ENGINEERING TOMORROW

Energibesparelser i industrielle ammoniakkøleanlæg

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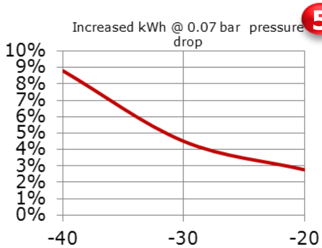
Energieffektivisering i industrien – Temadag - DTI

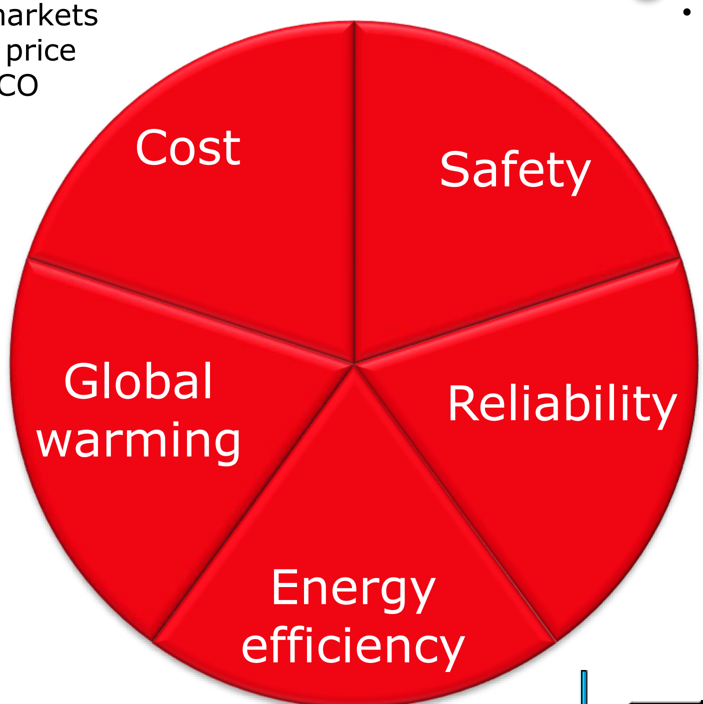
Industrial Refrigeration

Industry Drivers



5 Cost

- primary growth in emerging markets with higher price pressure, TCO awareness



1 Safety

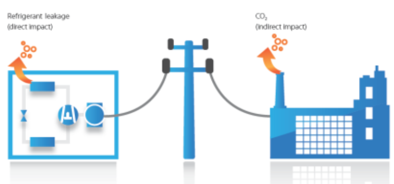
- products and system design

2 Reliability

- Automatic running

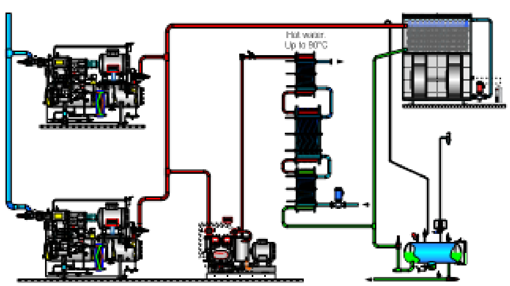
4 Global warming

- refrigerants focus, plays along with NH3 and CO2



3 Energy efficiency

- new and retrofit systems
- Industriel heat pumps



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Ammonia

Industrial Refrigeration - Refrigerants

Ammonia Facts

- Natural refrigerant
- GWP=0
- ODP=0
- Environmentally friendly
- **High efficiency**
- Low Cost
- Widely available
- Self-alarming – by odour

Ammonia is the natural choice

- Ammonia is the dominant refrigerant in industrial systems.
- Specific design requirements needed, do to ammonia's classification as toxic and flammable fluid.

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Low Charge Ammonia system for cold storage

Mitigating risks

New innovative and compact ammonia system design opens the door for new applications

- No need for an engine room
- Roof-top based design
- "VLC" very low NH3 charge
- **Claimed to have up to 98% less ammonia than regular systems** (lowest charge < 100 g / kW)
- Fully automated, self-contained NH3 system
- Very fast installation

