# ATMOsphere Europe 2011

## waste heat recovery of a transcritical $CO_2$ system with adsorption technology

11.10.2011

Raphael Gerber

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- Adsorption technology
- Combining two technologies
- Efficiency analysis
- Barriers & solutions
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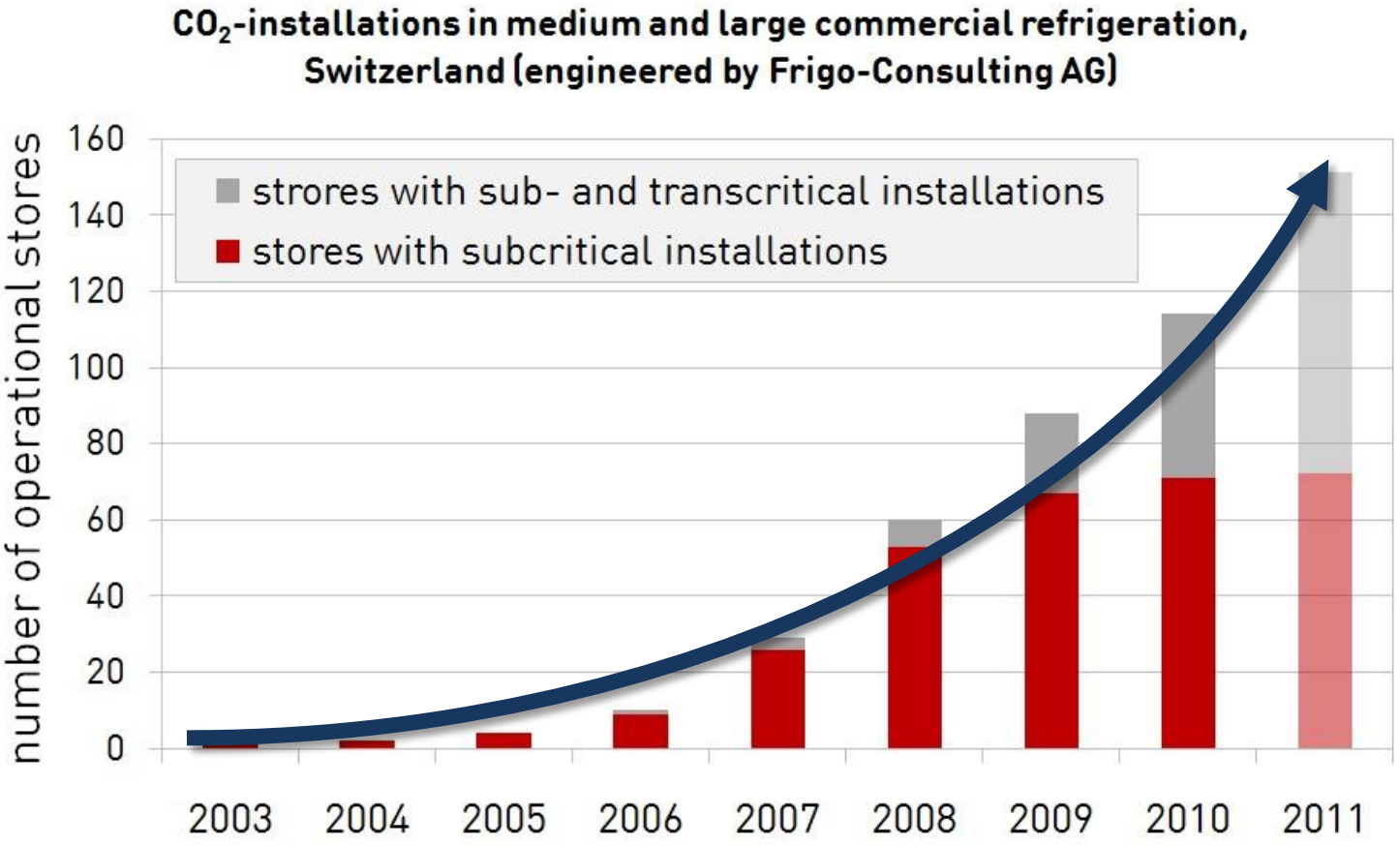
- Summary

