RAC
Low Emission

Webinar 2: Resource and energy efficiency – April 20, 2021

Technologies and energy efficiency of refrigeration systems

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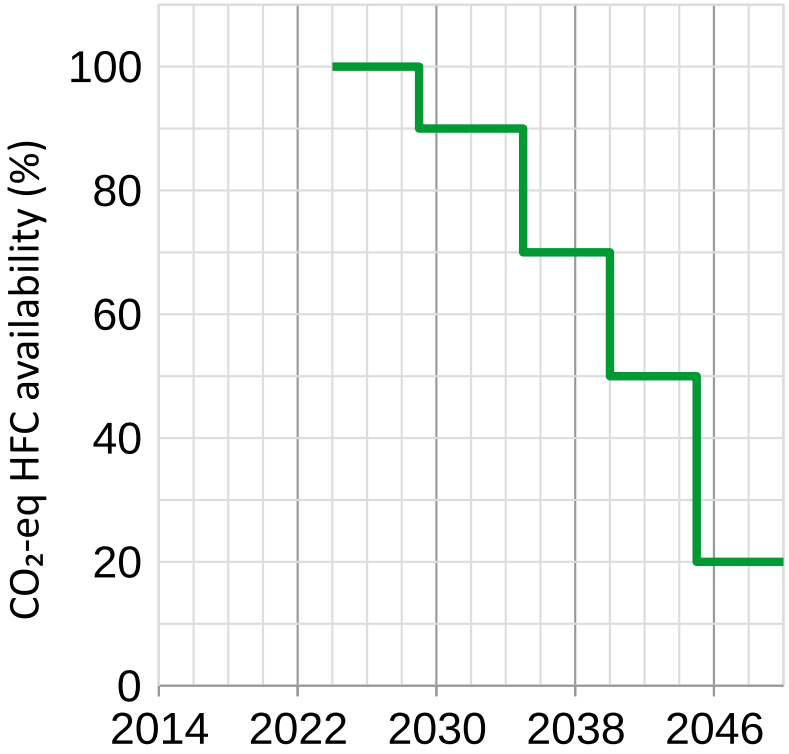
Kigali Amendment to the Montreal Protocol