1

DX-system

2

LPR-system

3

Pump-system

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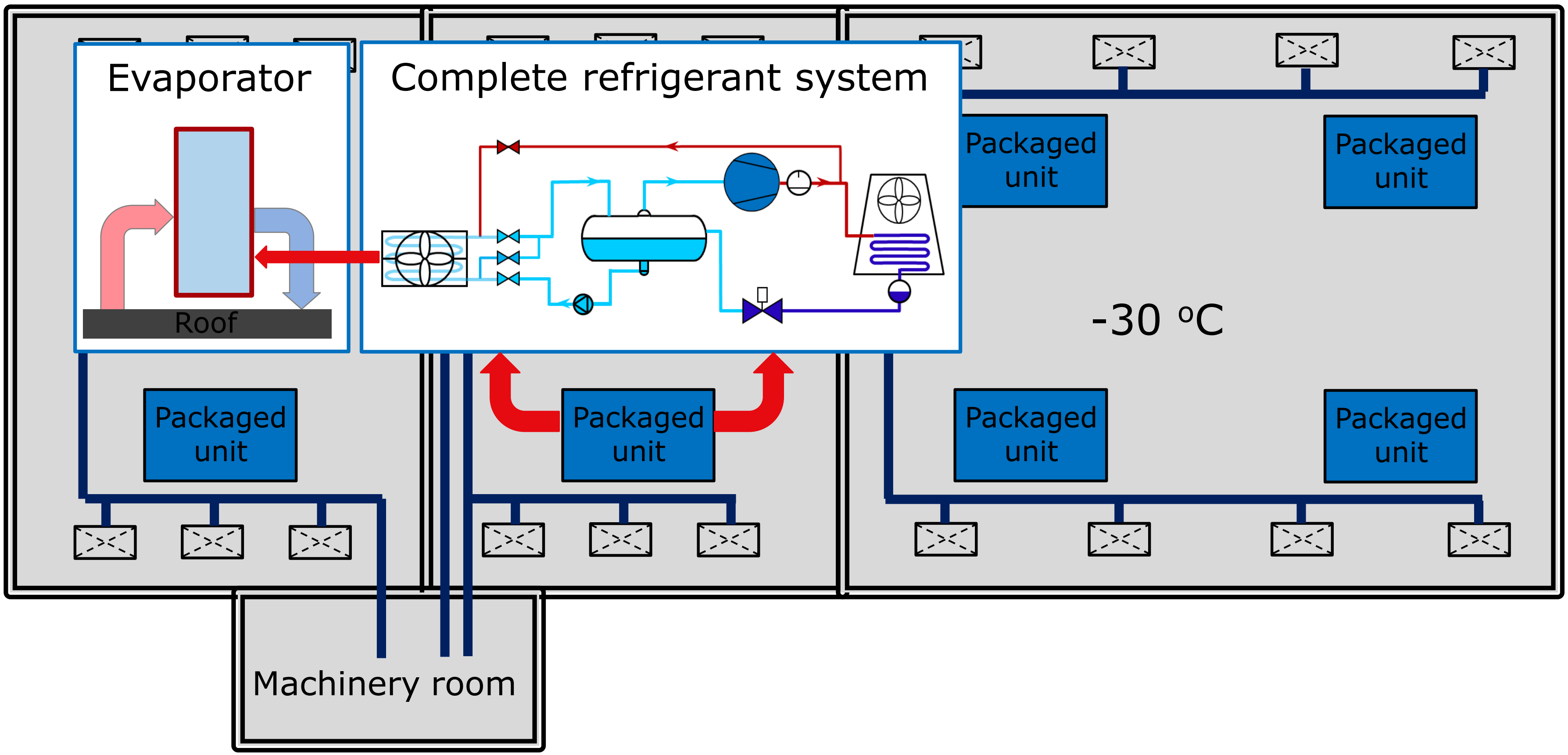
Low charge ammonia system for cold storage

New upcoming trend in the USA - Cold storage with 8 self-contained, packaged units



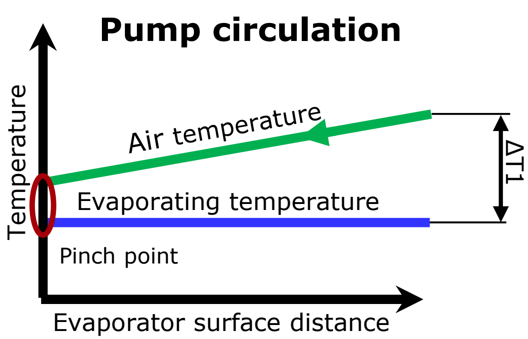
Ammonia low charge systems

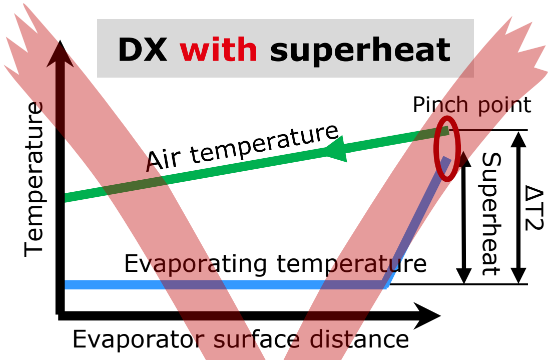
- Ammonia DX

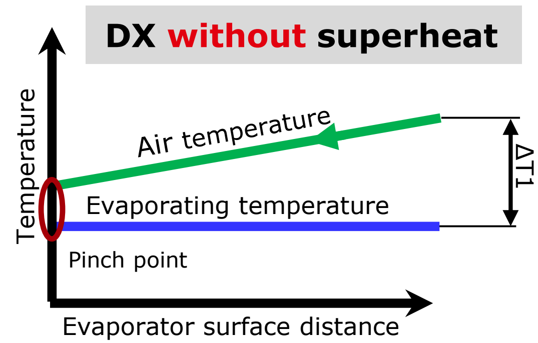
DX in Ammonia low charge systems

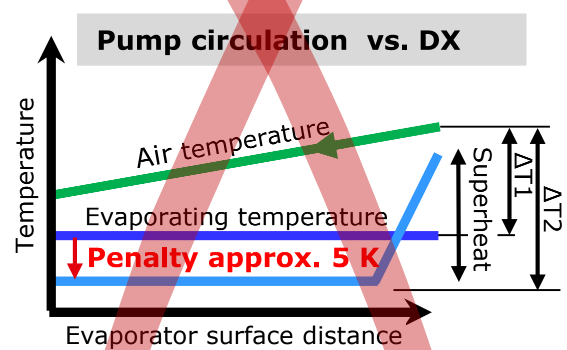
Operation costs of pump circulation vs DX-systems

