

Sustainable, safe and efficient cooling in Data Centers with water as refrigerant



Kamila Kuflowski

Tel.: +49 172 1554811

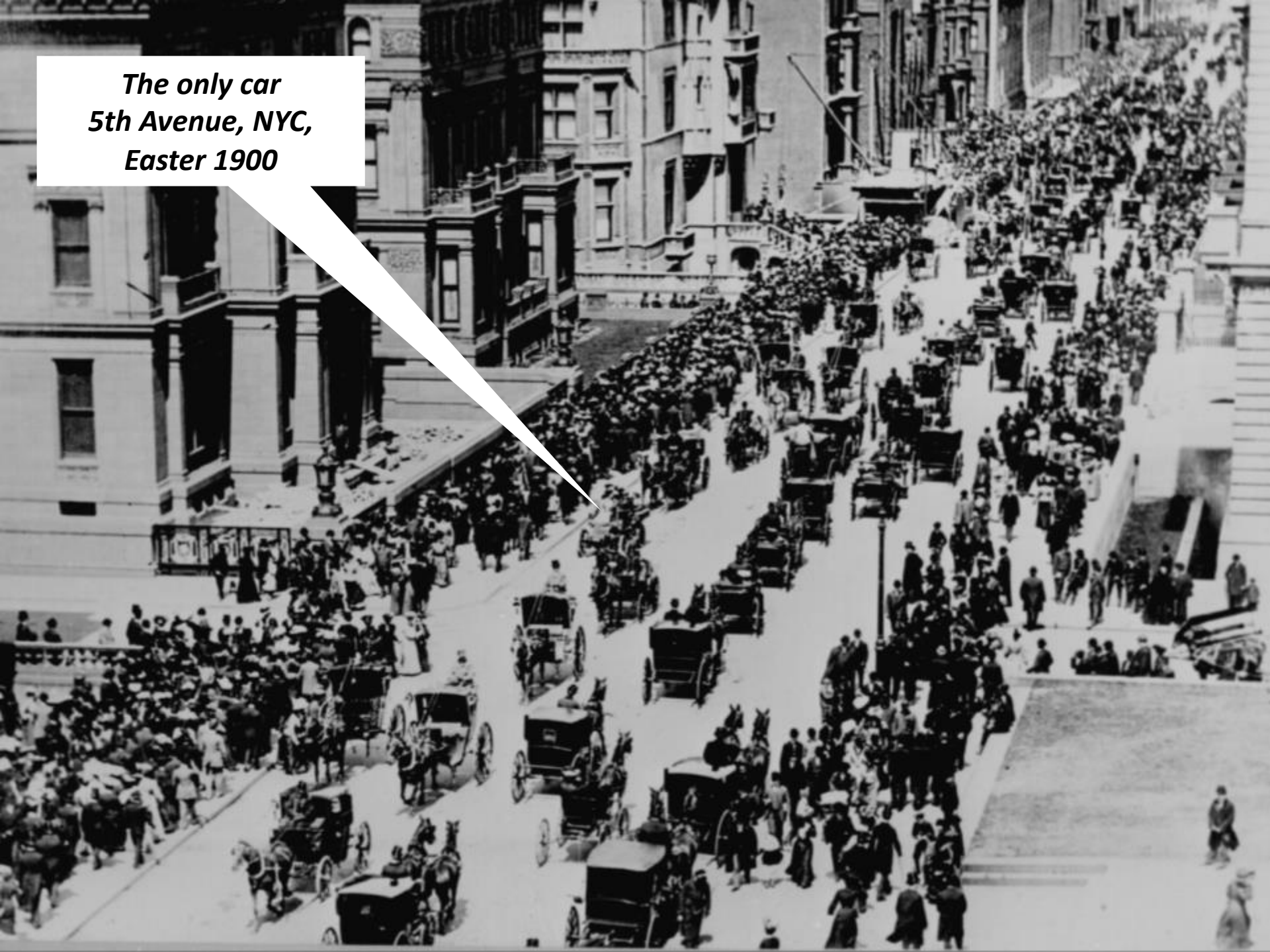
E-Mail: Kamila.Kuflowski@efficient-energy.de



efficient energy
be part of tomorrow



*The only car
5th Avenue, NYC,
Easter 1900*



Alterations are Completed
Building will be Occupied by
PALDING & BROS.
at 25 West 42nd St.