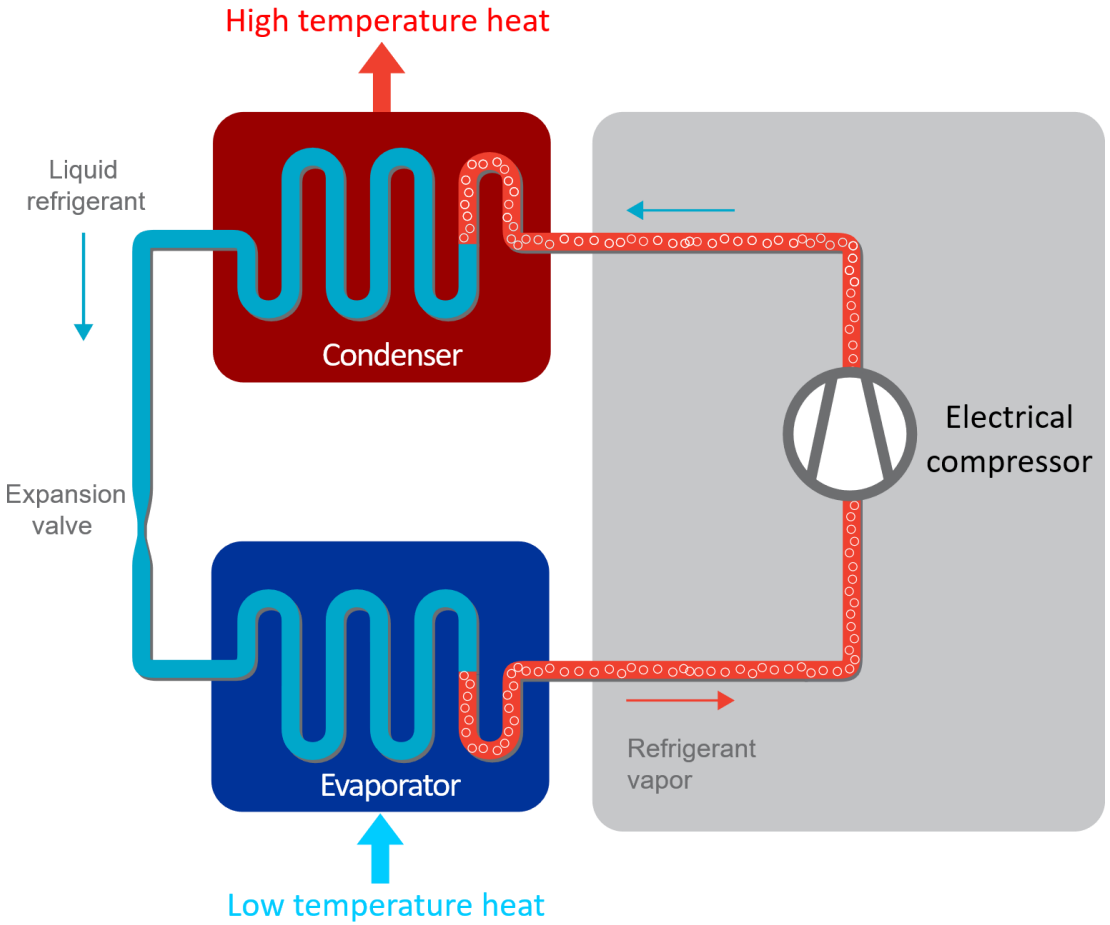
The Kigali Amendment regulates the phase down of HFC availability in Central und South America



- The availability of HFC refrigerants will be reduced in 4 steps.
- The process begins in 2024 with the recording of the actual state and ends in 2045 with 20 % CO_2-equivalent availability of HFCs.
- **Therefore, a transition to alternative refrigerants has to be organized.**

Types of refrigeration systems

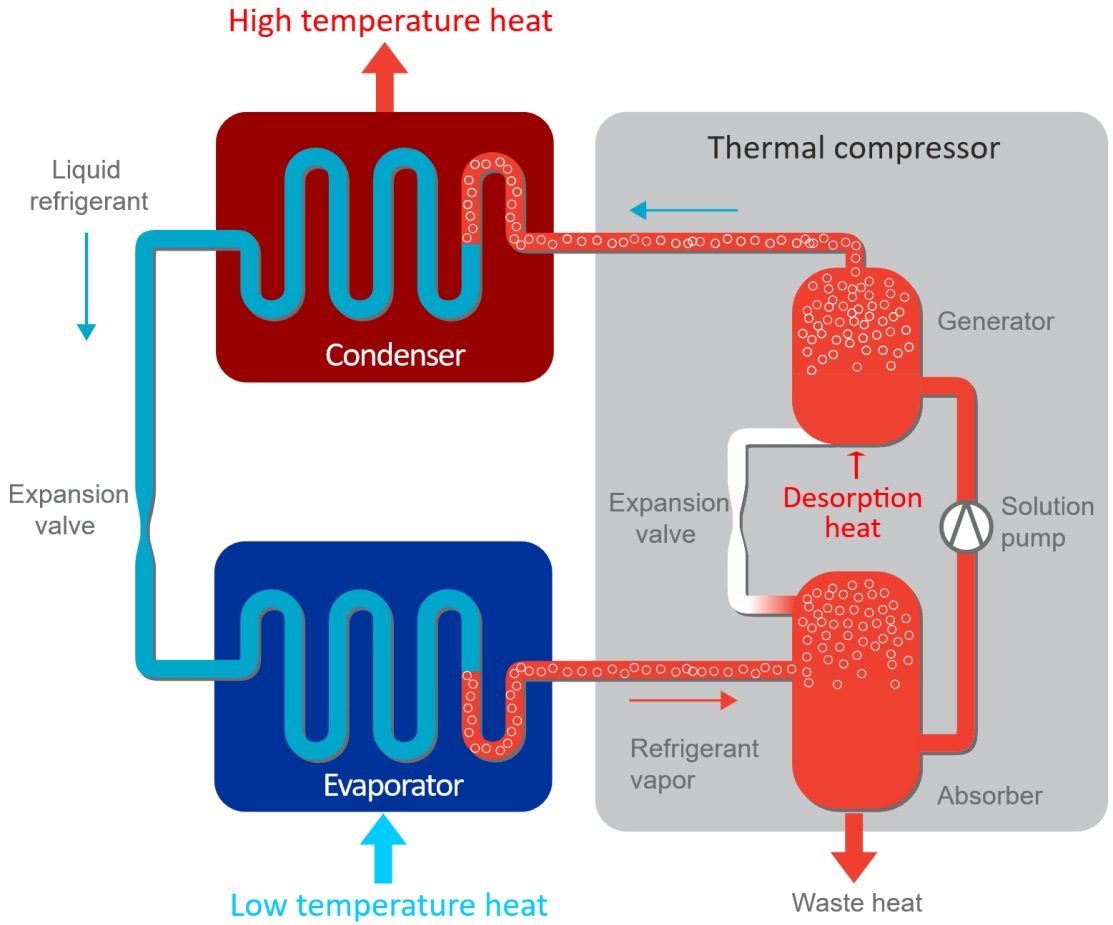
Refrigeration systems
usuallay with an electrical compressor



