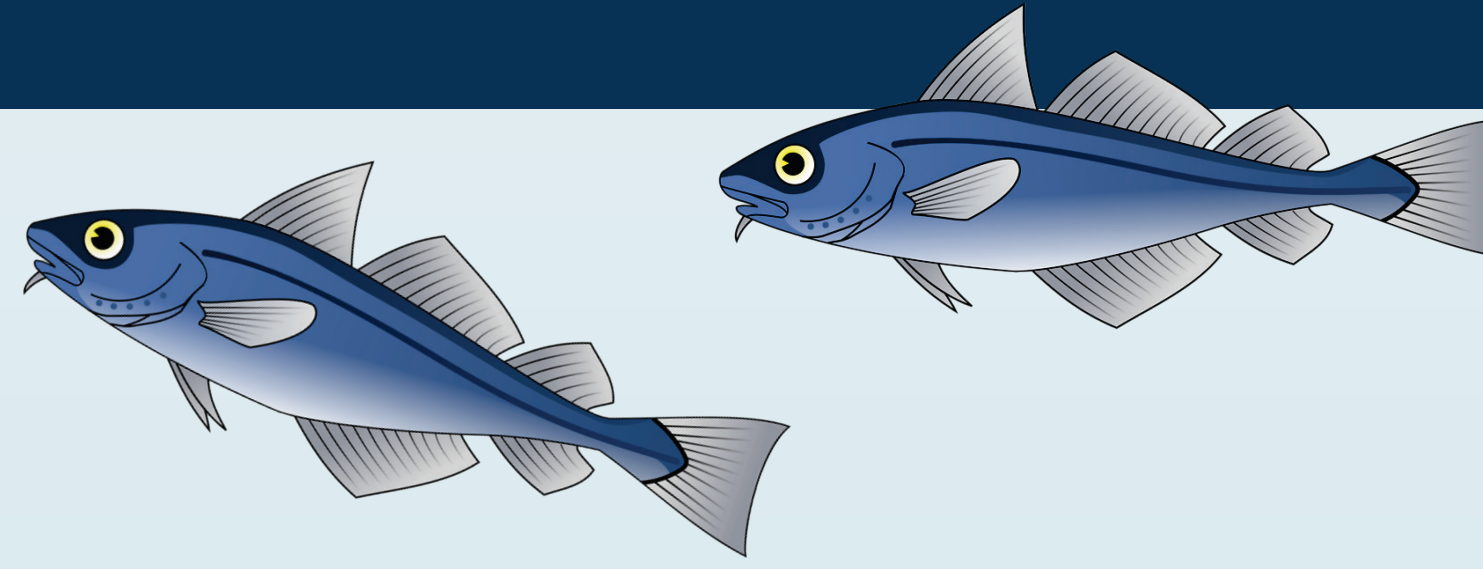
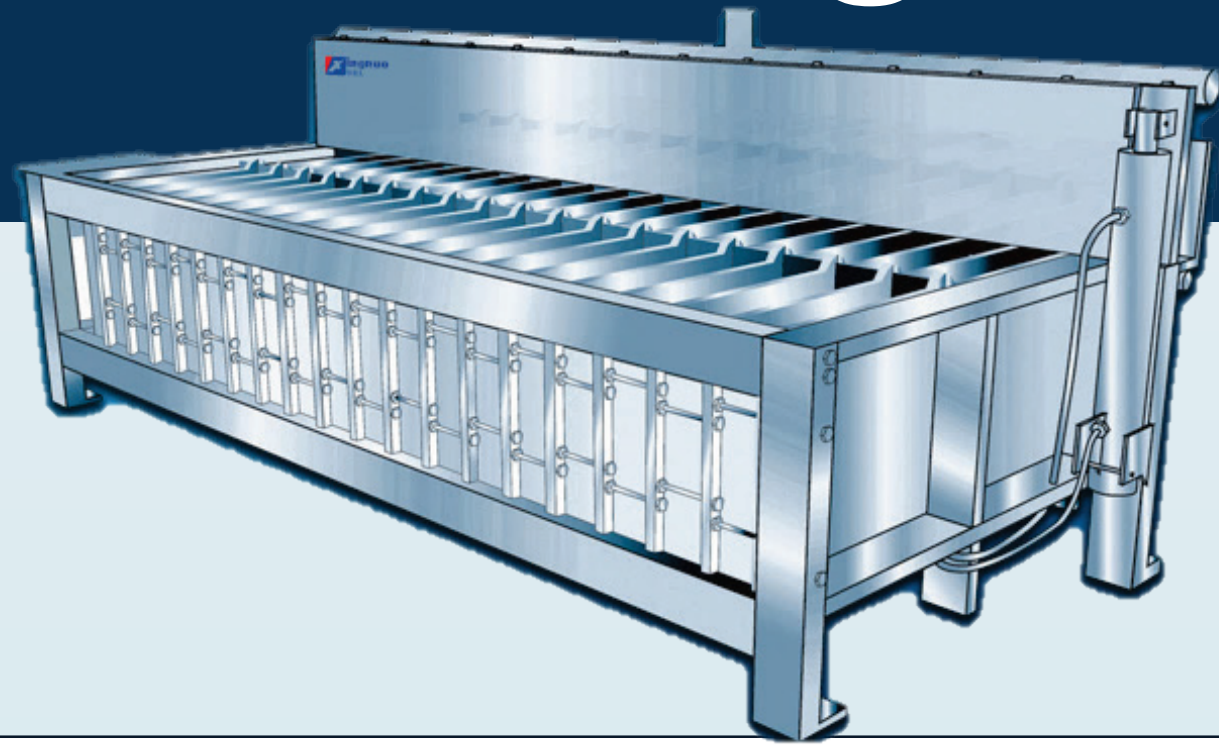


