IT-Kühlung-Lösung

“Moin Moin”

worum geht es überhaupt ?

ESO 9802 ASF
18/12 – AT35°C

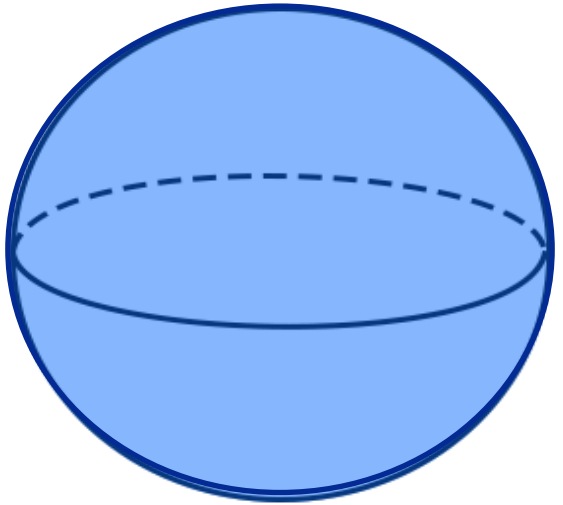
Q_0 = 1.000 kW (962 kW)
EER 3,89
100% FC = AT 2°C

Luft

V = 352.000 m³/h
Fans 16*1,67 kW

Ball – ø 87m

A380
Spannweite – 79,30 m
Länge – 72,30 m



worum geht es überhaupt ?

ESO 9802 ASF
18/12 – AT35°C

Q_0 = 1.000 kW (962 kW)
EER 3,89
100% FC = AT 2°C

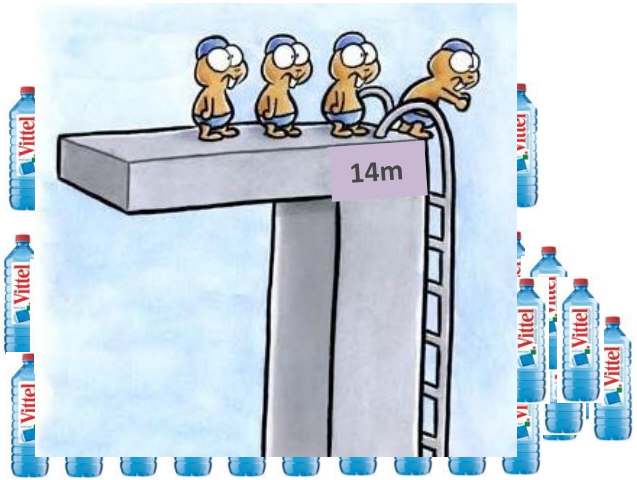
Wasser

V = ~ 150 m³/h
Δp = 138 kPa

Pumpe – 7,5 kW

138 kPa = x 150.000

pool 10 x 10 x 1,5m



10

150.000

worum geht es überhaupt ?

ESO 9802 ASF
18/12 – AT35°C

Q_0 = 1.000 kW (962 kW)
EER 3,89
100% FC = AT 2°C

Strom

P-el = 247,5 kW

kW – thermal = °C

CO_2 = ~127 kg/h

V8 = ~ 337 HP

kW – mechanical = km/h

CO_2 = ~ 0,2 kg/km

worum geht es überhaupt ?

ESO 9802 ASF
18/12 – AT35°C

Q_0 = 1.000 kW (962 kW)
EER 3,89
100% FC = AT 2°C

Kältemittel

T_C = 49,3°C
T_{HG} = 65,0 °C
T_0 = 9,8°C

m = 2 x 12.222 kg/h

temperature level = ~ 65°C

velocity = ~ 25 m/s = ~ 90 km/h

chiller basics - point of reference

A 35°C

chilled water

B 18°C inlet / entering

C 12°C outlet / leaving

D 700 kW

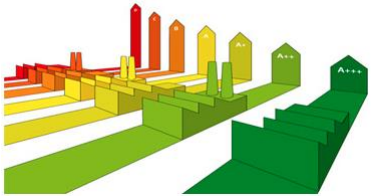
E 8.760 h/a

F DX - MIX - FC

G < OPEX

CHW – L = const !

chiller basics - what is energy efficiency



energy efficiency = the goal to reduce the amount of energy to provide required products and services !