- state of the art:
  cold vapor compression process
- driven by electricity
- high market significance

Sorption refrigeration systems

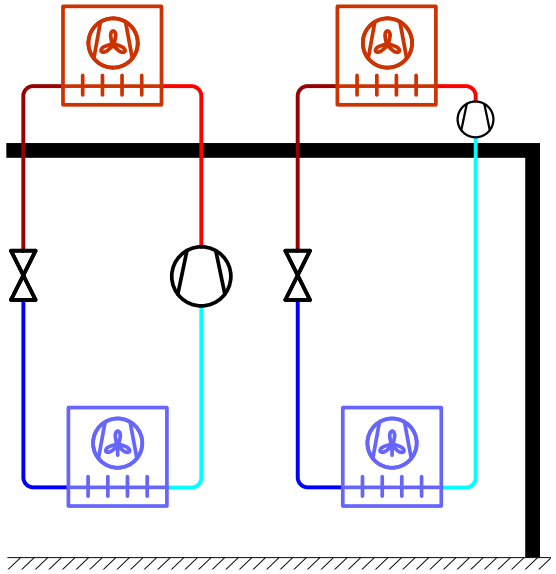
with a thermal instead of an electrical compressor



- drive by means of solar heat, waste heat and (natural) gas is possible
- technically sophisticated
- low market significance

due to time constraints:
not considered in detail below

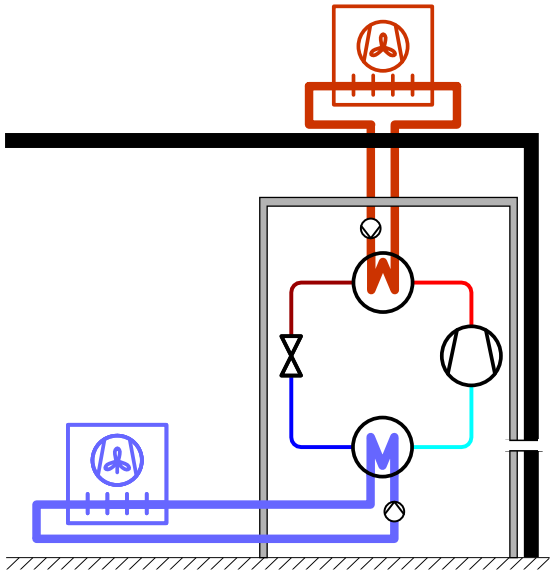
Types of electrically driven refrigeration systems



