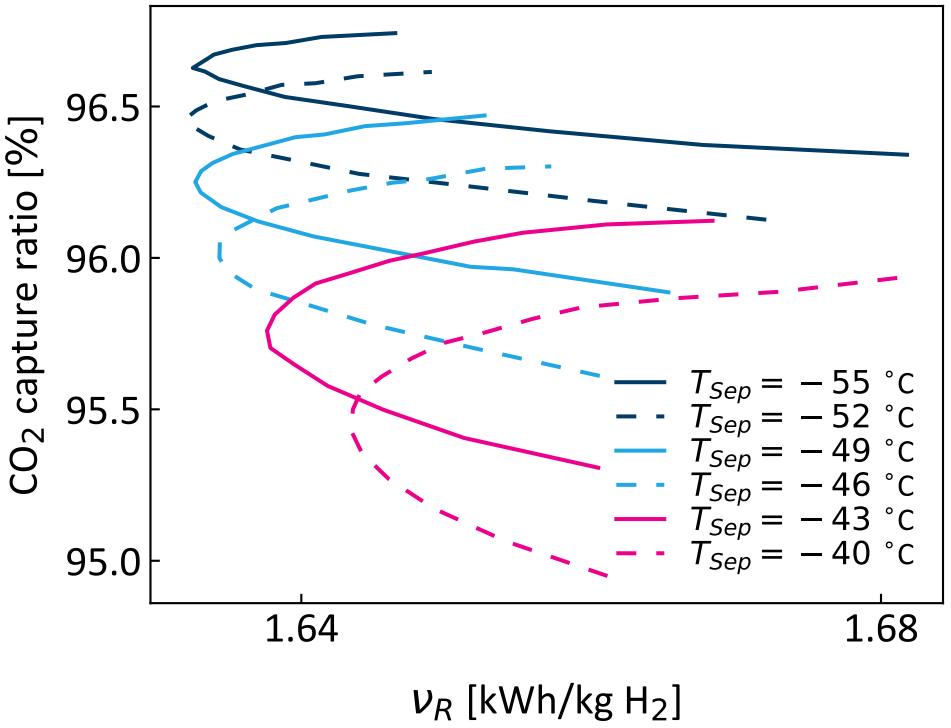
Impact of separation conditions



Pd membrane



Pressure Swing Adsorption



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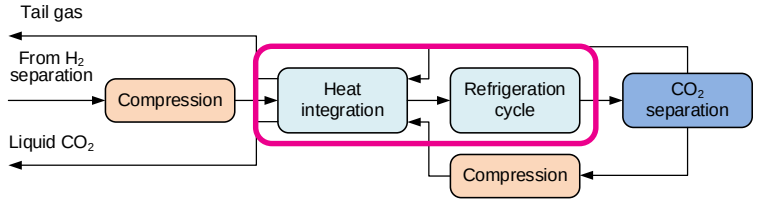
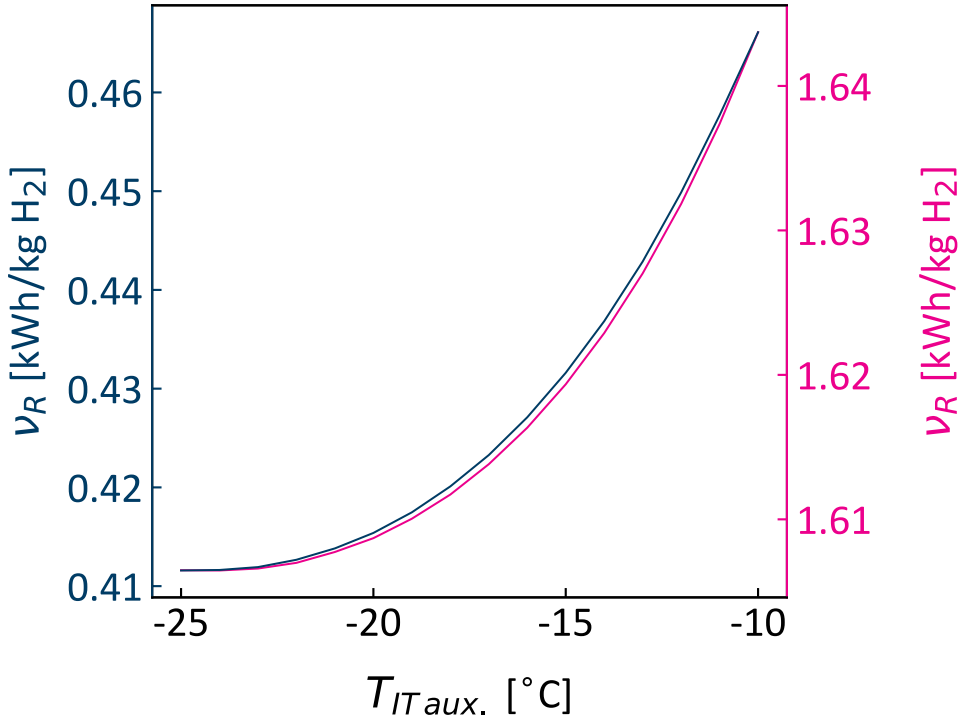
Refrigeration cycle performance