NEW method







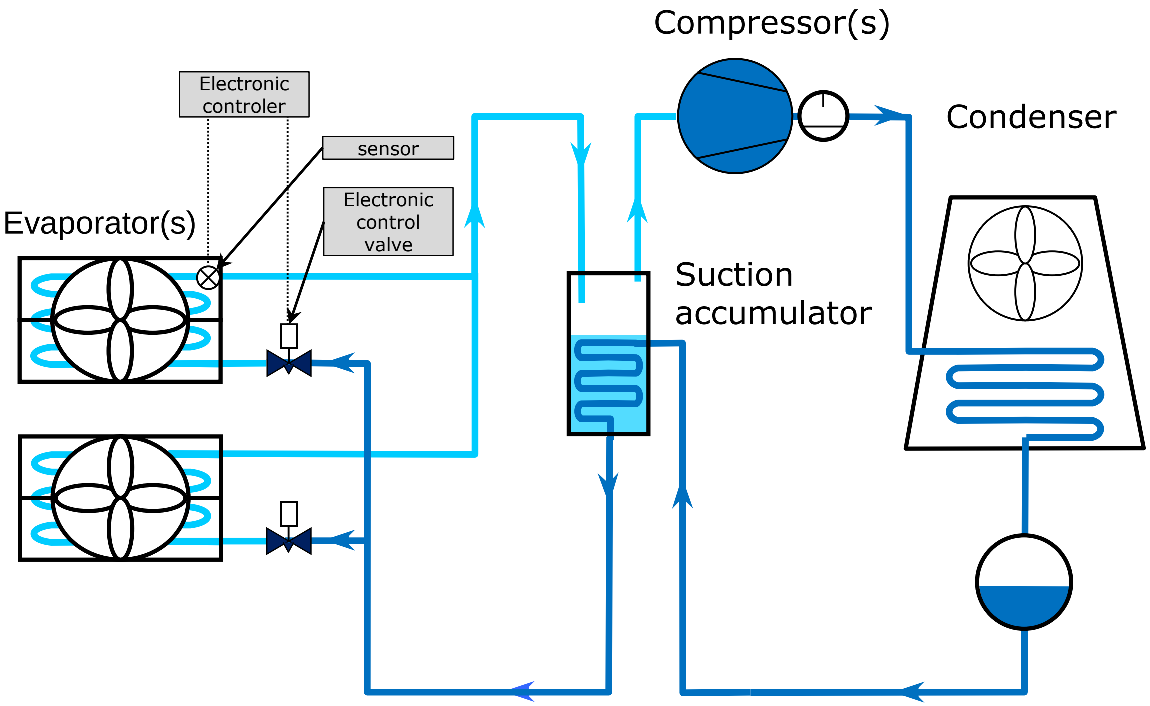


- Reduced evaporating temperature
- Reduced efficiency

5 [K] => ~11,5% increased kWh*)
*(Ammonia @ -30 / +30)

- No superheat
- No reduction in evaporating temperature
- High efficiency

Enhanced Ammonia DX-system suction accumulator

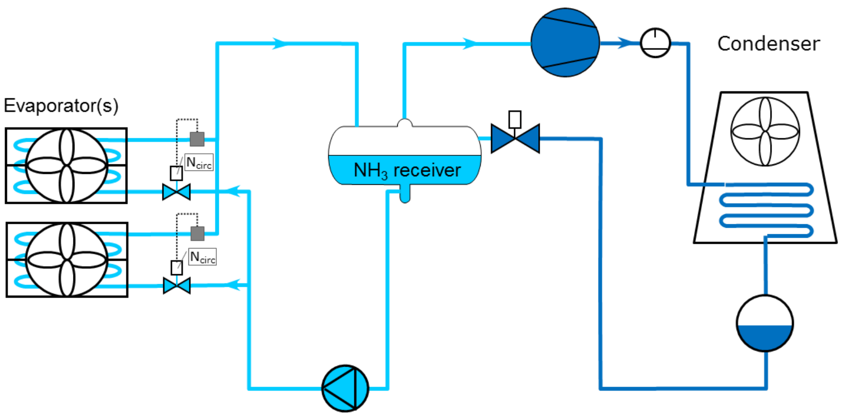


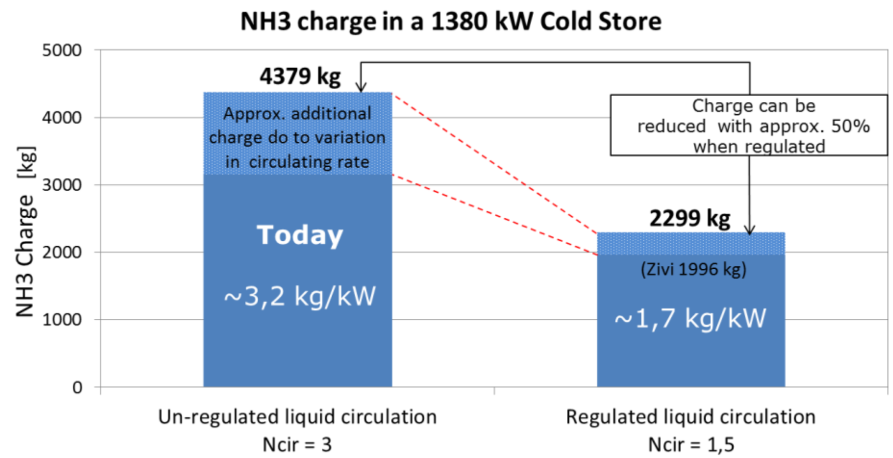
New method, implemented in some prefabricated low charge ammonia units and in a few site-built low charge systems