Direct System

- refrigerants: HFC, CO_2, HFO;
- condenser outside the building
- long refrigerant pipes with large filling quantities
- simple control system (HFC)

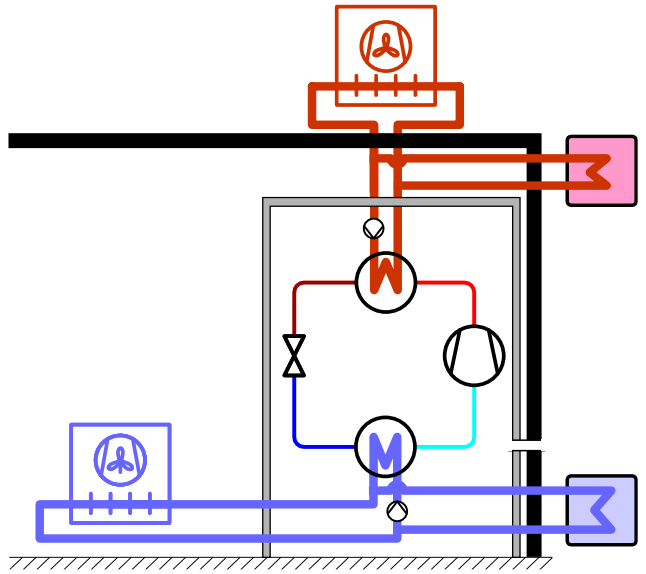
- low energy efficiency
- hydrocarbons (HC) as refrigerants with low filling quantities



Indirect System

- with coolant circuits for heat transfer
- encapsulated system with ventilation
- flammable, toxic refrigerants: HC, NH_3
- short refrigerant pipes with low filling quantities
- sophisticated control systems

- high energy efficiency



Extended indirect System

- additionally with cold and heat storage

- very high energy efficiency (not considered below)

3 Application fields

Process cooling

- Human air conditioning
- data centers
- cooling of chemicals, biological, pharmaceutical plants
- food production in plants
- blast freezers with year-round requirement

Commercial cooling

with low requirements in winter

- storage
- handling
- production
- packing and
- commissioning of all kinds of goods

Supermarket cooling

higher running time in winter due to refrigerated cabinets Amb. temp. 22 °C

- food retail
- discount stores
- hypermarkets

→ Comparison of annual energy consumption for 3 temperature ranges for these Application fields

– HFC systems (low energy efficiency) vs. state of the art systems with environmentally neutral refrigerants

– based on measurements and simulations with “CoolTool” (http://www.cooltool-software.com/)