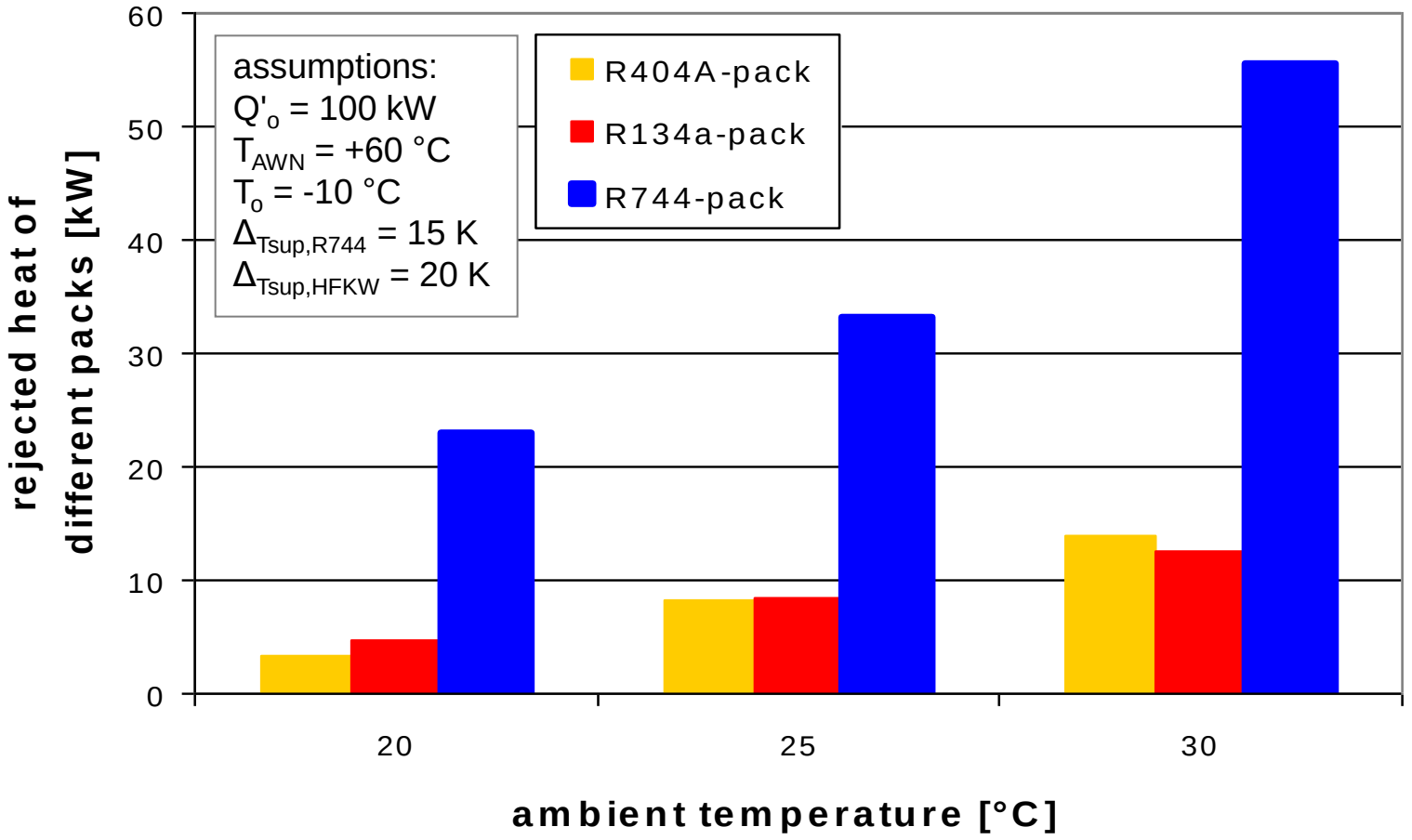
# $CO_2$ commercial references





# Useful rejected heat of different packs

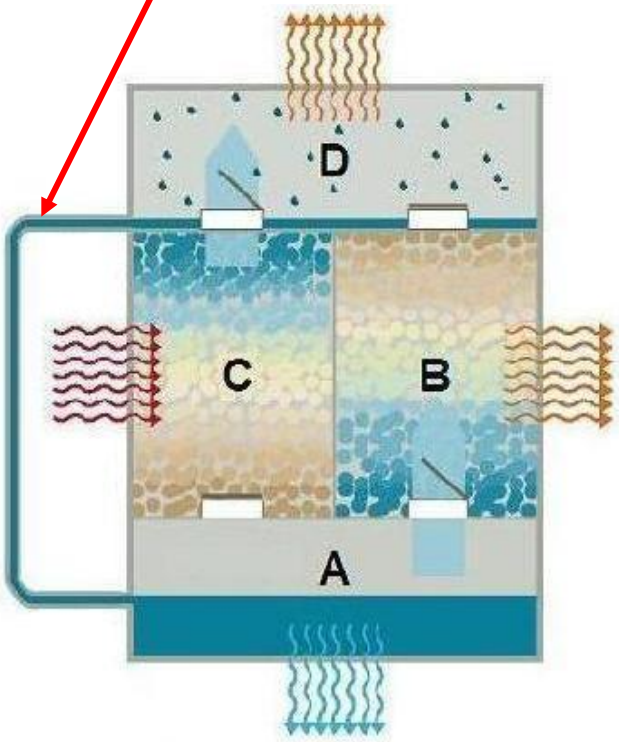




# adsorption technology



## Water as natural refrigerant




**A:** $H_2O$ evaporates and rises into chamber B

**B:** $H_2O$ deposes on the surface of the silica gel and heat is rejected (dry cooler)

**C:** (waste) heat drives out $H_2O$ in chamber C, which rises to chamber D

**D:** $H_2O$ condensates and heat is rejected to the dry cooler

**E:** The function of chamber B and C is switched periodically

# Place of installation



- Prodega St-Blaise, Switzerland
- Cash & Carry Market
- Medium temperature refrigerated area: 400 $m^2$
- Total refrigerated area: 1’150 $m^2$
- Transcritical $CO_2$-pack
  - cooling capacity: 86 kW
  - evaporation temperature: -10 °C