504



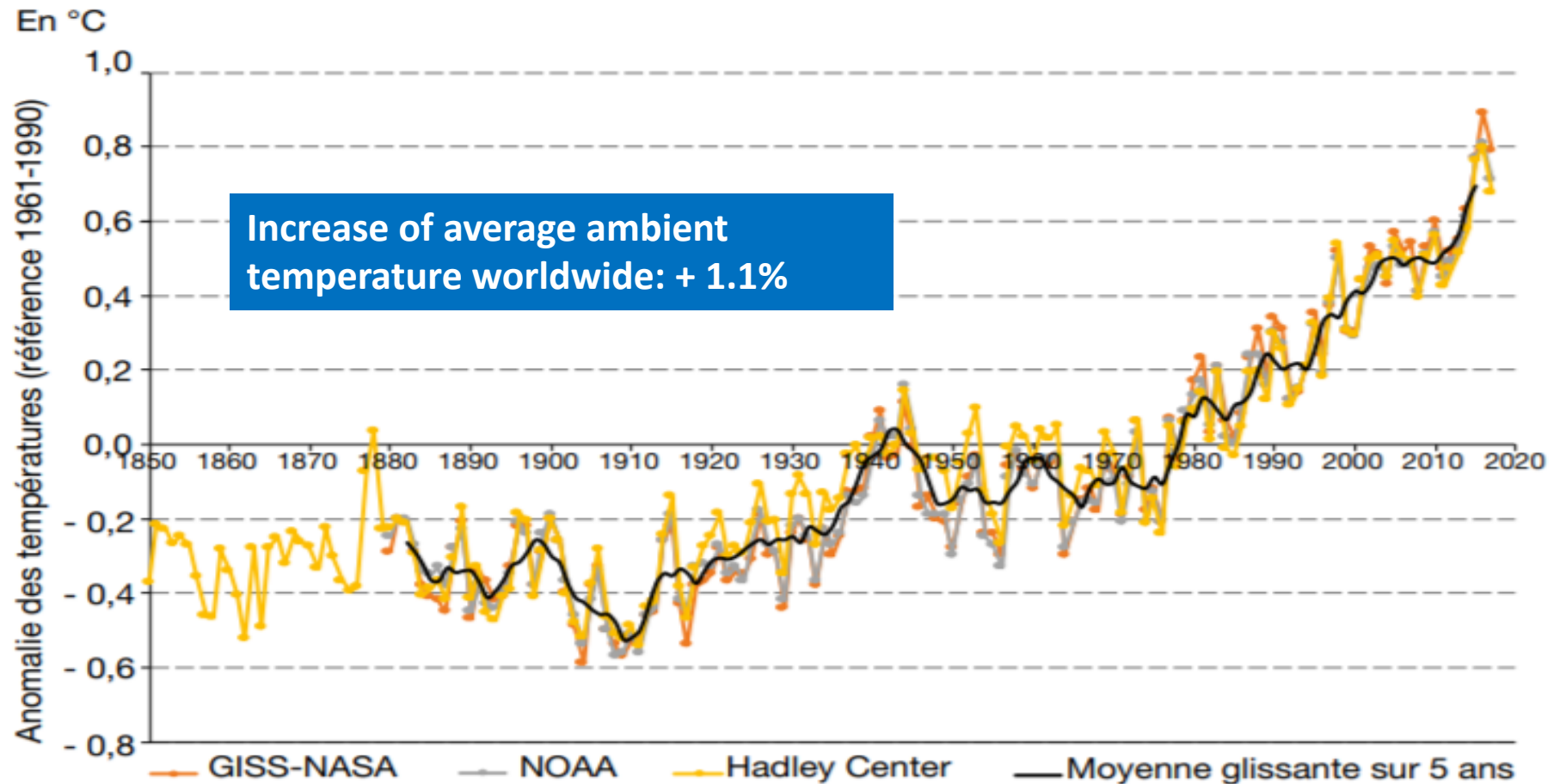
3529-6

*The only horse
5th Avenue, NYC,
Easter 1913*



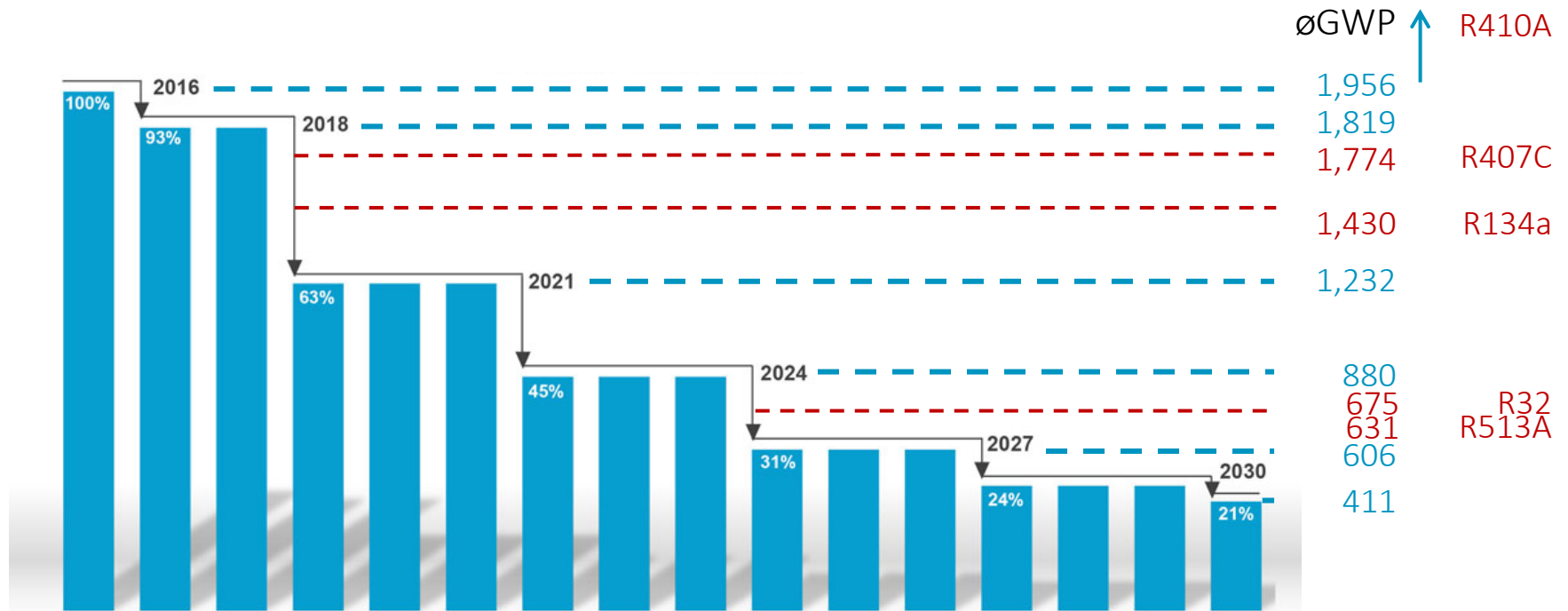
3529-6

Impact of CO2-Emissions on our climate



Sources : NASA ; NOAA ; Hadley Center

F-Gas-Directive – Phase Down & øGWP



The availability of the HFCs is limited step by step due to the possible average GWPs.