Ammonia low charge systems

- Ammonia pumped systems with **regulated circulating rate**

Ammonia low charge pump circulating system with regulated circulation rate



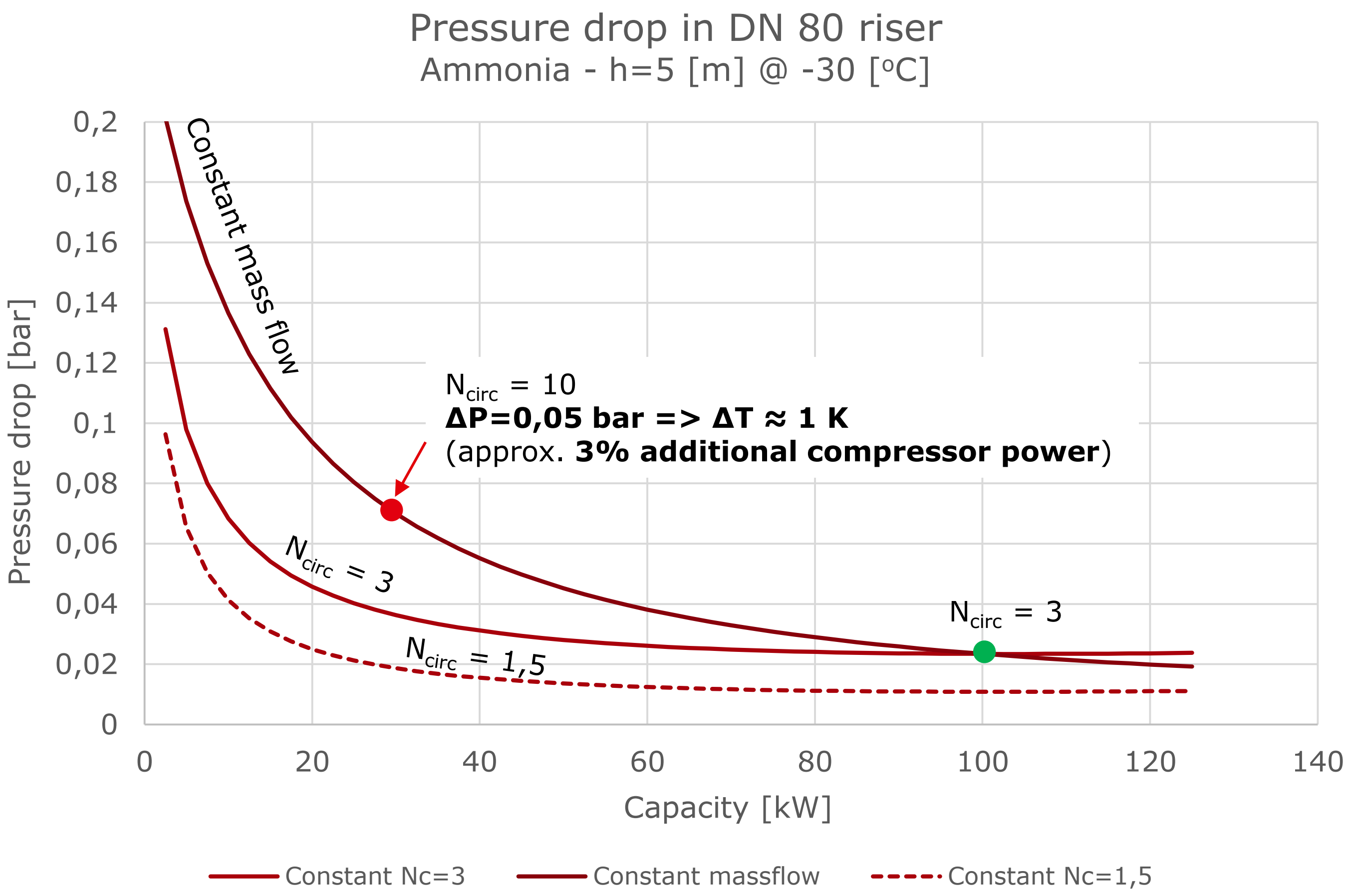


Example based on:
Cold Store: 580 kW freezing @ -35 ºC and 800 kW cooling @ -5 ºC total 1380 kW
14 evaporators @ -35 ºC and 22 evaporators @ -5 °C

New method, tests ongoing

Why regulated circulation rate?