Low Temperature Plate Freezing of Fish Using CO2 Heat Pump



Technology for a better society

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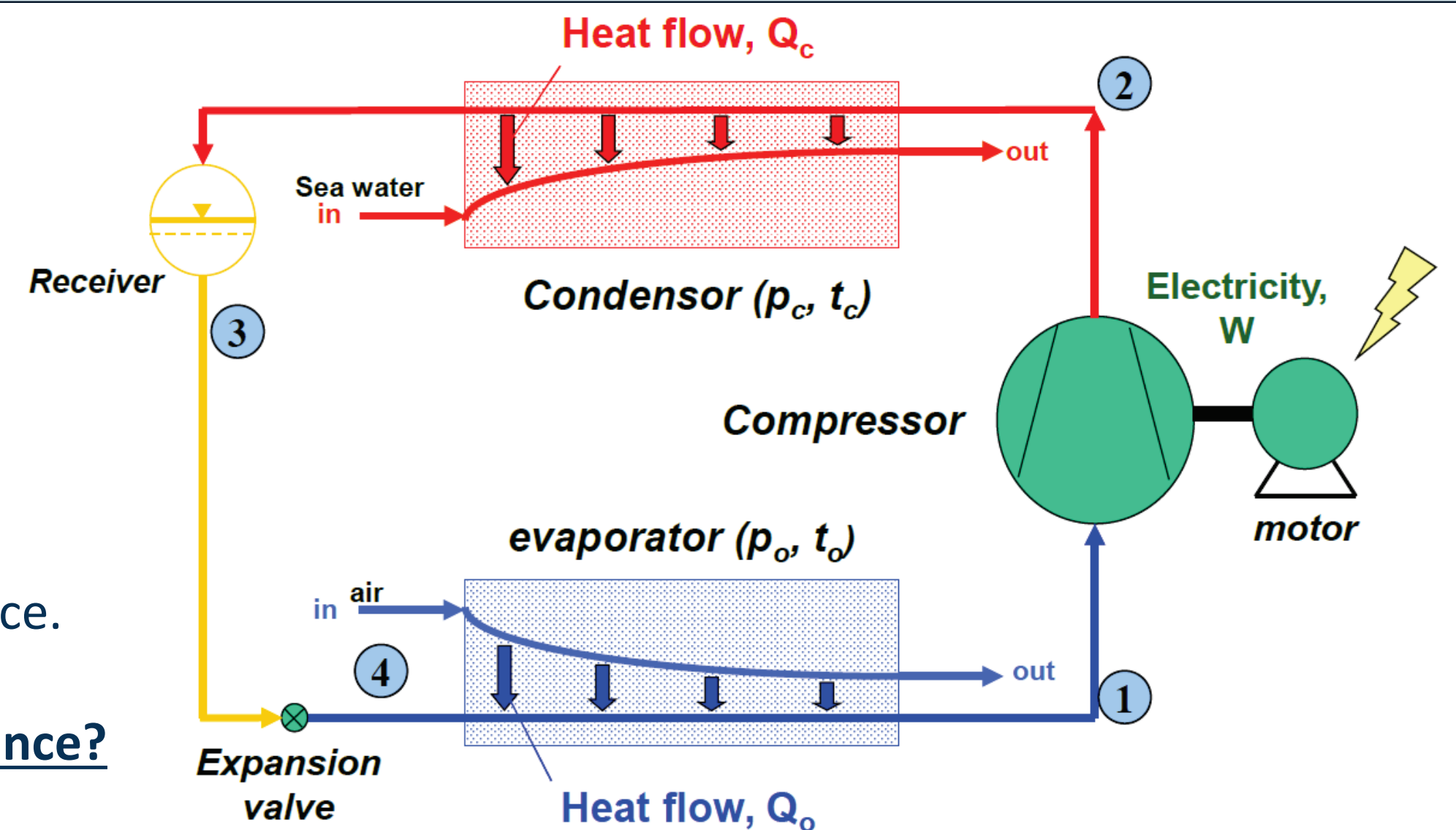