EER = $\frac{Q_0}{P\text{-el}}$

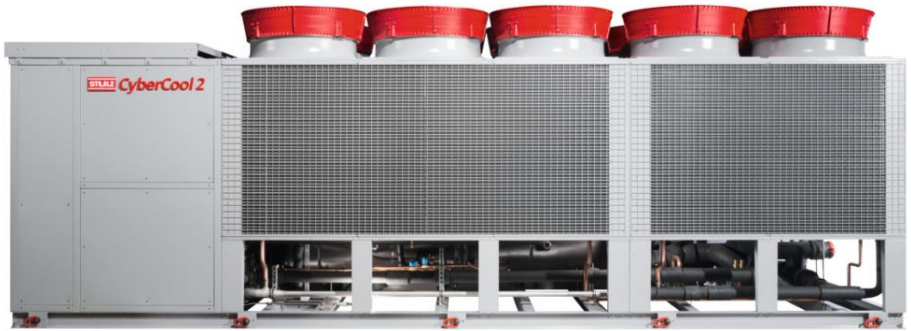
Q_0

700 kW

P-el

cmprs - fans - pumps

chiller basics – fluids in motion



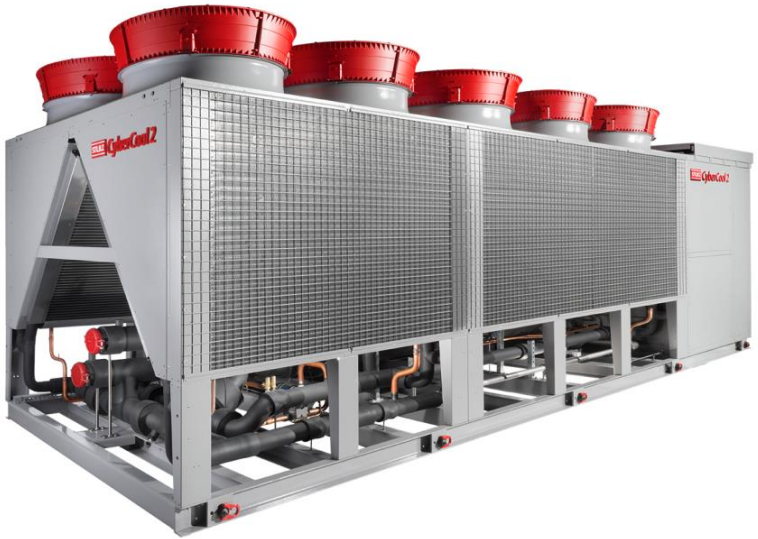
fluids

- air fans = 8.760 h/a
- water pumps = 8.760 h/a
- refrigerant cmpr < 8.760 h/a

operation modes

- DX
- MIX
- FC

CyberCool 2



Glycol / Non-Glycol
Netzwerk Kälteeffizienz
30.09.2015

Chiller Team

Agenda

- Glycol / Non-Glycol
  - CHW - System Design p/s
  - Beispiel Rechenzentrum
  - CRAH / CRAC
  - Glykol Faktor (Chiller / Pumpe)
  - System Design G / NG
  - System Operational
  - Facts & Figures
  - Fazit

CHW System Design p/s

Primärkreislauf/ Chiller | Sekundärkreislauf / CRAH

erzeugt Kaltwasser | verbraucht Kaltwasser

18°C

12°C

8.760 h/a

12°C

CHW System Design p/s

Was zirkuliert?

18°C

12°C

EG 30 EG 0

A EG 30 < EG 0

B EG 30 > EG 0

Chiller Design Glycol / Non-Glycol

		Glycol	Non - Glycol
FC – Register		Glycol	Glycol
DX – Verdampfer		Glycol	Wasser

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System Design Parameter

Chiller / primär

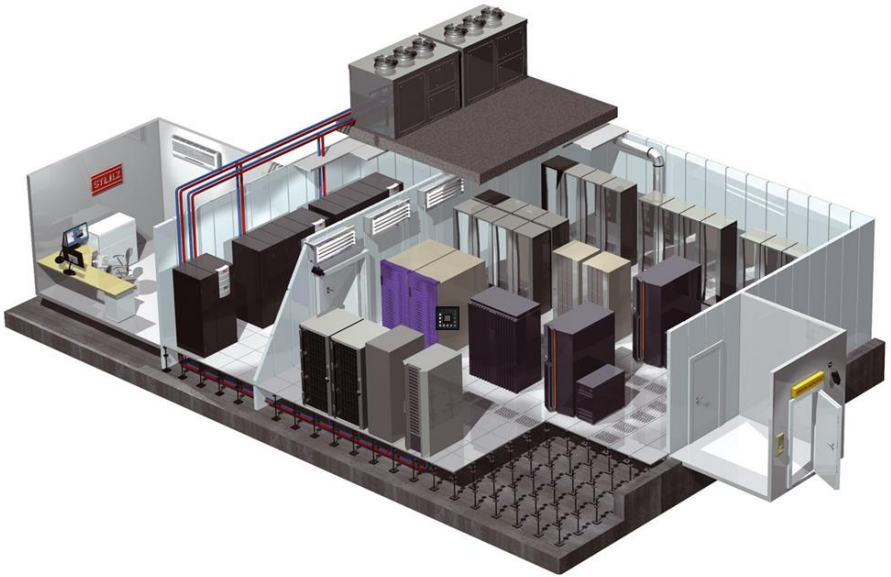
- Kühllast 700 kW
- CHW temp. 18 / 12°C
- AT 35°C

CRAH / sekundär

- Raum Bedingungen 28°C / 40% r.H.