Refrigerant options

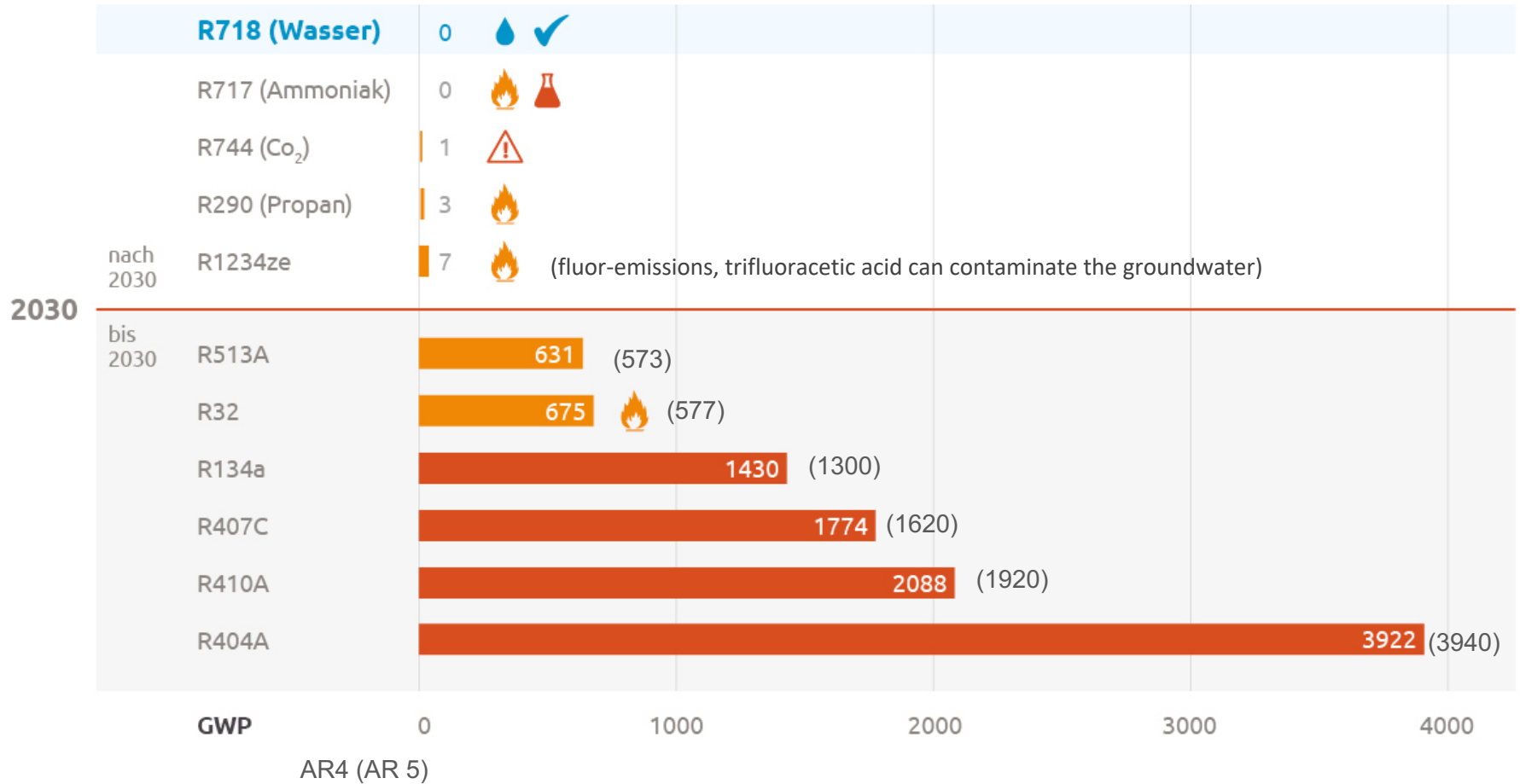
more flammable

more toxic

[illegible]

58 140.12 Ce (frequent futher oxidation) 0.78	59 140.9077 Pr (occasional further oxidation) 0.77	60 144.24 Nd (occasional further oxidation) 0.70	61 144.91 Pm (occasional further oxidation) 0.67	62 173.04 Sm (occasional further oxidation) 0.54	63 157.25 Eu (occasional further oxidation) 0.50	64 157.25 Gd (occasional further oxidation) 0.70	65 160.9204 Tb (occasional further oxidation) 0.27	66 162.50 Dy (occasional further oxidation) 0.34	67 164.9304 Ho (occasional further oxidation) 0.30	68 167.26 Er (occasional further oxidation) 0.30	69 168.9343 Tm (occasional further oxidation) 0.32	70 173.04 Yb (occasional further oxidation) 0.30	71 174.967 Lu (occasional further oxidation) 0.30
90 232.0371 Th (occasional further oxidation) 0.17	91 231.0363 Pa (occasional further oxidation) 0.10	92 226.0254 U (occasional further oxidation) 0.10	93 237.0437 Np (occasional further oxidation) 0.10	94 238.0289 Pu (occasional further oxidation) 0.10	95 243.0287 Am (occasional further oxidation) 0.10	96 247.0771 Cm (occasional further oxidation) 0.10	97 247.0771 Bk (occasional further oxidation) 0.10	98 251.1089 Cf (occasional further oxidation) 0.10	99 252.0839 Es (occasional further oxidation) 0.10	100 257.1037 Fm (occasional further oxidation) 0.10	101 261.1089 Md (occasional further oxidation) 0.10	102 265.1089 No (occasional further oxidation) 0.10	103 269.1089 Lr (occasional further oxidation) 0.10