Load variation in ammonia pumped systems
Pressure drop in DN 80 riser



Load variation in ammonia pumped systems
Effect of un-regulated circulation rate

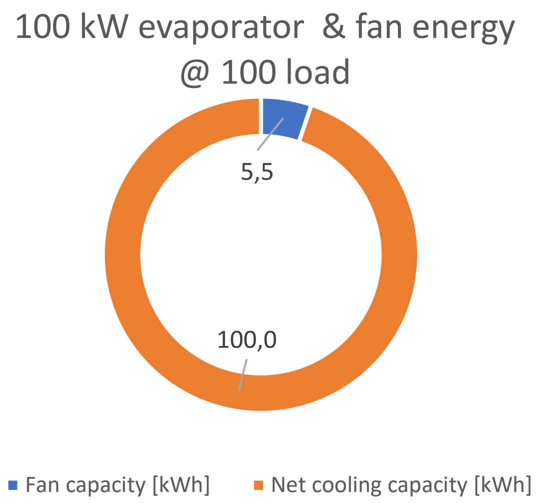
100 kW evaporator & 5 m riser @ -30

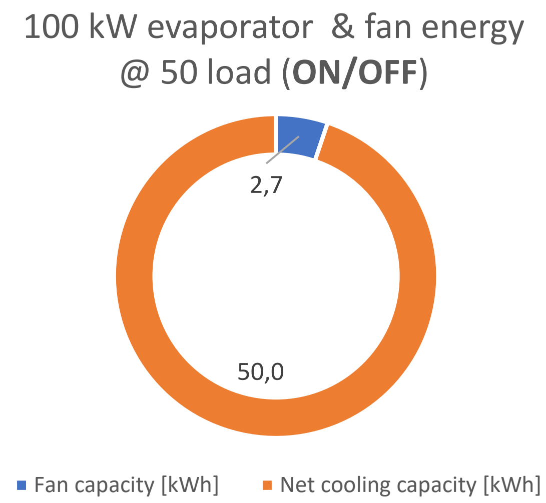
Te = -30 & (DN80)		N=3	N=10	Ratio
M_riser	[kg]	1,0	3,6	3,5
M_evap	[kg]	14,2	32,9	2,3
M_head_in	[kg]	1,7	1,7	1,0
M_head_out	[kg]	0,1	0,4	4,1
Total (header + evap)	[kg]	16,0	35,0	2,2
Total	[kg]	17,0	38,6	2,3
(All liquid (header+evap))	[kg]	123,7		

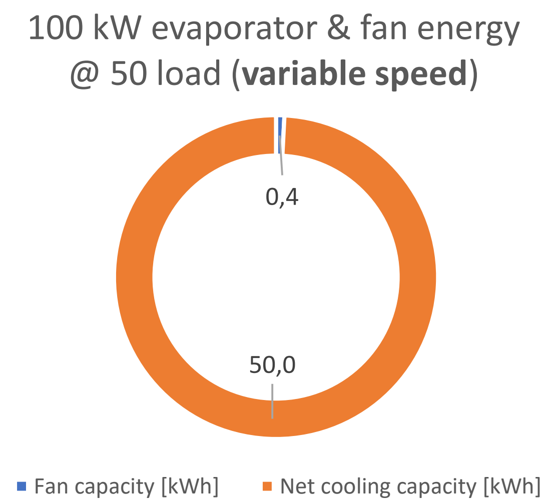
Void correlation:
Zivi (evaporator + header out)
Yashar (riser)

Note: Liquid hold-up in the evaporator + riser is increased from **17 to 38,6 kg**