Annahme

- scenario A: CHW-Media / EG0
- scenario B: CHW-Media / EG30



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CRAH

Unit	Scenario A - EG0	Scenario B - EG30
Unit type:	ASD 1000 CW	ASD 1000 CW
Cooling capacity (total):	79,8 kW	71,8 kW
Cooling capacity (sensible):	79,8 kW	71,8 kW
Net total cooling capacity:	76,2 kW	68,2 kW
Net sensible cooling capacity:	76,2 kW	68,2 kW
Air (Data per unit)		
Airflow:	20.000 m³/h	20.000 m³/h
Return air temperature:	28 °C	28 °C
Return air humidity:	40 rel. %	40 rel. %
Hydraulics (Data per unit)		
Medium inlet temperature:	12,0 °C	12,0 °C
Medium outlet temperature:	18,0 °C	18,0 °C
Medium volume flow:	11,4 m³/h	11,1 m³/h
Percentage of glycol:	0 %	30 %

Einfluss Glykol/ EG0 – EG30

- Kälteleistung: ca. - 10%
- Volumenstrom: ca. - 5%

Agenda

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Glycol Faktor (Chiller Volumenstrom)

Chiller / primär

- Kälteleistung 700 kW
- CHW temp. 18 / 12°C
- c – EG0 4,2 kJ/(kg K)
- c – EG30 3,8 kJ/(kg K)

$$\mathbf{Q = m * c * \Delta T} \qquad Q = \frac{m^3}{s} * \frac{kJ}{kg * K} * K = W$$

Annahme

- Scenario A: approx. 100 m³/h (EG0)
- Scenario B: approx. 110 m³/h (EG30)

Einfluss Glykol/ EG0 – EG30

- Volumenstrom: approx. + 10%

Glycol Faktor (CHW Pumpe)

Chiller / primär

- Kälteleistung 700 kW
- Druckverluste 150 kPa (EG0); 170 kPa (EG30)
- Effizienz Pumpe 0,7
- Scenario A: approx. 100 m³/h (EG0)
- Scenario B: approx. 110 m³/h (EG30)

$$\mathbf{P-el} = \frac{\mathbf{V} * \Delta\mathbf{p}}{\boldsymbol{\eta}} \qquad P-el = \frac{\frac{m^3}{s} * \frac{N}{m^2}(Pa)}{-} = \frac{Nm}{s} = W$$

Annahme

- Scenario A: approx. **6,0 kW** / 7,5 kW (EG0)
- Scenario B: approx. **7,4 kW** / 11 kW (EG30)

CHW-Pumpe

- in Betrieb 8.760 h/a

Agenda

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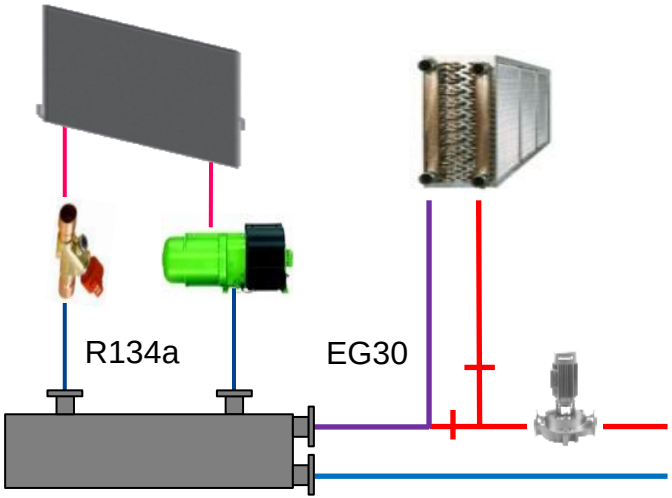
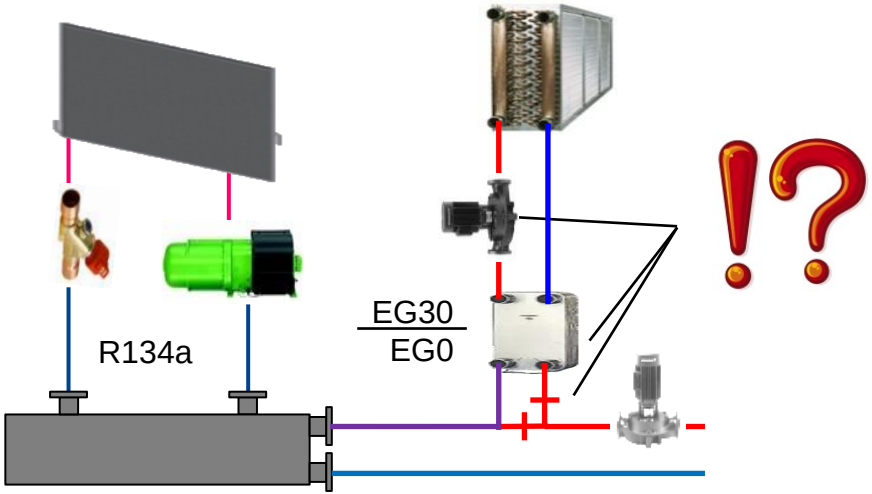
System Design