HFCs and natural replacements

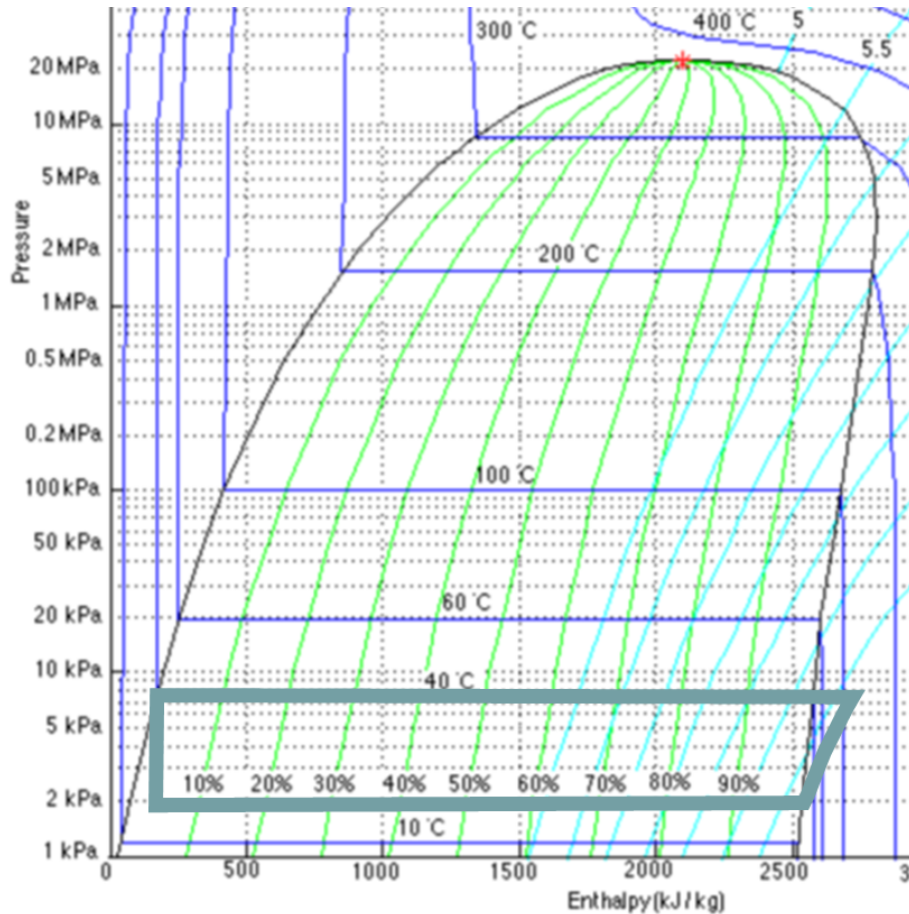


What makes a good refrigerant?

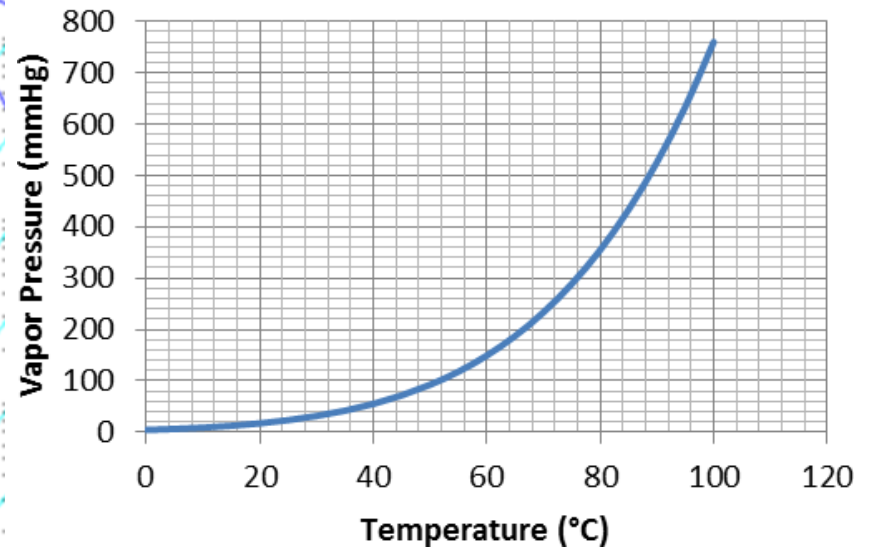
- Physical properties
 1. Environmentally benign (Low GWP, no ODP, biodegradable)
 2. Vapor pressure curve (reasonable pressures for application)
 3. Low viscosity
 4. Distinct miscibility with lubricants
 5. Good water solubility
 6. High electrical breakdown resistance
- Chemical properties
 1. High chemical stability
 2. Low flammability
 3. High chemical indifference
- Physiological properties
 1. No toxicity
 2. noticeable smell
- Economical properties
 1. High energetic coefficient of performance
 2. Volumetric refrigeration capacity
 3. Circulating refrigerant mass
 4. Availability
 5. Cost