- Performance depending on distribution of cooling duties
- Different feed conditions result in different performance improvements
- Potential for further improvement through rigorous optimization



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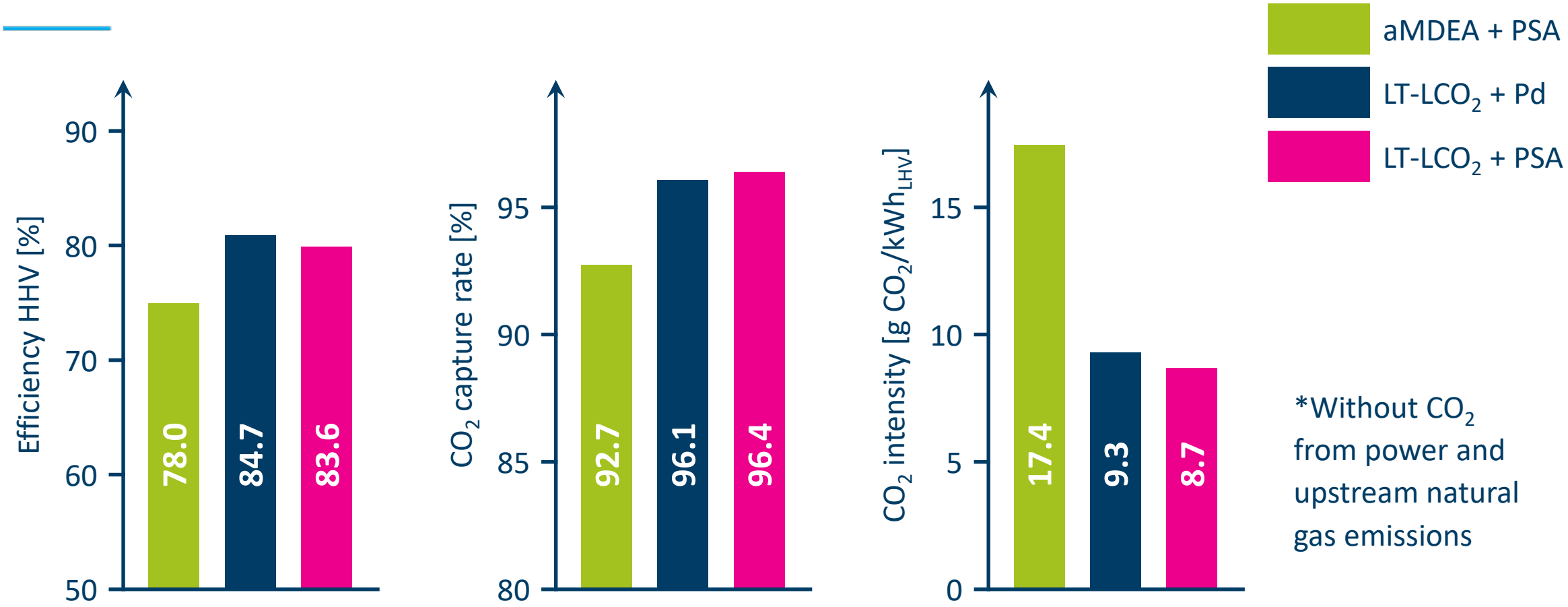
Comparison to aMDEA-PSA technology