Glycol



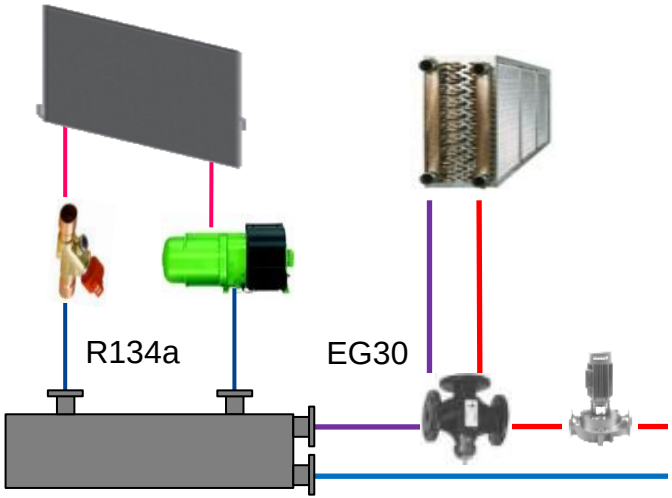
Non-Glycol



- P-el / FC Pumpe
- PWT / Grädigkeit
- PWT - CHW Zwangsdurchströmung

System Design

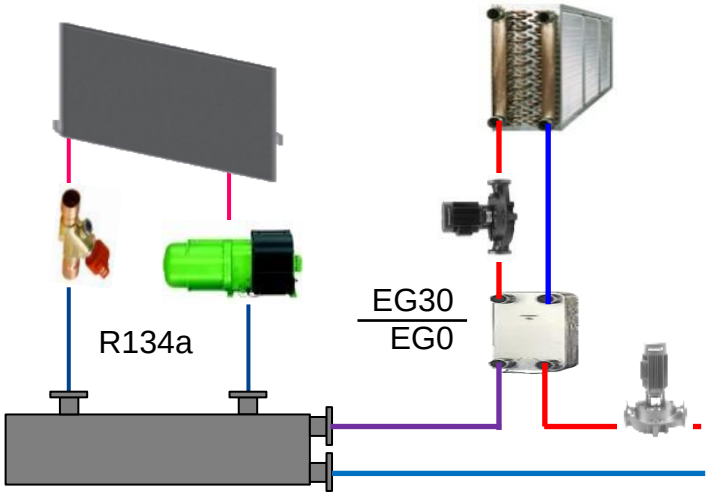
Glycol



dp 3-Wege Ventil

- 700 kW (100m³/h) dp= 30 kPa
- **K= ca. 1.575 €/a** **(15 ct/kWh)**

Non-Glycol



dp PWT - CHW

- 700 kW (100m³/h) dp= 70 kPa
- **K= ca. 3.680 €/a** **(15 ct/kWh)**

System Design

FC Pumpe Betrieb

- 700 kW; 18/12 – EG30
- P-el = 12 – 18 kW (15 ct/kWh)
- Hamburg – MIX ca. 5.000 h/a
- Hamburg – FC ca. 2.250 h/a

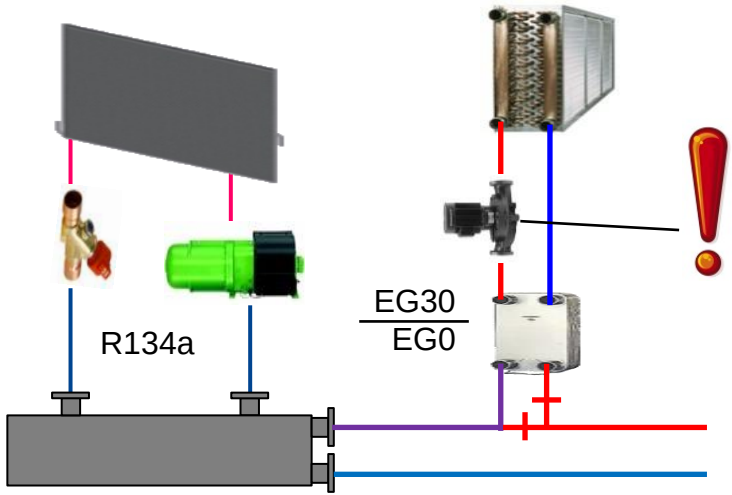
Betriebsmodus – Mix

- 12 kW **K = ca. 9.000 €/a**
- 18 kW **K = ca. 13.500 €/a**

Betriebsmodus – Mix + FC

- 12 kW **K = ca. 13.050 €/a**
- 18 kW **K = ca. 19.575 €/a**

Non-Glykol



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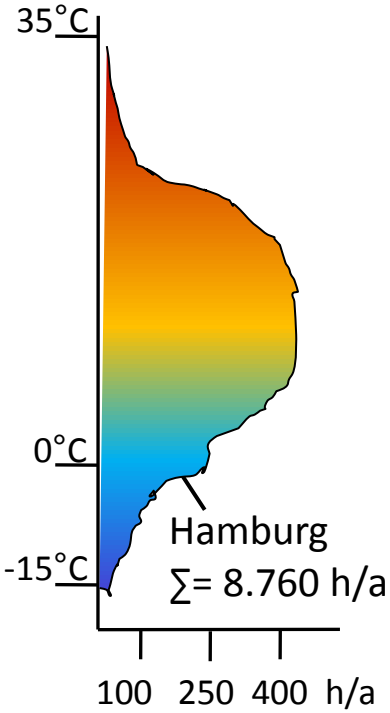
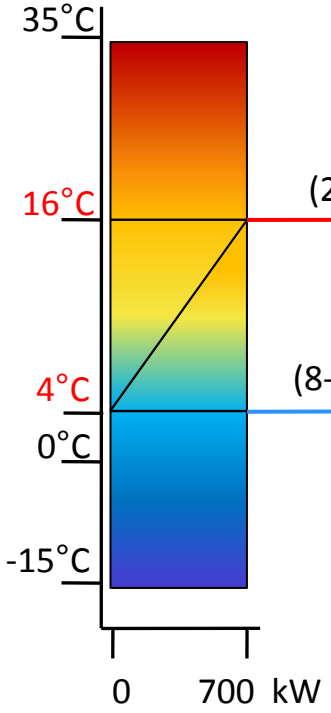
operation modes