Water as refrigerant



Vapor Pressure of Water



Log p-h diagram of water

Water as refrigerant - advantages

R718



No chemical & physical risks



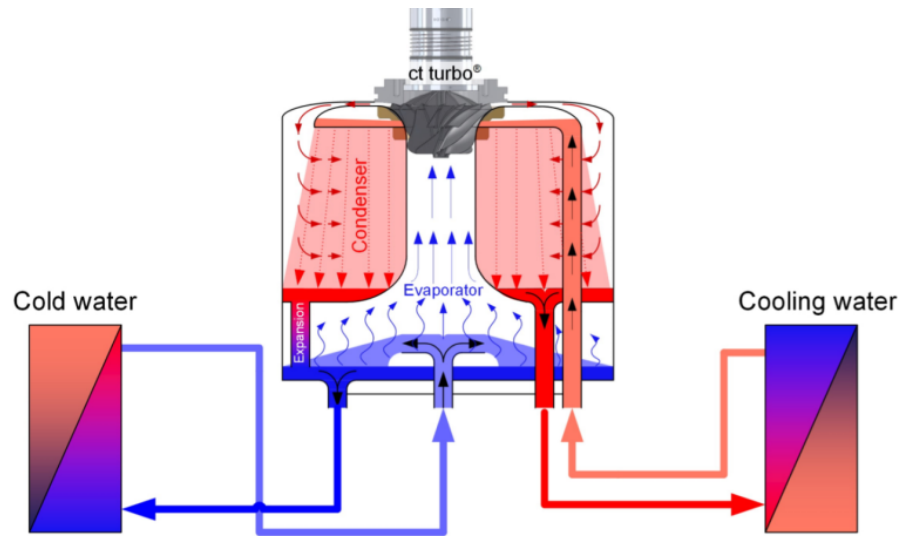
No
F-gas-phase
down



No
EN378

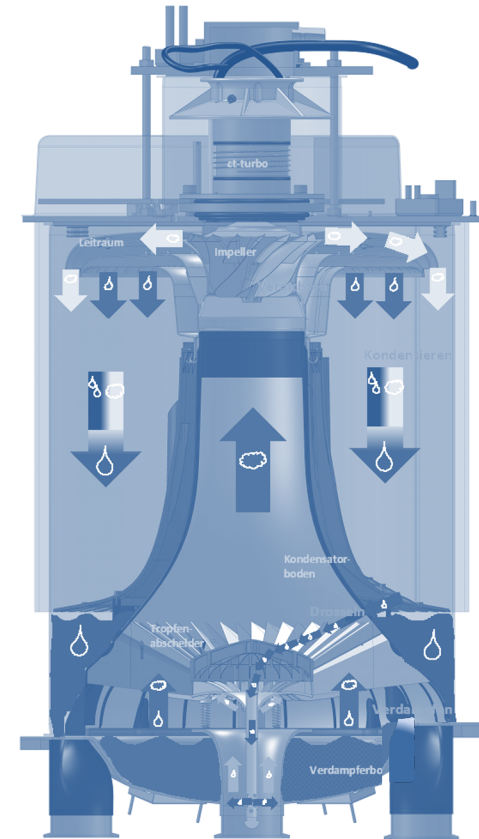
No reductions or
limitations

Water as refrigerant – working principle



operation under vacuum

state	temperature	pressure
evaporation	16,0 °C	0,018 bar
condensation	52,0 °C	0,136 bar



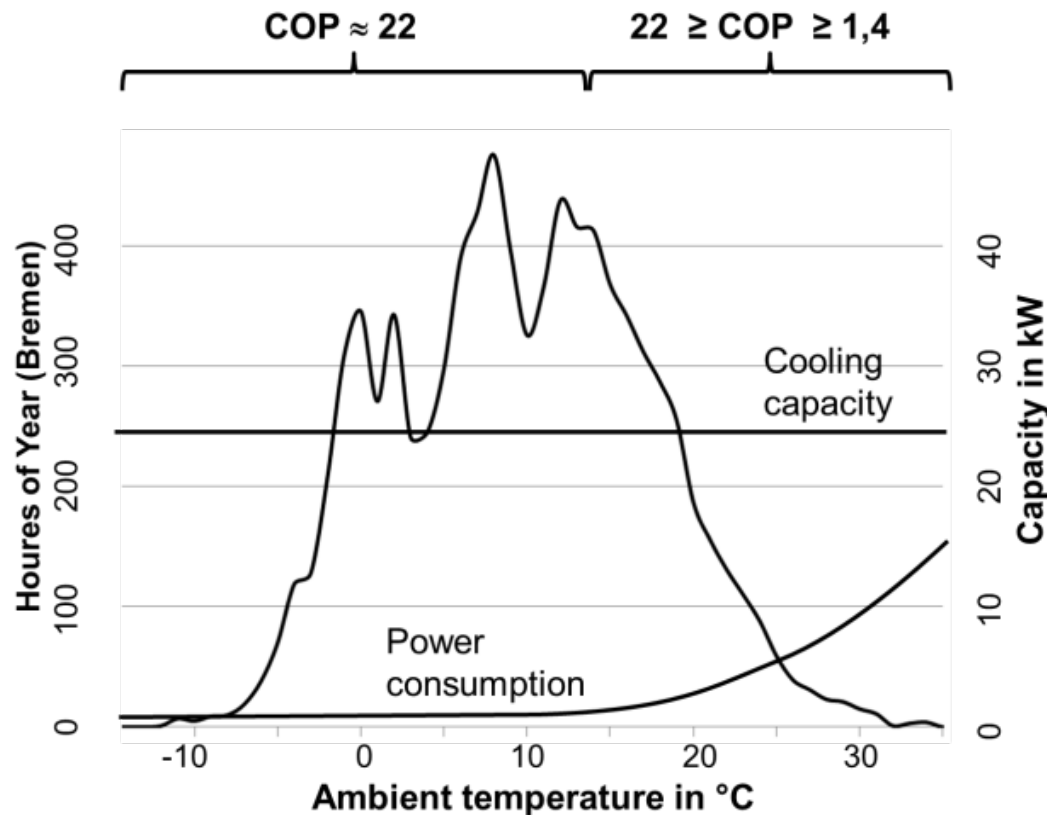
Water as refrigerant – Application Examples



Project Specification:

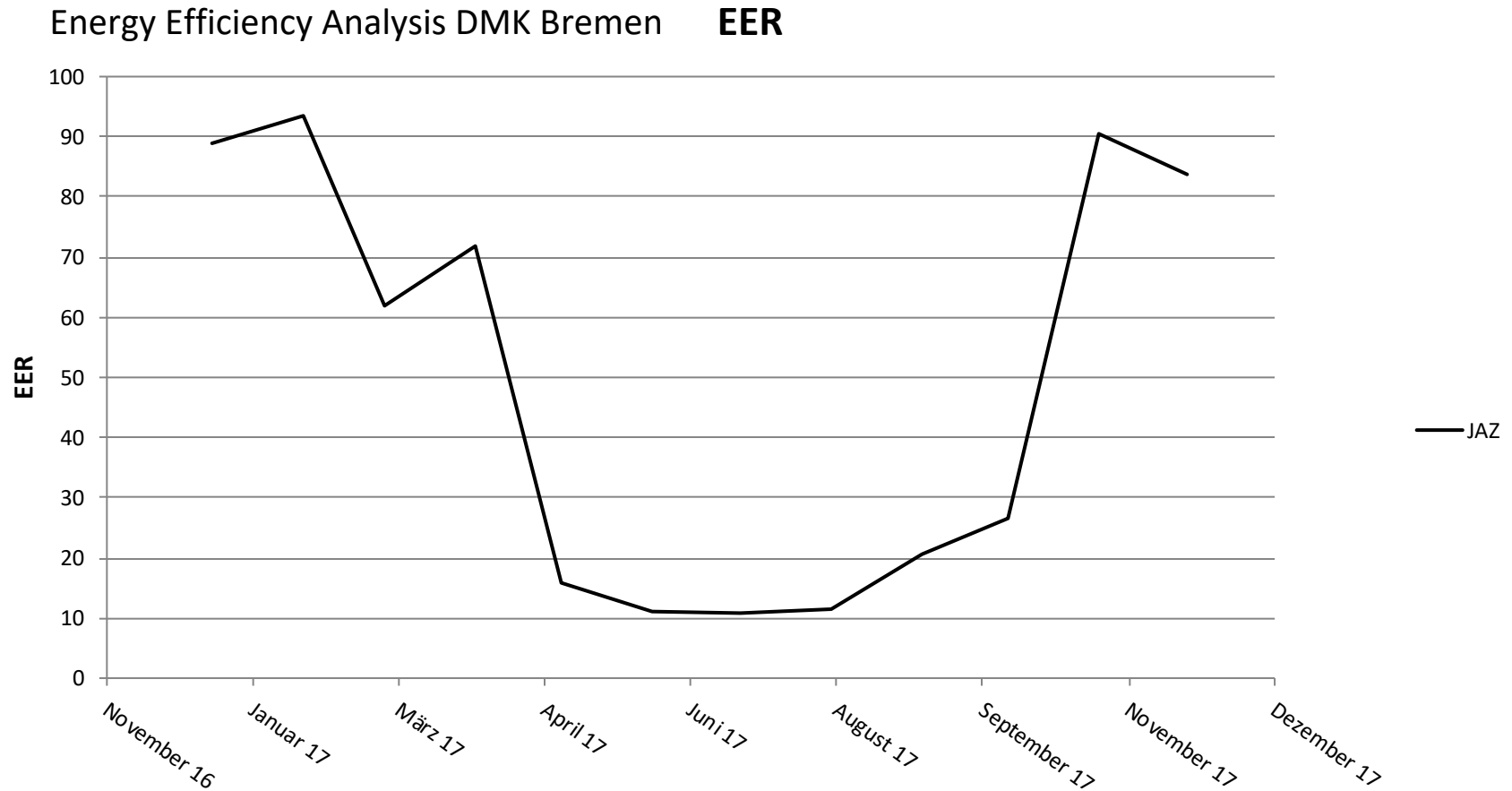
- Location: Bremen
- constant cooling capacity: 25 kW
- cold aisle temperature: 25° constant
- recooling: dry cooler

Water as refrigerant – Application Examples



- Ambient temperature distribution at the location of the unit
- Cooling capacity 25 kW all year
- Power consumption of unit rising from 1,1 kW (free cooling mode) to 17 kW (two stage operation)
- COP is rising up to 22 depending on operational mode