Speed control of evaporator fans vs ON/OFF



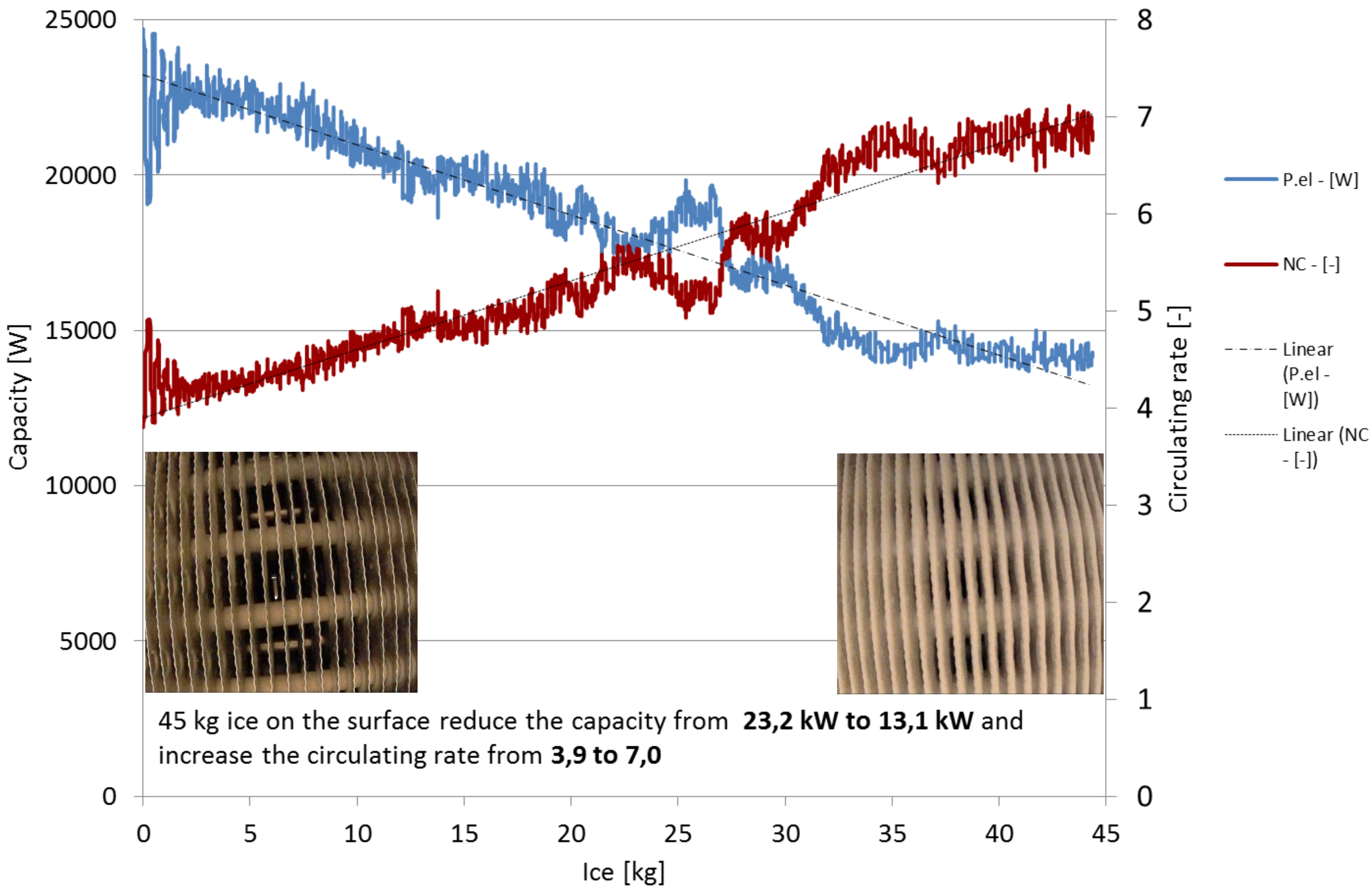




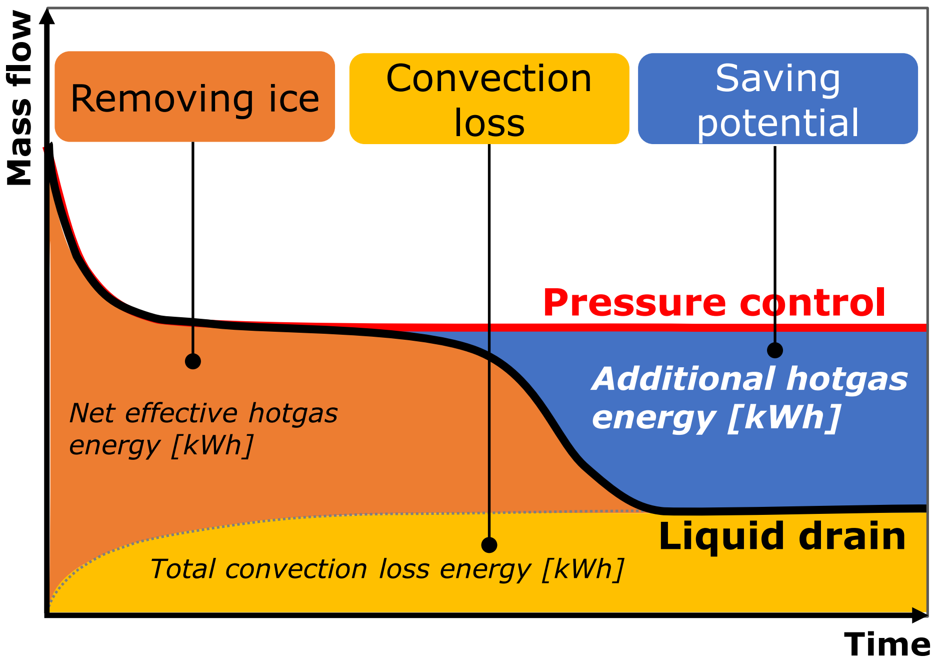
Note:
Speed control of evaporator fans requires ”regulated circulation rate” to efficient