(2K)

(8-10K)

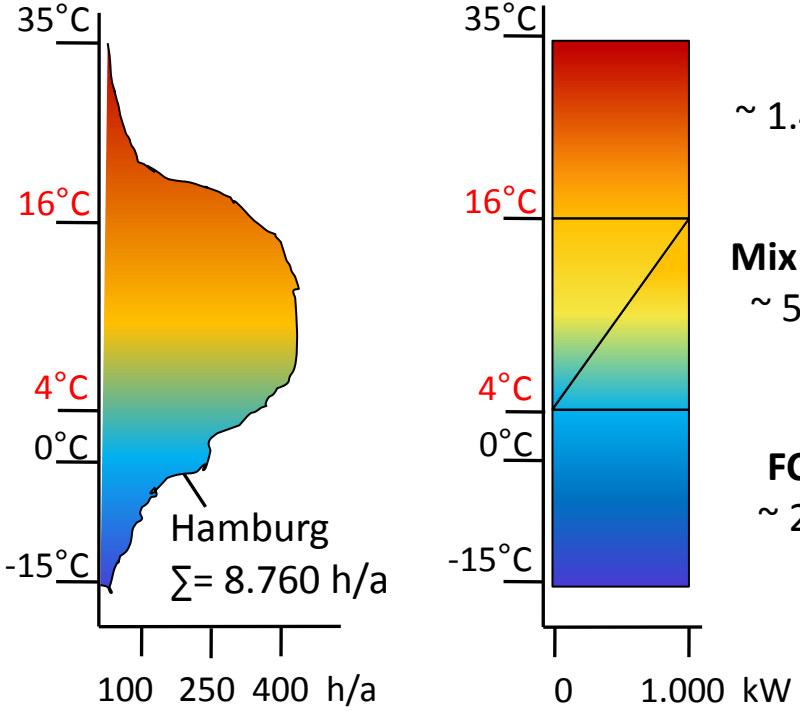
Start Mix - CHW entering temp.

18

12

Start FC - CHW leaving temp.

Aktive Chiller Komponenten 18/12 – EG30
w/o Systemtrennung / kein PWT



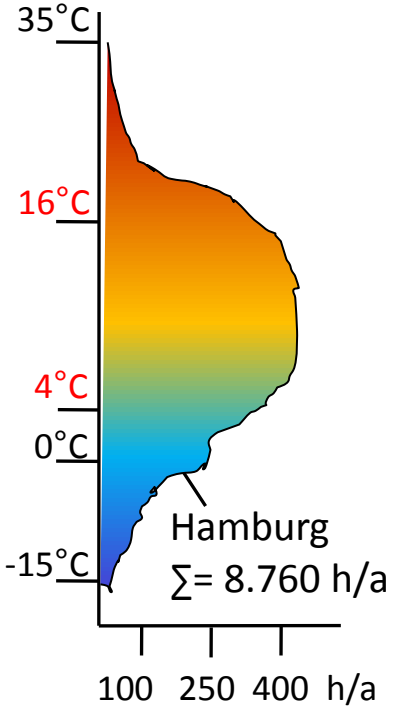
DX
~ 1.449 h/a
(17%)

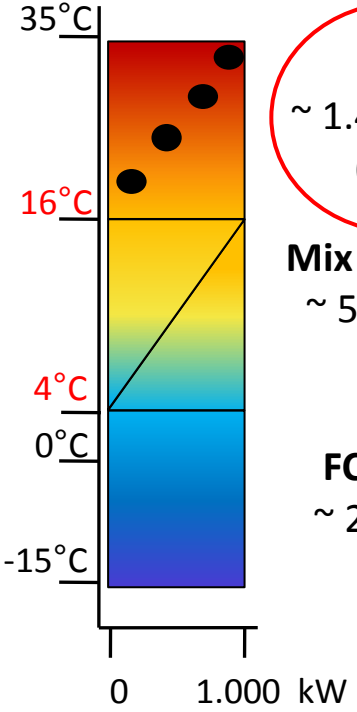
Mix – DX / FC
~ 5.062 h/a
(58 %)

FC – 100%
~ 2.249 h/a
(25 %)

FC	DX	Fan
		
		
		
~ 7.311 h/a (83 %)	~ 6.511 h/a (75 %)	~ 8.760 h/a (100 %)

Betriebszustände – Kaltwasserssatz luftgekühlt
18/12 – 35 AT





DX
~ 1.449 h/a
(17%)

Mix – DX / FC
~ 5.062 h/a
(58 %)

FC – 100%
~ 2.249 h/a
(25 %)