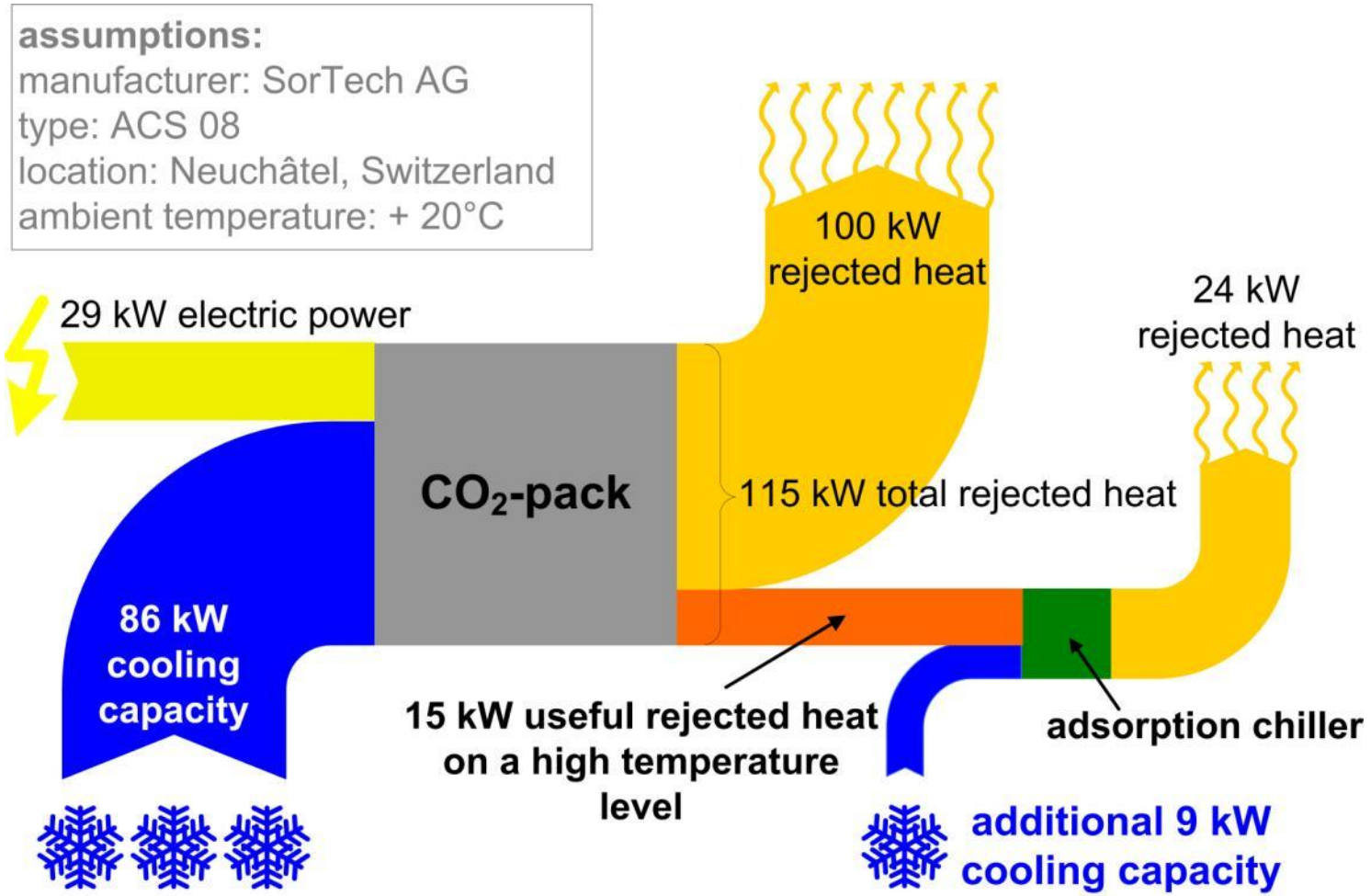
# Place of installation



- Prodega St-Blaise, Switzerland
- Cash & Carry Market
- Medium temperature refrigerated area: 400 $m^2$

# Energy flow




assumptions:
manufacturer: SorTech AG
type: ACS 08
location: Neuchâtel, Switzerland
ambient temperature: + 20°C
100 kW
rejected heat
24 kW
rejected heat
29 kW electric power
CO2-pack
115 kW total rejected heat
86 kW
cooling
capacity
15 kW useful rejected heat
on a high temperature
level
adsorption chiller
additional 9 kW
cooling capacity