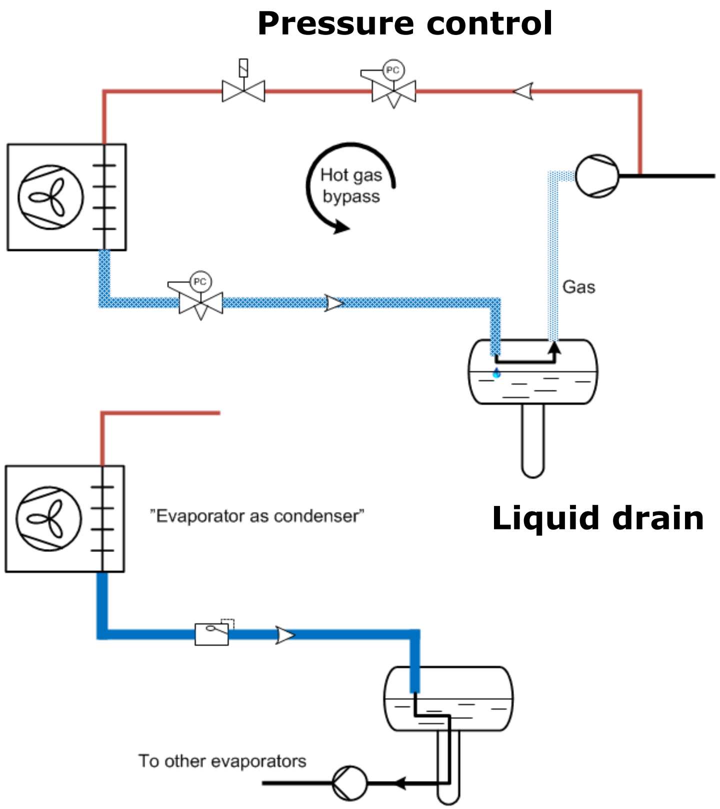
Defrost

Air cooler performance vs. ice build-up on surface



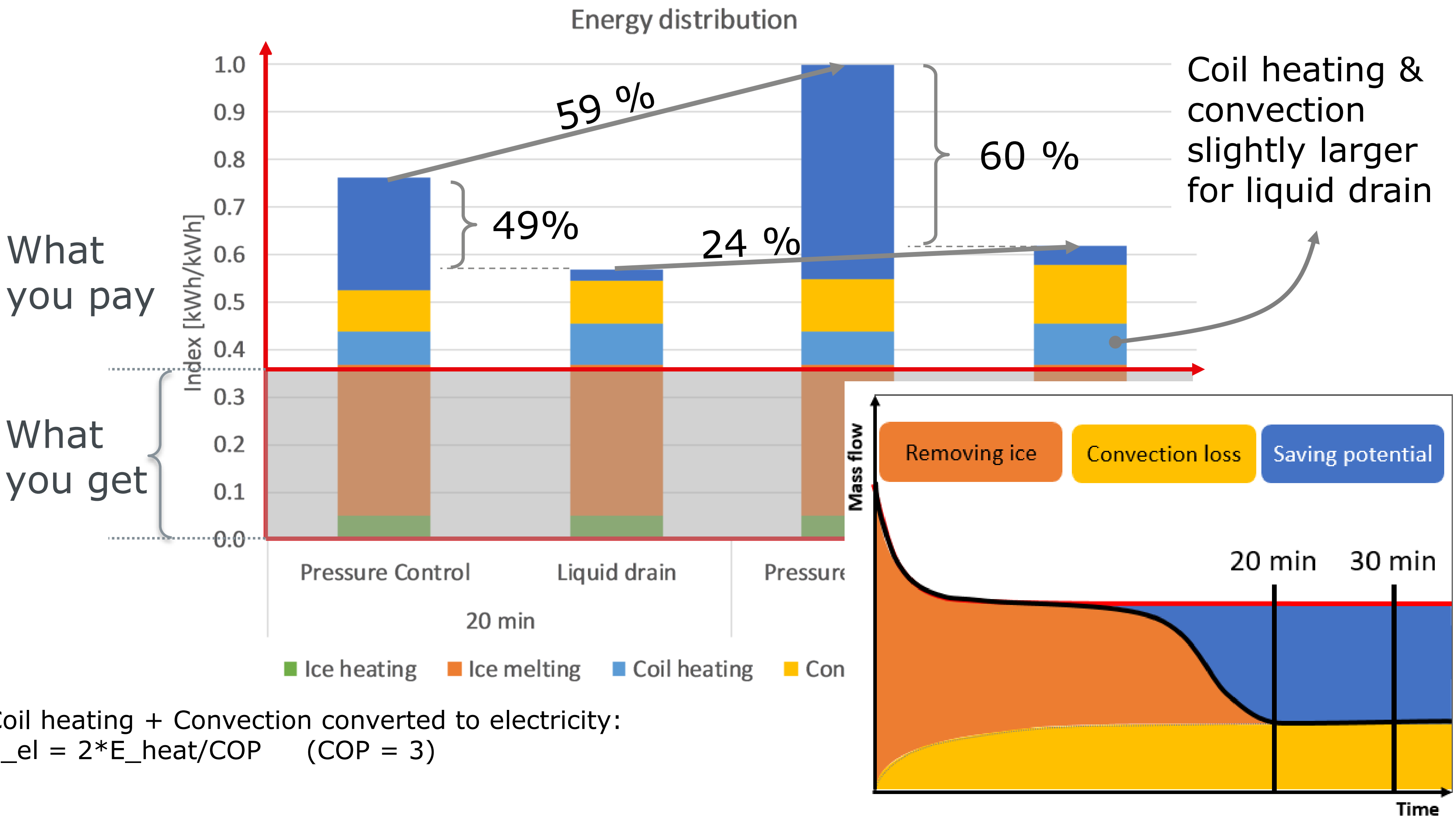
Mass flow
Liquid drain method vs. Pressure control method





Energy distribution

Pressure control: 10 °C (50 °F)
Liquid drain: 15 °C (59 °F)