EUROVENT CERTIFIED PERFORMANCE www.eurovent-certification.com
ESEER

AHRI CERTIFIED™ www.ahridirectory.org
IPLV

TGA / Komfort - Klimatisierung

Freikühl- Philosphie

Betriebskostenberechnung

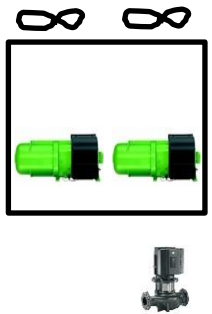
- Scenario A) Non-Glycol (PWT - 2K)
- Scenario A+) Non-Glycol (PWT - 5K)
- Scenario B) Glycol
- Standort: Hamburg 18/12 – AT35

Temp.	Hours	Status	DX Capacity	FC Capacity	LWT (FC)	Total Capacity	Compressor		Fans/Axitop		Pump		FC-Pump		Total
[°C]	[h/a]	[-]	[kW]	[kW]	[°C]	[kW]	[kW]	[kWh/a]	[kW]	[kWh/a]	[kW]	[kWh/a]	[kW]	[kWh/a]	[kWh/a]
17	357	DX	752	0	0,0	752	95.1	33.951	19,2	6.854	0,0	0			40.805
16	348	MIX	639	113	17,1	752	57.8	20.114	22,8	7.934	0,0	0			28.048
15	395	MIX	590	162	16,7	752	54.4	21.488	22,8	9.006	0,0	0			30.494
14	419	MIX	541	211	16,3	752	49.3	20.657	22,8	9.553	0,0	0			30.210
13	346	MIX	492	260	15,9	752	44.2	15.293	22,8	7.889	0,0	0			23.182
12	337	MIX	442	310	15,5	752	40.8	13.750	22,8	7.684	0,0	0			21.434
11	394	MIX	393	359	15,1	752	35.7	14.066	22,8	8.983	0,0	0			23.049
10	379	MIX	344	408	14,7	752	30.6	11.597	22,8	8.641	0,0	0			20.238
9	408	MIX	295	457	14,4	752	27.2	11.098	22,8	9.302	0,0	0			20.400
8	445	MIX	246	506	14,0	752	22.1	9.835	22,8	10.146	0,0	0			19.981
7	473	MIX	197	555	13,6	752	18.7	8.845	22,8	10.784	0,0	0			19.629
6	435	MIX	147	605	13,2	752	13.6	5.916	22,8	9.918	0,0	0			15.834
5	396	MIX	98	654	12,8	752	8.5	3.366	22,8	9.029	0,0	0			12.395
4	368	MIX	49	703	12,4	752	5.1	1.877	22,8	8.390	0,0	0			10.267
3	356	FC	0	752	12,0	752	0.0	0	19,2	6.835	0,0	0			6.835

Scenario B)

Beispiel – Software CC2

Freikühl- Philsophie

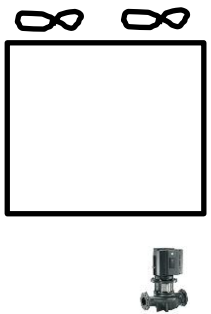


23

36

11

70



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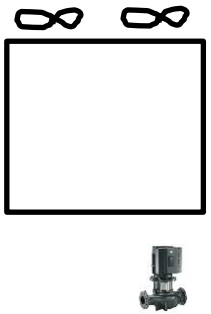

23

11

68

Temp.	Hours	Status	DX Capacity	FC Capacity	LWT (FC)	Total Capacity	Compressor		Fans/Axitop		Pump		FC-Pump		Total
[°C]	[h/a]	[-]	[kW]	[kW]	[°C]	[kW]	[kW]	[kWh/a]	[kW]	[kWh/a]	[kW]	[kWh/a]	[kW]	[kWh/a]	[kWh/a]
17	357	DX	752	0	0,0	752	95.1	33.951	19,2	6.854	0,0	0			40.805
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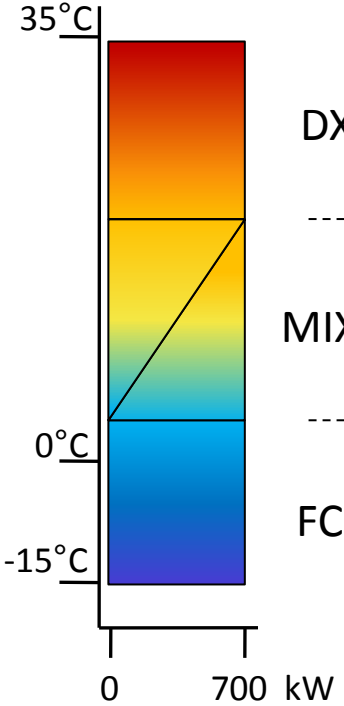
10	379	MIX	344	408	14,7	752	30.6	11.597	22,8	8.641	0,0	0			20.238