Introduction

Plate freezers are one of the fastest way for deep-freezing. The recent comeback of CO2 as refrigerant enables more eco-friendly systems without lowering the efficiency.

Using CO2 as an refrigerant also allows for an even lower evaporating temperature than for many other common refrigerant. This will improve freezing time significantly, and can increase a facility's capacity. However, lowering the evaporation temperature decrease the heat pumps performance.

Will lowering the evaporating temperature increase the freezers performance?
What influences freezing time?



Freezing

- Food freezing is complicated
 - Freezing point depression
 - Change in thermodynamic properties
- Analytical models are not very accurate
- Developed a freezing model in MATLAB
- Run for different wall temperatures, thickness and fish species

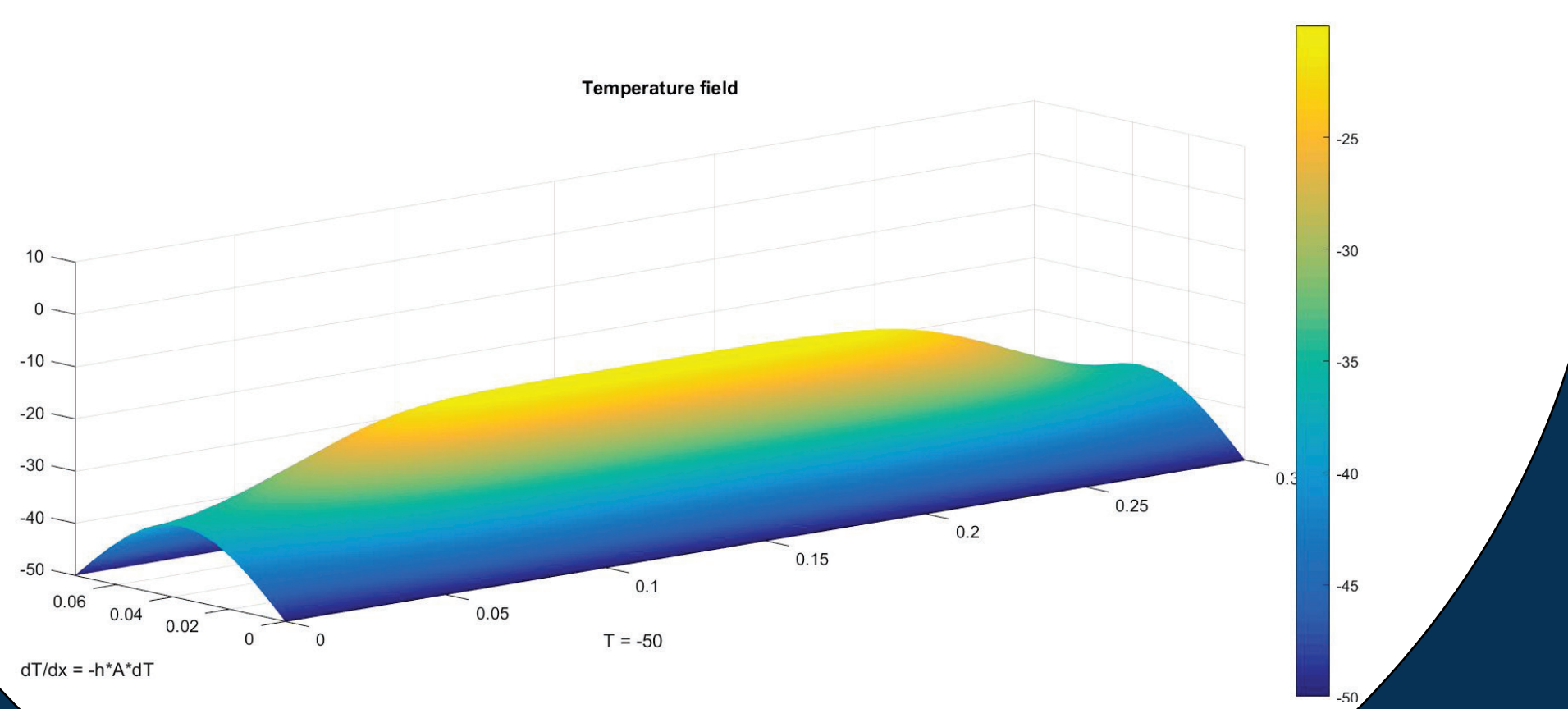


Figure: Temperature in cod with core temperature at -20C

Conclusion

- Lowering evaporation temperature reduces freezing time by 25%, but energy efficiency is equally reduced!
 - Which means equal energy use per batch, but increases capacity for lower evaporative temperature.
- Thickness linearly increases freezing time
- Fish species can be important