Water as refrigerant – Application Examples



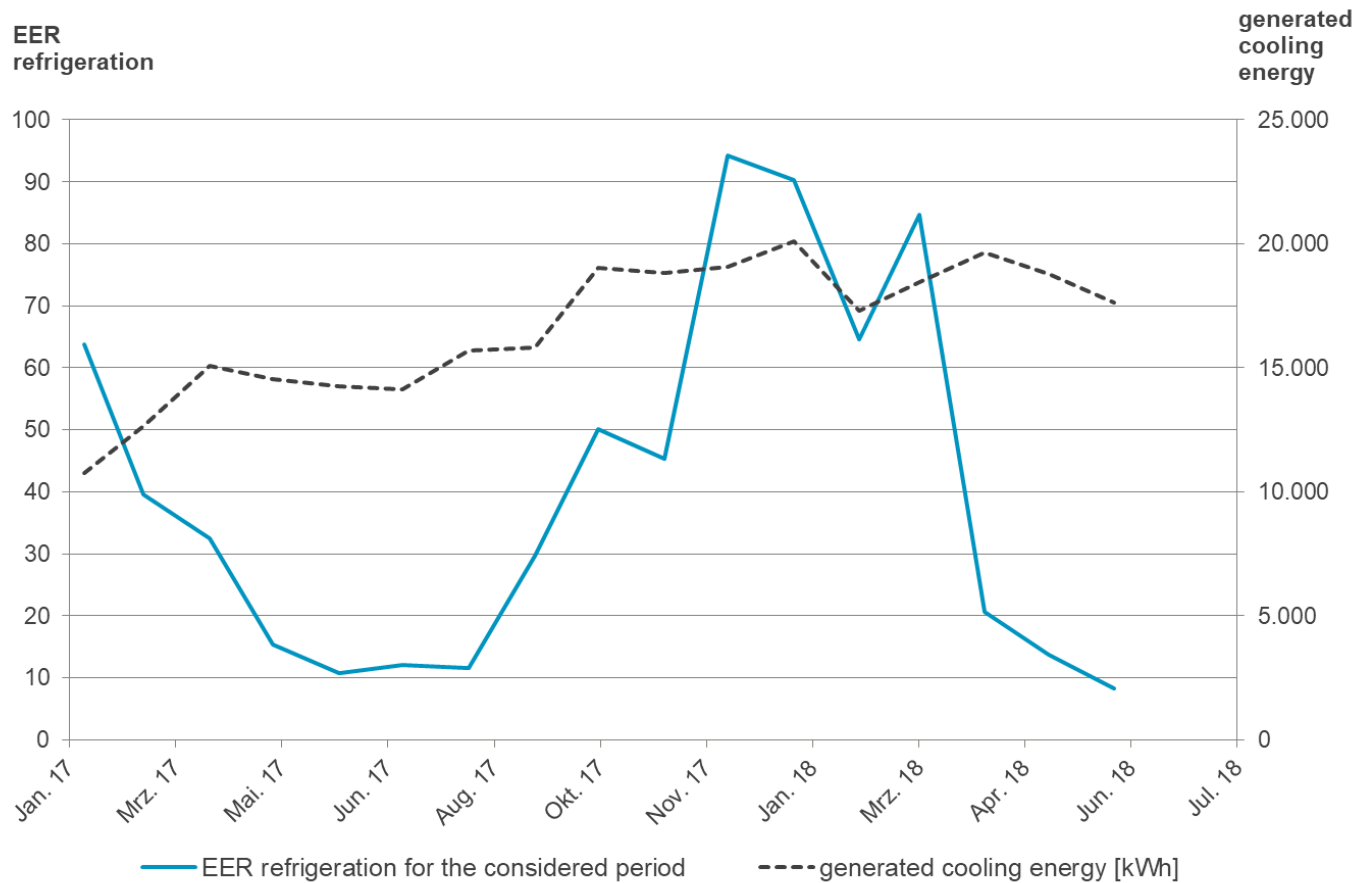
Water as refrigerant – Application Examples



Project Specification:

- Location: Calw (South Germany)
- constant cooling capacity: 35 kW
- Chilled water supply: 19°C
- Cold Aisle temperature: max. 25°C
- recooling: dry cooler

Water as refrigerant – Application Examples



EER for the considered period: 21

Water as refrigerant – Application Examples



Project Specification:

- Location: Weilheim (South Germany)
- constant cooling capacity: 60 kW
- Chilled water supply: 16°C
- recooling: adiabatic cooler

Water as refrigerant – Application Examples

Cube Data Center BT: a Data Center within a Data Center in an enclosed housing/high-density area for one customer with special needs/demands.

- Cooling water supply through central cooling water system.
- Chilled water setpoint temperature: 14°C
- Cold Aisle Temperature: 20°C
- cooling supply of 70kW
- Initial cooling capacity: 10kW
- Integrated Master Slave Control System
- Same system setup 2 x in Hamburg, 1 x in Berlin



Key advantages for Data Centers

- Unlimited refrigerant availability at low costs, no shortcuts
- no legal restrictions
- no safety and gas warning installations necessary
- no specialized refrigeration technicians necessary
- no regular leakage checks (DIN EN378 doesn't apply)
- low pressure systems with no hazards and risks for the operating personnel
- due to the above, minimization of downtimes
- high chilled water outlet temperatures
- very low energy costs due to integrated free cooling



Questions?

Kamila Kuflowski

Tel.: +49 172 1554811

E-Mail: Kamila.Kuflowski@efficient-energy.de