Refrigerants for comparison of Energy consumption and efficiency

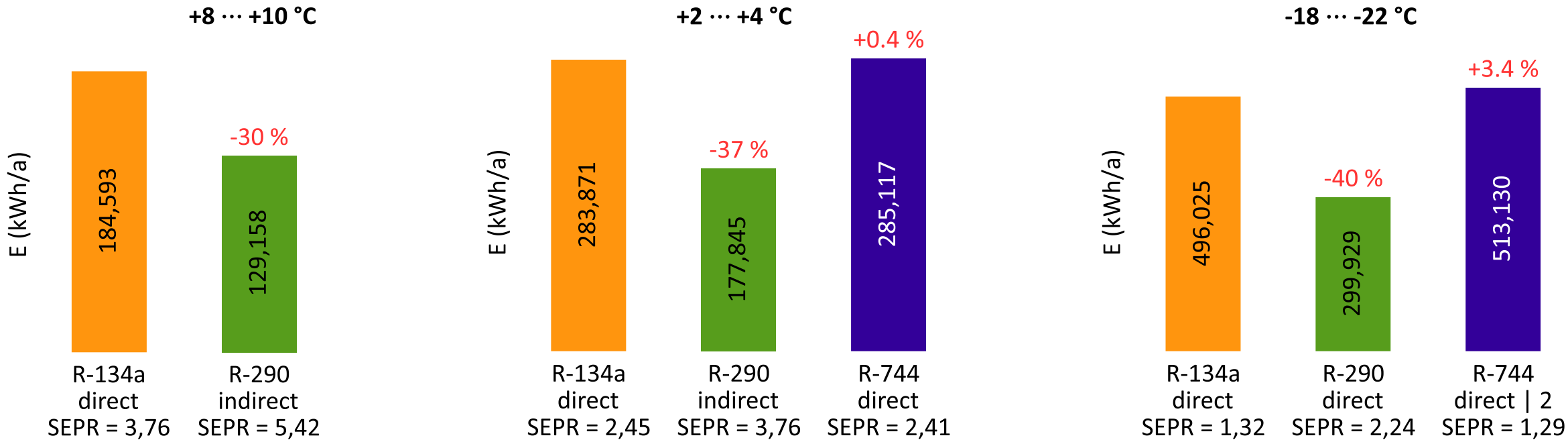
R-134a, R-404A: HFC refrigerants (to be phased out)
R-290, R-744: propane (hydrocarbon), CO_2 (carbondioxide)

HFO not considered below (not supported by the German Ministry of Environment)

SEPR = Seasonal Energy Performance Ratio
(Ratio of energy expenditure to benefit)

Process cooling at 3 temperature ranges

100 kW cooling capacity



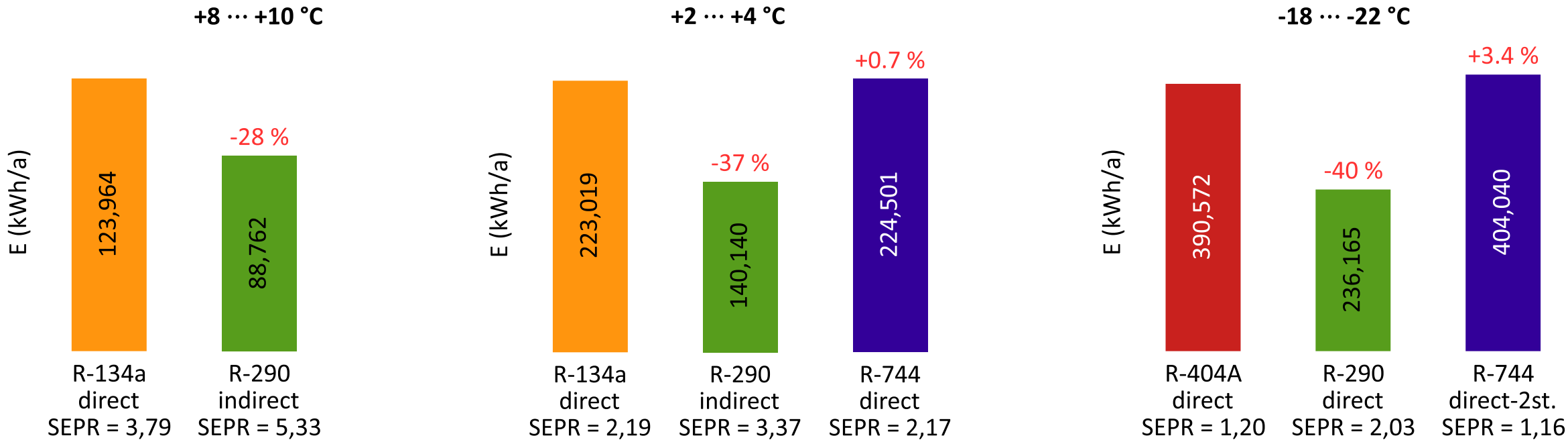
Simple HFC systems have a high energy consumption

– energy consumption of CO_2 systems is in the same range

– energy consumption of indirect propane systems is in all temperature ranges 30 - 40 % lower