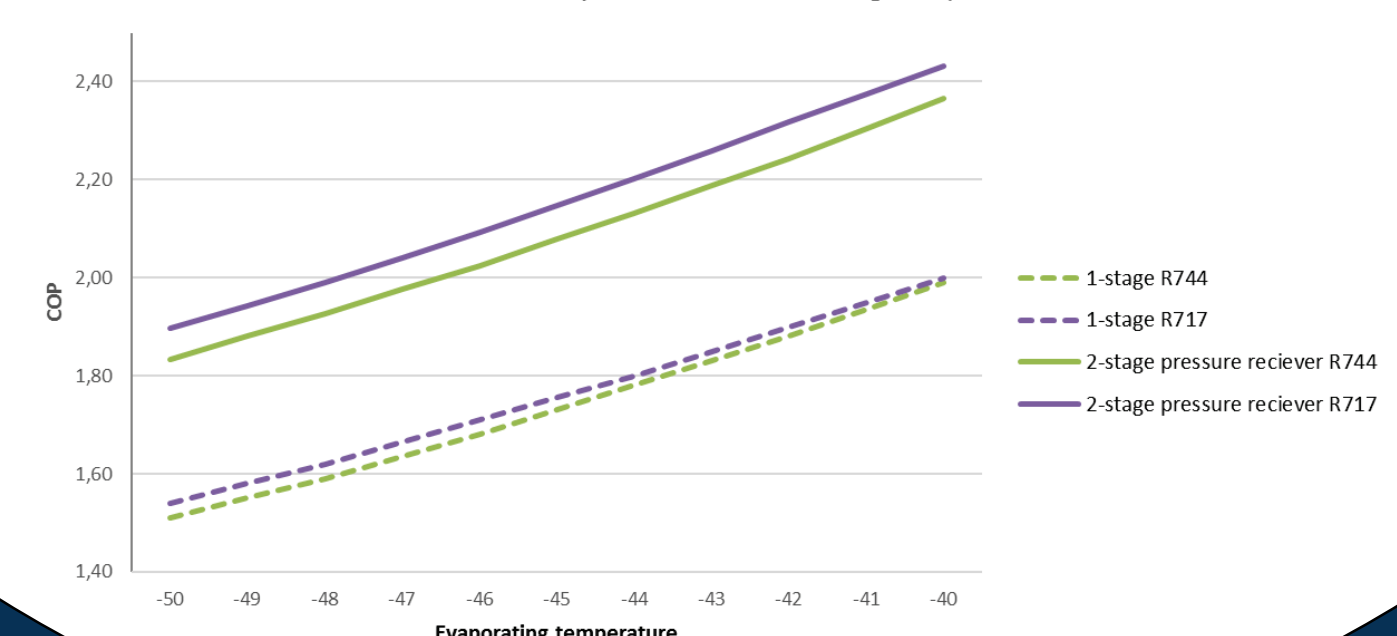
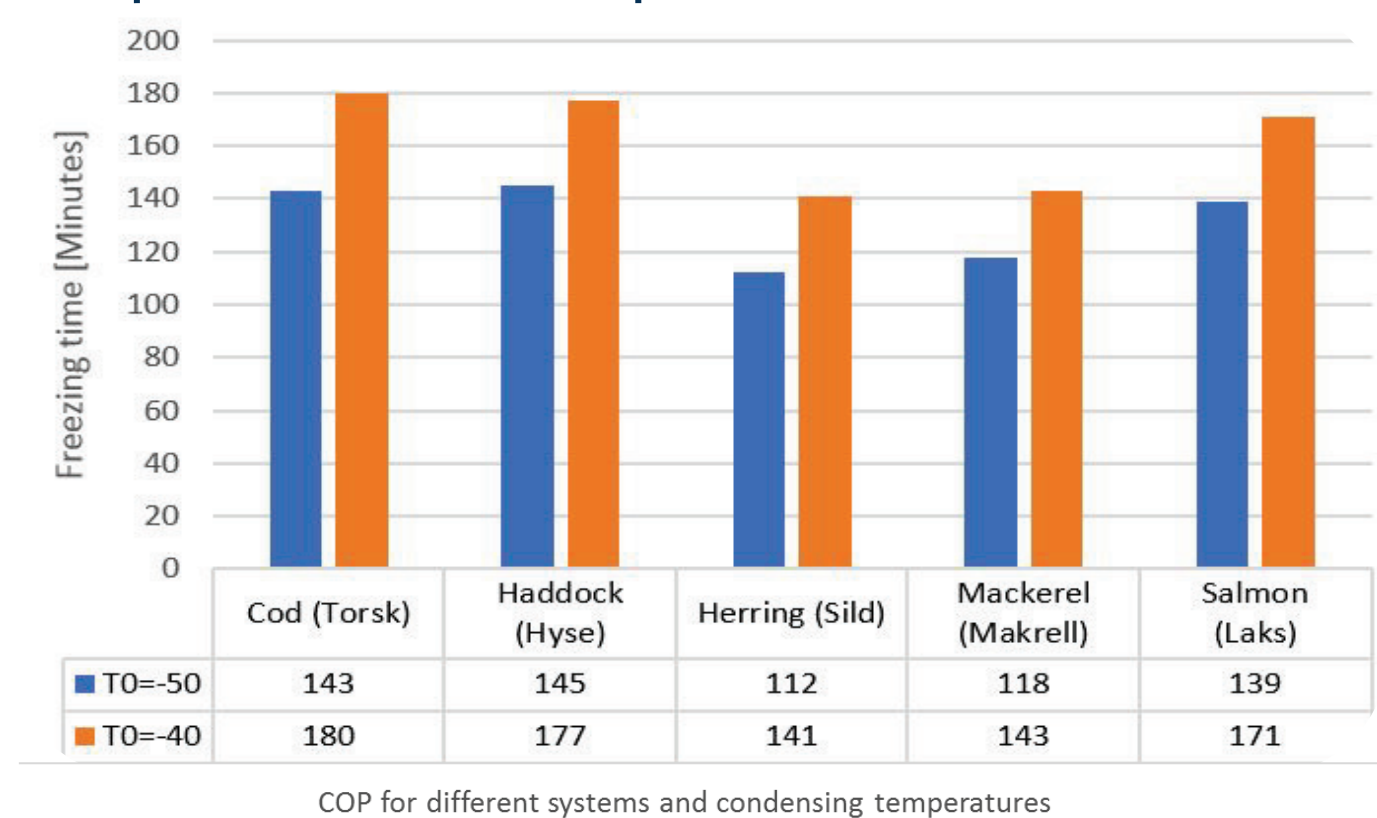


Figure: COP for different systems ($\eta_{is} = 0.65$ for R717 and $\eta_{is} = 0.71$ for R744)