# Potential application for cooling energy



**10‘000 kWh**

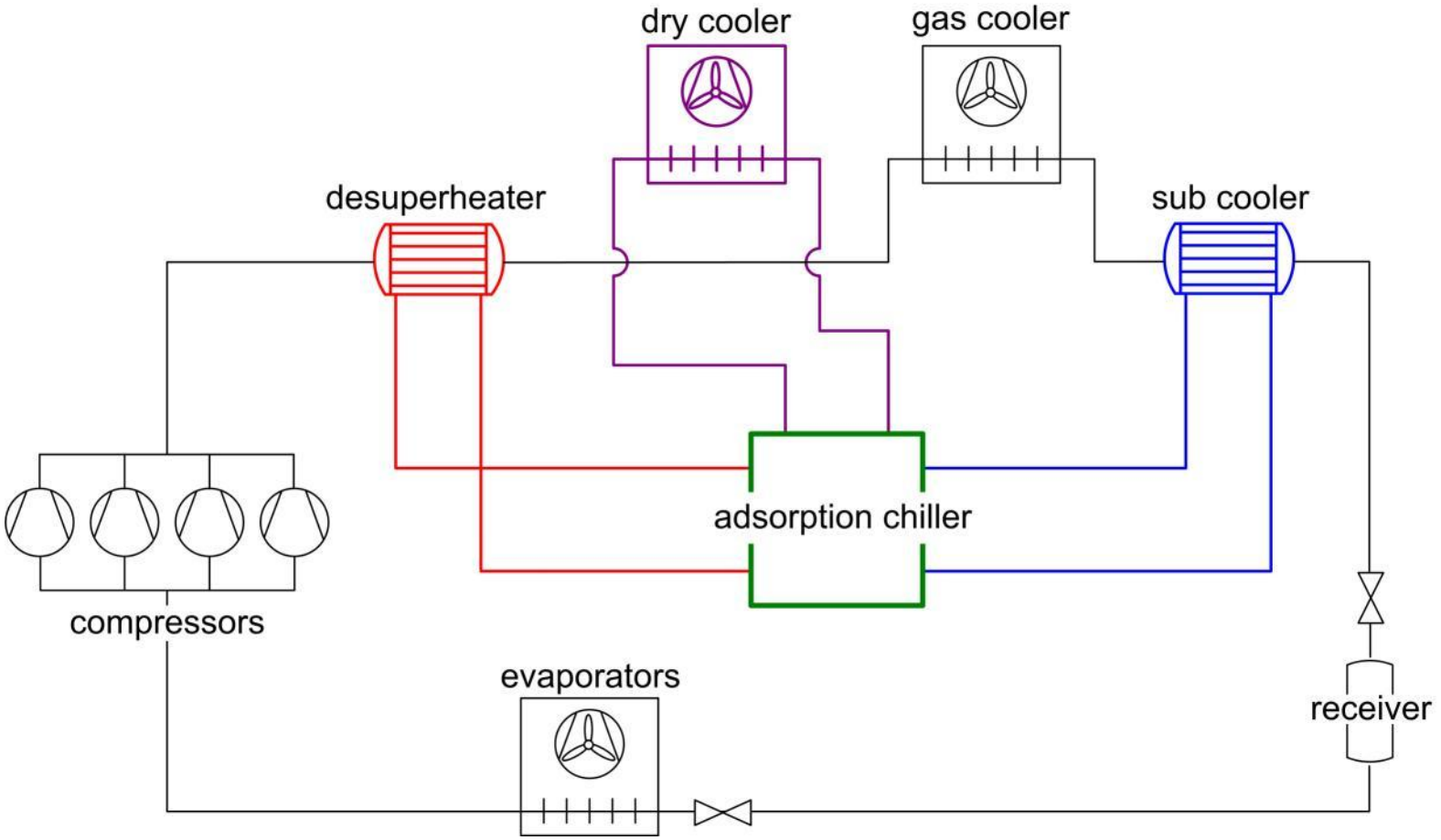
**cooling energy per year**

**assumptions:**
manufacturer: SorTech AG
type: ACS 08
location: Neuchatel, Switzerland
temperature range: $T_{amb,min}$ = +14°C
$T_{amb,max}$ = +34°C

- air conditioning
  - ➔ support air conditioning
- sub cool $CO_2$-pack
  - ➔ support $CO_2$-refrigeration-system
  - ➔ process optimization of $CO_2$-refregeration-system