operation modes - characteristics



DX

100 %

$t_0 - t_C$ = low lift / high EER

MIX

< 100 %

min Δp = stable running conditions

> 0 %

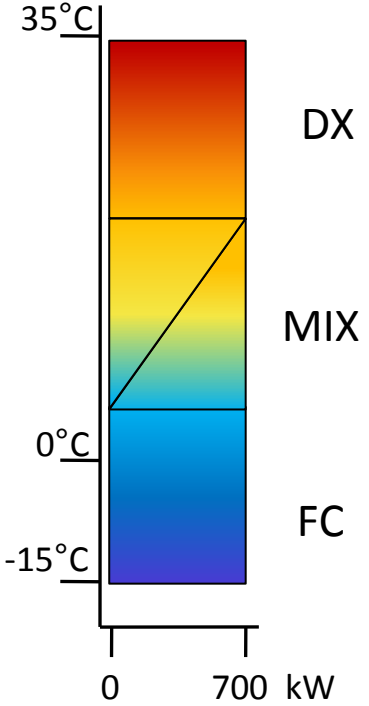
max FC-capacity = low OPEX

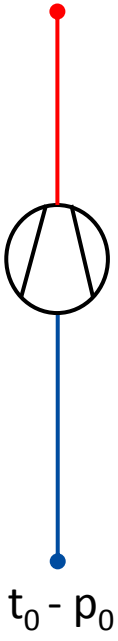
FC

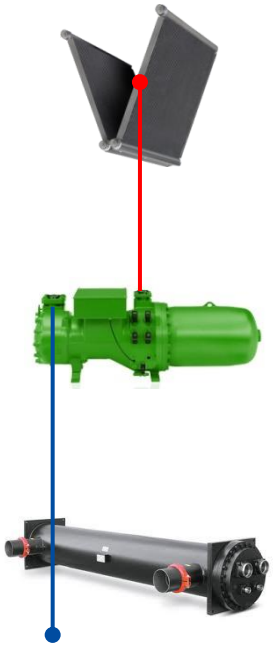
100 %

max FC-capacity = a.s.a.p.

MIX mode problem





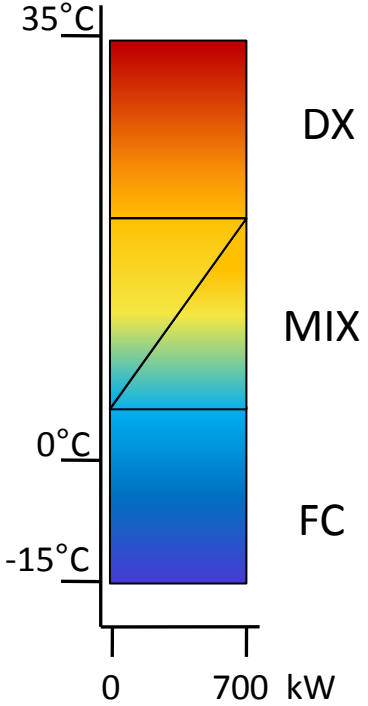


$\Delta p = p_C - p_0$

Δp = lift

min Δp = ?

Mix mode problem



tender text --- $Q_{0\ /\ FC}$ – AT 5°C

$t_{C\ -\ min}$

DX maintaining minimum

FC achieving maximum

lowering fan speed

DX (+) FC (-)

shutting off DX coils

DX (-) FC (+)

ICS valve / CC2 stand.

DX (+) FC (+)

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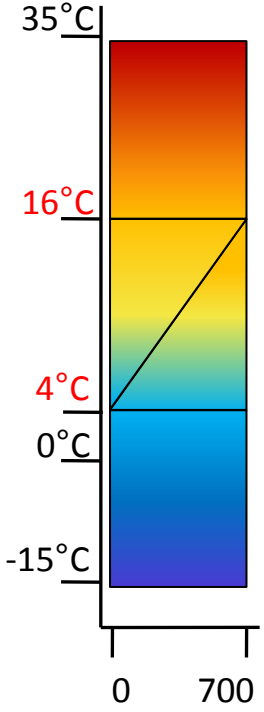
Hamburg / aktive Chiller Komponenten 18/12

EG30

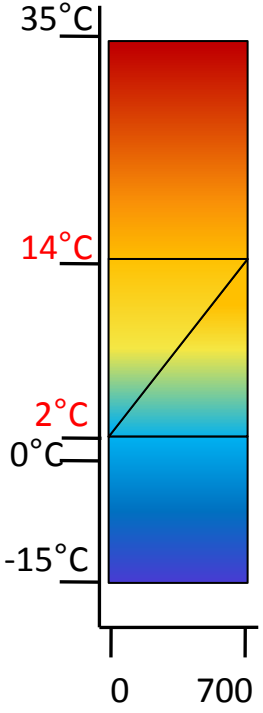


DX
~ 1.449 h/a
(17%)

Mix
~ 5.062 h/a
(58 %)

FC–100%
~ 2.249 h/a
(25 %)

EG0 (2K)

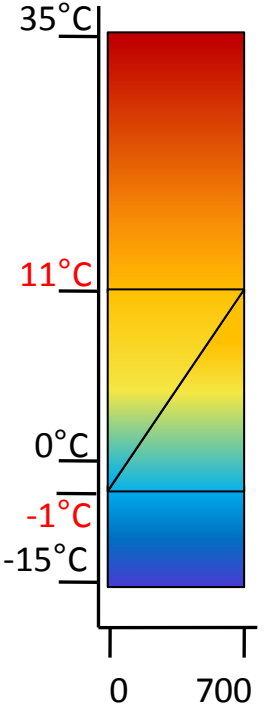


DX
~ 2.521 h/a
(29%)

Mix
~5.032 h/a
(57 %)

FC – 100%
~ 1.207 h/a
(14 %)