*Without CO_2 from power and upstream natural gas emissions

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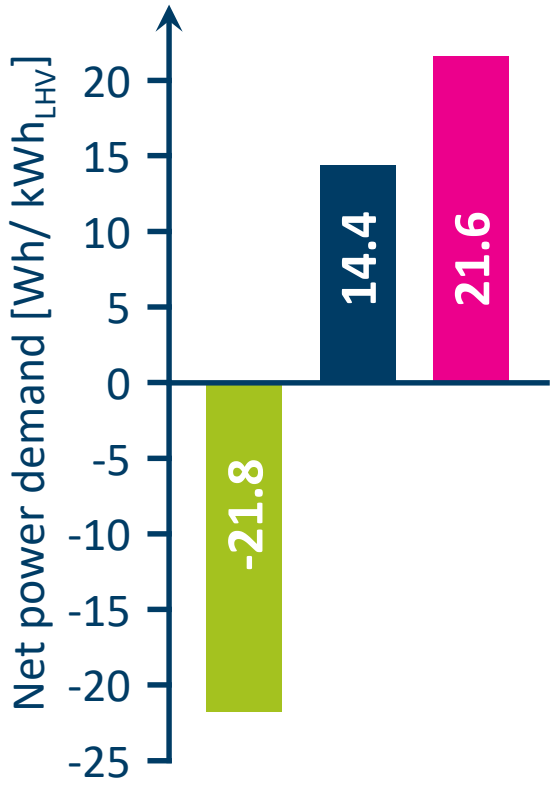
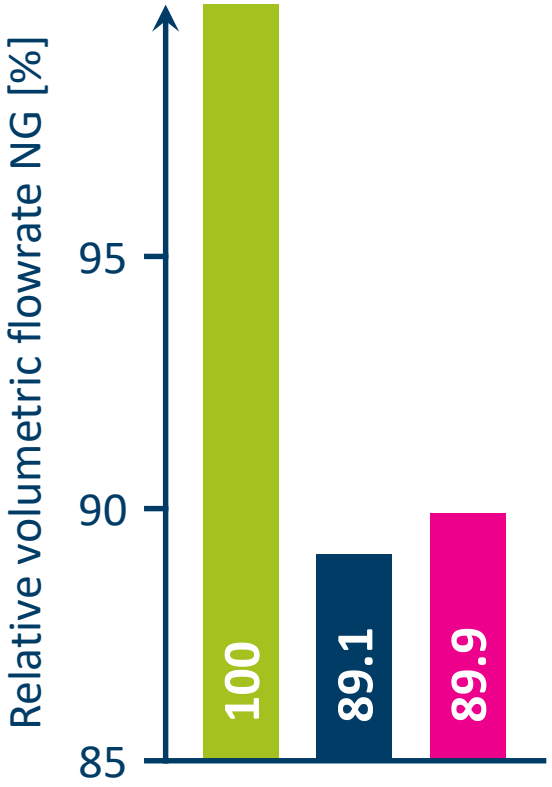
Comparison to aMDEA-PSA technology





- Improved performance through:
  - Reduced natural gas demand
  - Increased carbon capture ratio
  - Novel process layout (to be published in a paper)
- Requires however more external power through lower power generation

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Conclusion

- Natural gas reforming with carbon capture has potential for:
  - Very low CO_2 intensity of hydrogen
  - High efficiencies independently of the hydrogen separation technology

- Liquefaction of CO_2 as separation technology:
  - Relatively new technology with further potential for improved performance above the achieved 20 % reduction in energy consumption
  - Based on widely applied unit operations

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