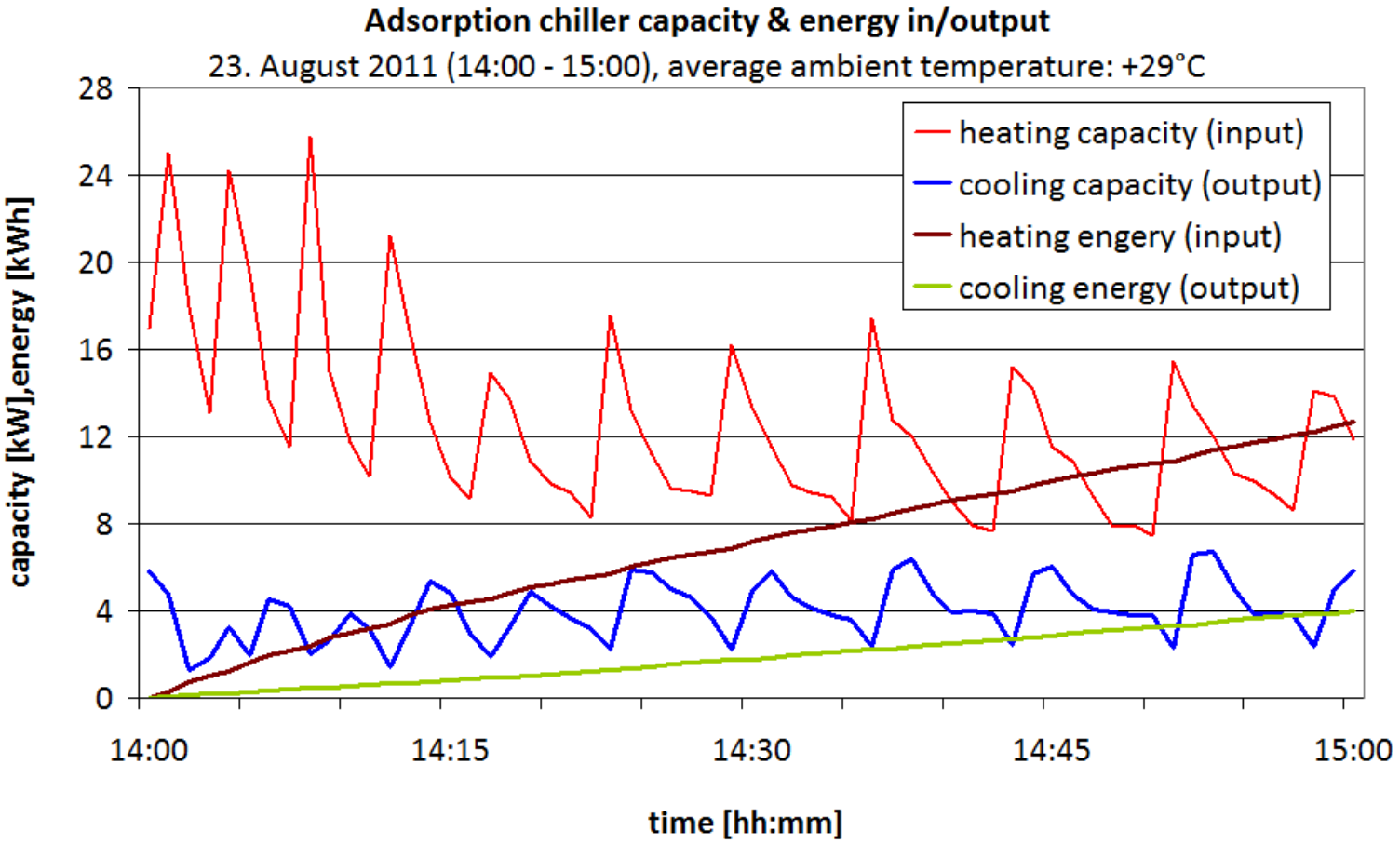
# Integration of adsorption chiller





# Efficiency