EG0 (5K)

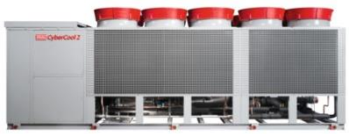


DX
~ 4.017 h/a
(46%)

Mix
~ 4.487 h/a
(51 %)

FC – 100%
~ 256 h/a
(3 %)

Glykol / Non-Glykol; Hamburg 700 kW 18/12

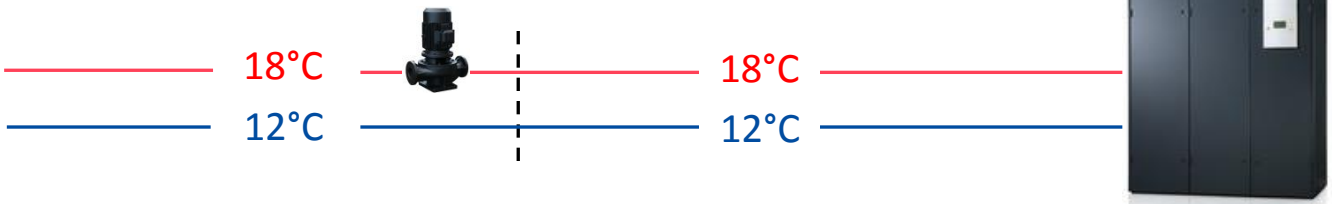


	Scenario B **EG 30** DX - MIX - FC	**Scenario A** **EG 0 / 2K** DX - MIX - FC	**Scenario A** **EG 0 / 5K** DX - MIX - FC
	190.647 + 157.902 + 0 **348.549 kWh/a**	257.323 + 158.325 + 0 **415.648 kWh/a**	351.173+ 160.380 + 0 **511.552 kWh/a**
	48.178 + 144.004 + 25.817 **217.999 kWh/a**	68.982 + 140.896 + 24.328 **234.206 kWh/a**	98.322 + 131.796 + 7.578 **237.695 kWh/a**
 CHW 7,5/11 kW	10.868 + 55.682 + 24.739 **91.289 kWh/a**	18.908 + 55.352 + 13.277 **87.537 kWh/a**	30.128 + 49.357 + 2.816 **82.301 kWh/a**
 FC 15 kW	0 + 0 + 0 **0 kWh/a**	0 + 75.480 + 18.105 **93.585 kWh/a**	0 + 67.305 + 3.840 **71.145 kWh/a**
	657.837 kWh/a	**830.976 kWh/a**	**902.693 kWh/a**

Glycol / Non-Glycol; Hamburg 700 kW 18/12 (15 ct/kWh)

	Scenario B EG 30 DX - MIX - FC	Scenario A EG 0 / 2K DX - MIX - FC	Scenario A EG 0 / 5K DX - MIX - FC
			
	348.549 kWh/a **52.282 €/a**	415.648 kWh/a **62.347 €/a**	511.552 kWh/a **76.732 €/a**
	217.999 kWh/a **32.700 €/a**	234.206 kWh/a **35.131 €/a**	237.695 kWh/a **35.654 €/a**
 CHW 7,5/11 kW	91.289 kWh/a **13.693 €/a**	87.537 kWh/a **13.130 €/a**	82.301 kWh/a **12.344 €/a**
 FC 15 kW	0 kWh/a **0 €/a**	93.585 kWh/a **14.037 €/a**	71.145 kWh/a **10.671 €/a**
	98.675 €/a	**124.645 €/a**	**135.401 €/a**

CHW System Auswertung



	Chiller	CHW-Pumpe	Glykol (5+5m³)	CRAH
SYSTEM-CAPEX				
EG 30	-	~ 1.500 €	~ 30.000 €	-
EG 0 – 2 K	2 x ~25.252 €	-	-	-
EG 0 – 5 K	2 x ~15.151 €	-	-	-
SYSTEM-OPEX				
EG 30	-	~ 1.500 €/a	-	~ 2.000 €/a
EG 0 – 2 K	~ 25.970 €/a	-	-	-
EG 0 – 5 K	~ 36.726 €/a	-	-	-

Agenda

- Glycol / Non-Glycol
  - CHW - System Design p/s
  - Beispiel Rechenzentrum
  - CRAH
  - Glykol Faktor (Chiller / Pumpe)
  - System Design G / NG
  - System Operational
  - Facts & Figures
  - Fazit

Kernaussagen

Systemvergleich - OPEX

- Glykol: **~ 102.175 €/a**

ROI < 1 Jahr

- Non-Glycol (2K): ~ 124.645 €/a (+22% - spec CC2)

ROI < 1.5 Jahre

- Non-Glycol (5K): ~ 135.401 €/a (+32% / +9%)

Fazit 1/2 - chiller

Glykol

CAPEX (-)
OPEX (-)

Non - Glycol

CAPEX (+)
OPEX (+)

Δp (+)
TTD (+)

P_{el} (+)
h/a (+)

P_{el} (+)
h/a (+)

Fazit 2/2 - System

Glykol	Non - Glycol	Energie Effizienz
Chiller (+) CRAH (-)	Chiller (-) CRAH (+)	Glykol >> Non- Glykol

questions & answers

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“Tschüss”