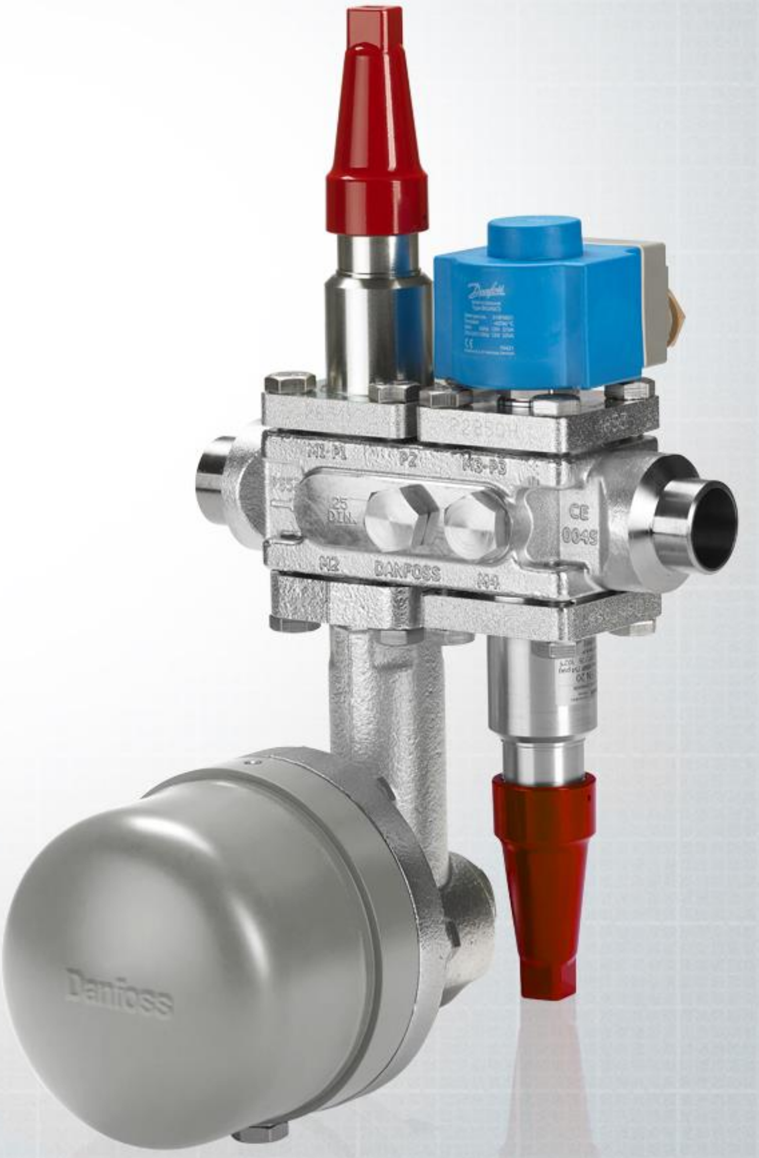


Coil heating + Convection converted to electricity:
E_el = 2*E_heat/COP   (COP = 3)

Our **formula for efficiency:**

The Danfoss ICF Valve Station
+ ICFD Defrost Module
= Superior defrost performance

It is a formula that unites the well-known benefits of the Danfoss ICF technology with the most efficient defrost method known into one state-of-the-art defrost solution for industrial refrigeration applications.



A formula that releases **a state-of-the-art value creation**

Reduced energy consumption

- Reduction of blow-by gas by up to 90%
- Less loading of compressors

Improved job site efficiency

Easy installation due to a reduction in components and weldings plus no need to disassemble and re-assemble

Improved defrost performance

- Reduce hot gas consumption
- Reduce downtime of evaporator when defrosting
- Low liquid storage

Broad application range

- Fully compatible to ICF 15-4, ICF 20-4, and ICF 20-6
- Several ICF variants available to fit specific system design and needs
- Wide application range spanning evaporators up to 200kW (58 TR) evaporator capacity

Easy system design

Support optimal system design with the Coolselector®2 application tool

Estimating savings – simplified method:

$$Savings\left[\frac{kWh}{defrost}\right] \approx \frac{\dot{Q}_{e,\dim}[kW]}{COP} \cdot \tau_{defrost}[h]$$

$$COP \approx 2.5 \ at \ Te = -25°C \ and \ Tc = 30°C$$

Location	Measured Savings [kWh/defrost]	Estimated savings [kWh/defrost]
Bring	20.0	22.0
DTI	5.0	5.1
Reitan	12.6	10.7

- Example calculation, Bring:

$$Savings \approx \frac{66\,kW}{2.5} \cdot \frac{50\,\text{min}}{60\,\text{min}/h} = 22.0\,{kWh}/{defrost}$$

Controls

Conclusions

- The industrial refrigeration industry has been using ammonia for more than 100 years. Experience shows that ammonia has been and still is the one of the most effective refrigerants due its unique properties.

Today's challenges:

- Ammonia is still the preferred refrigerant for industrial applications, however safety is a topic that has to be treated professionally.
- Low charge ammonia systems is an obvious solution for mitigating the risk. "low charge" is the name of the game for new ammonia systems, in paticular in the US market.
- high effeciency solutions need to be implemented where it can reduce the total cost of ownership
- Realiable solutions is an must

Questions

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