Commercial cooling at 3 temperature ranges

100 kW cooling capacity



Simple HFC systems have a high energy consumption

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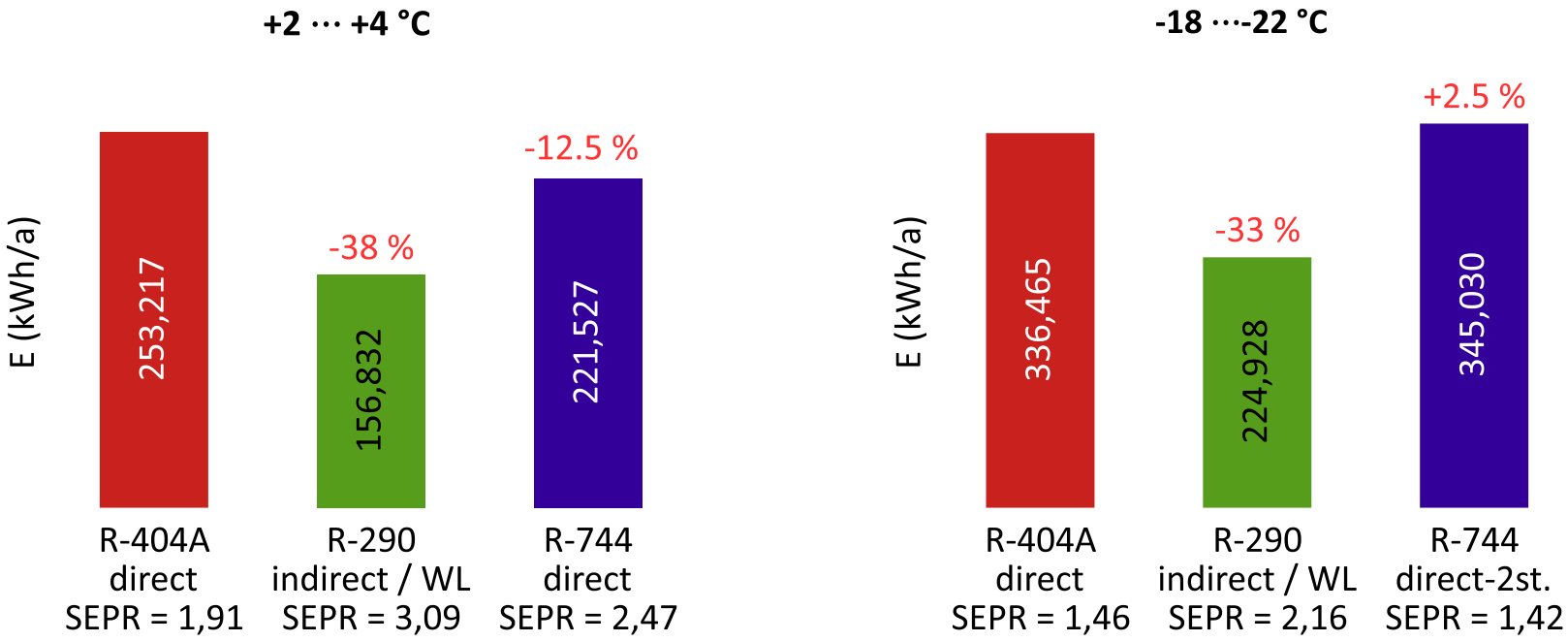
Supermarket cooling at 2 temperature ranges

100 kW cooling capacity



Simple HFC systems have a high energy consumption

– energy consumption of CO_2 systems is 12.5 % lower at normal cooling temperatures
– and 2.5 % higher at deep cooling temperatures
– energy consumption of indirect propane is in all temperature ranges 33 - 38 % lower

Summary

HFC refrigerants

- will globally no longer be available in the medium to the long term

Alternative (environmentally neutral) refrigerants are

- available
- proven
- cost effective
- and they are in part significantly more energy efficient