System solution

CO2 as working fluid

- + Compact systems
- + High efficiency
- + Lower evaporating temperature
- + Natural refrigerant
- High operating pressure
- High cost
- 2-stage has higher efficiency, but also higher cost
 - Beneficial when using ammonia because of high pressure ratio and high discharge temperature
- Calculate COP for different systems and refrigerants using Excel

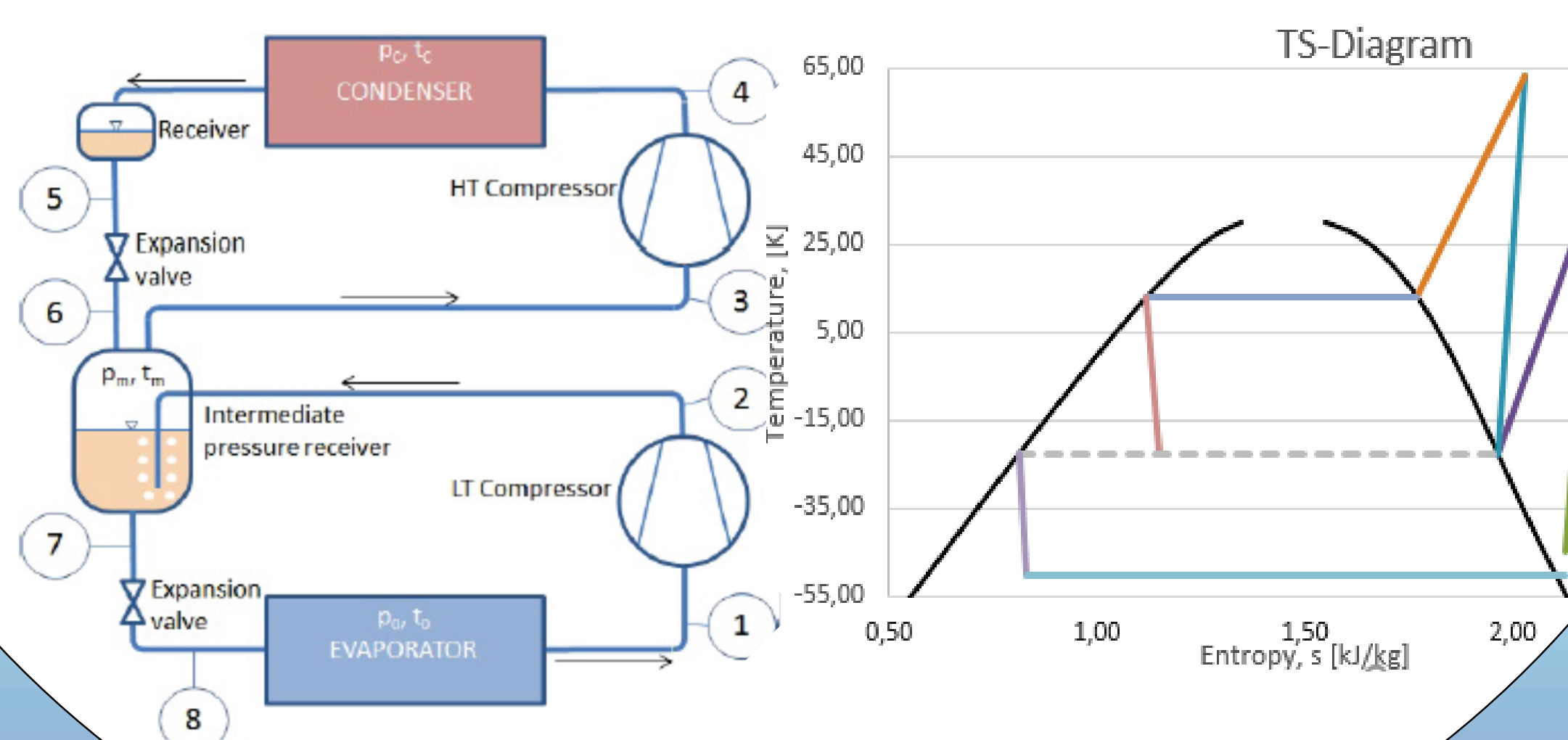


Figure: A 2-stage system and its corresponding TS-diagram for CO2

What more can be done?

- More accurate model
- Implement pressure drop
- Implement freezing point depression
- Assessing economical aspects
- Determining control system
- Adiabatic temperature freezing

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