analysis of refrigeration system





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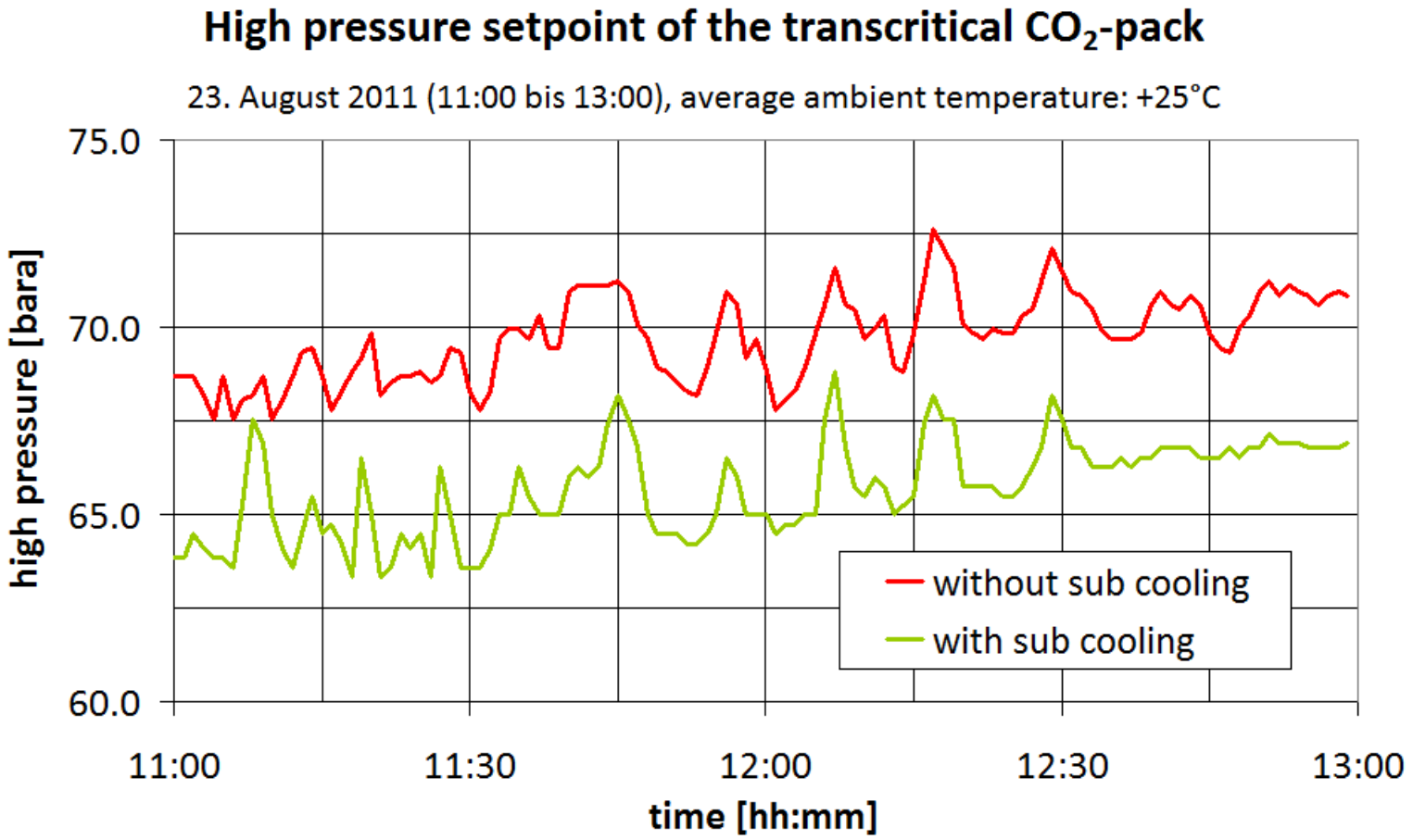
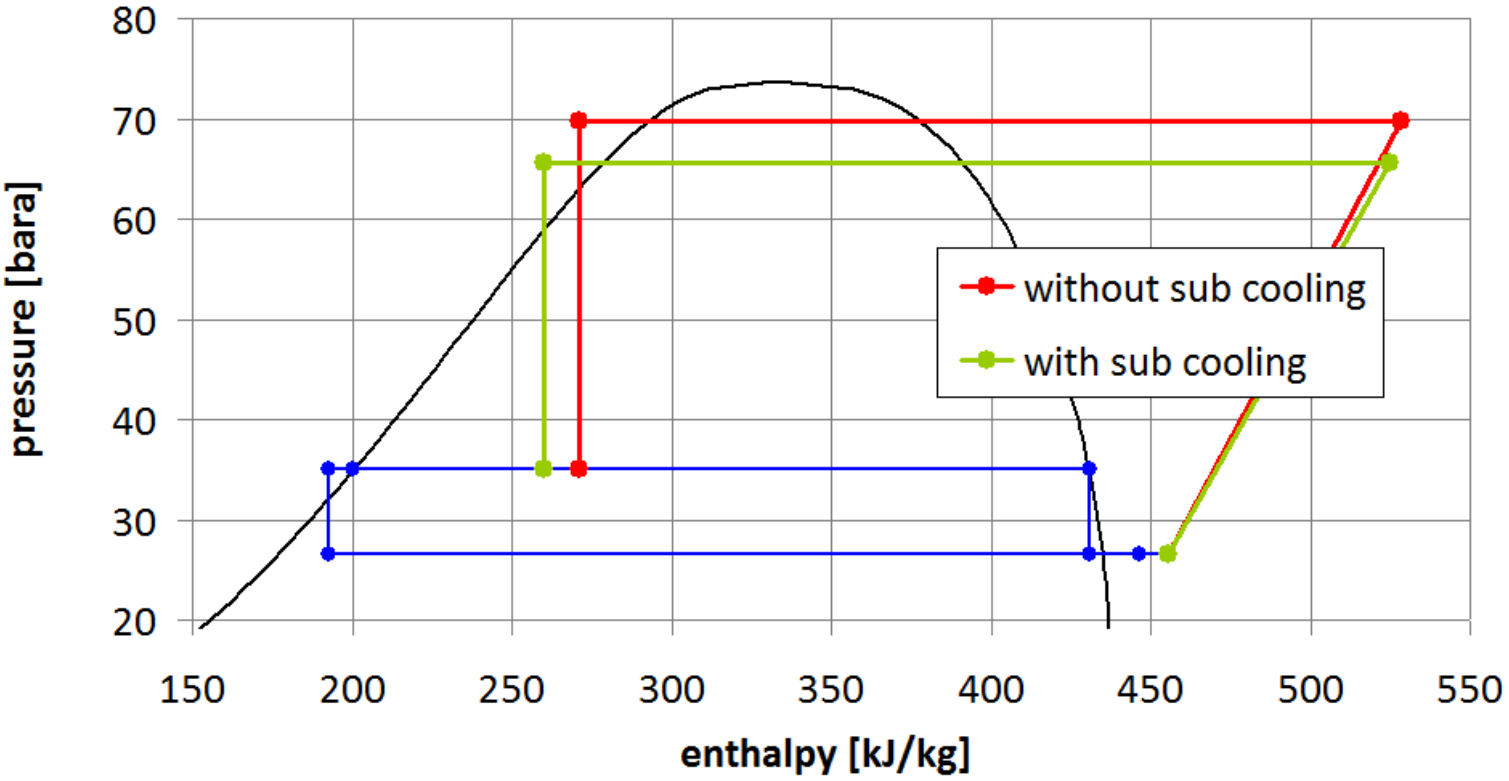


# Efficiency analysis of refrigeration system



**Prozess of transcritical CO2-pack plotted in p-h-diagramm**

23. August 2011 (11:00 bis 13:00), average ambient temperature: +25°C



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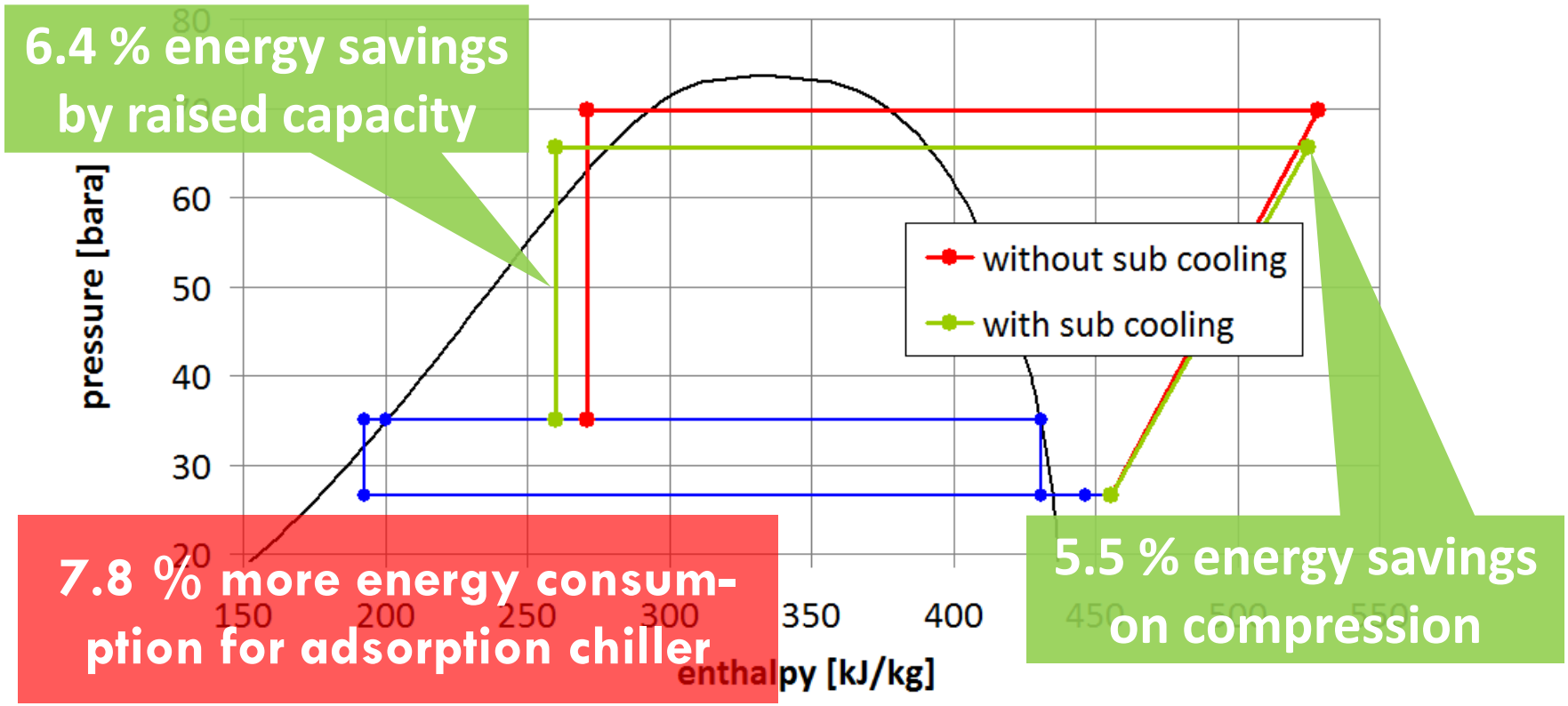

# Barriers and solutions



- finding good parameters for varying operating conditions is crucial
- defective valve flap of adsorption chiller needed repair

# Lessons learned



- The adsorption chiller is not used to capacity due to lower waste heat available
  - lower workloads of $CO_2$-pack than assumed
  - system can be further optimized by increasing available waste heat
- Special attention needs to be put on system dynamics
- Initial evaluations indicate that the cold storage is not absolutely necessary and thereby cost can be reduced

# Further applications



- Support cold vapor process with:
  - high amounts of waste heat
  - on a high temperature level
  - especially in warm climates
- Particularly for systems with the refrigerants:
  - R744 ($CO_2$)
  - R717 ($NH_3$)
- Air conditioning by waste heat

# Partners



**engineering**

FRIGO CONSULTING AG
Competence in $CO_2$
INGENIEURBÜRO FÜR KÄLTETECHNIK
WWW.FRIGOCONSULTING.CH

**by order of**

TRANSGOURMET

cash+carry prodega

**implementation**

SorTech AG

ALPIQ

# Summary



- The adsorption technology is an option to optimize the overall efficiency of transcritical $CO_2$-systems bases on standard components.
- Further analysis and optimization will allow higher efficiencies of future systems.
- Only natural refrigerants are used: $CO_2$ and water.

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