



Business Case for
Natural Refrigerants

04/09/2018 – Singapore

Transcritical CO₂ for cold storage facilities

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Application of CO₂ compared to R_{404A} under different climatic conditions

- Case study Edeka Warehouse / Germany
- Modernization
 - Change from R_{404A} to CO₂
- Storage area of 6,450 m²
 - Fruits (2,650 m²)
 - Chilled goods (3,800 m²)



Technology: Before Modernization

Storage area of 5,200 m²

- Technical equipment
 - 8 rack units
- Refrigerant:
 - R 422D (GWP = 2,620)
 - R 404A (GWP = 3,922)
 - R 407F (GWP = 1,825)



Technology: After Modernization Storage area of 6,450 m²

- Technical equipment
 - 2 rack units
 - Volumetric refrigeration capacity (R404 to CO₂) by factor 4-5
- Refrigerant:
 - R 744 (GWP = 1)



Technology: After Modernization Storage area of 6,450 m²

- Refrigerant: R 744
- Chilled goods unit:
 - MT 156 kW (to -2 °C)
 - LT cascade: LT 25 kW (to -33 °C)
 - Gas cooler: 320 kW (t_{GC} 38 °C)
- Fruit unit:
 - MT 135 kW (to 0 °C)
 - Gas cooler: 232 kW (t_{GC} 38 °C)

Modernizing under following conditions



Conversion during operation



Sustainable plant



Energy saving of approx. 10 %.

Conversion during operation



Sustainable plant

- Natural refrigerant
 - CO₂ / R 744
 - GWP 1
 - Long lasting
 - Stability of prices



Price comparison

- Refrigerant prices
 - R 744 = 17 SGD / kg
 - R404A = 127 SGD / kg
- 600 kg in use
 - R 744 = 10.200 SGD
 - R404a = 76.200 SGD



Energy saving of approx 10 % by increasing the evaporation temperature

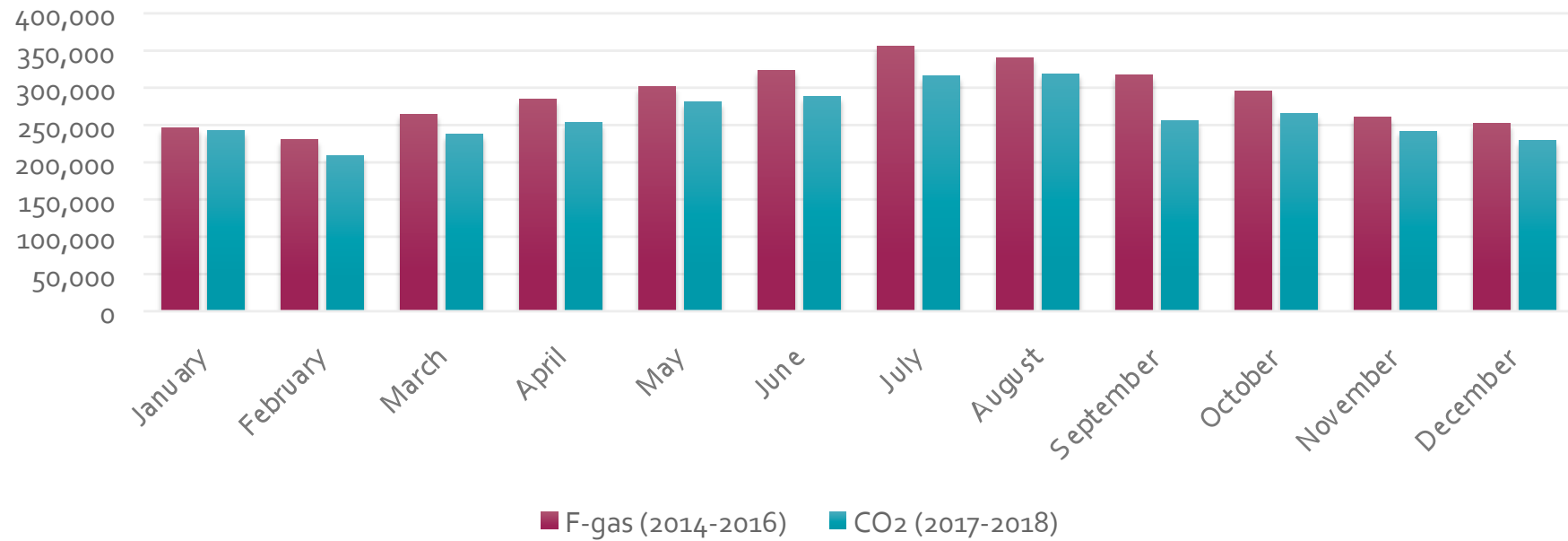
8 – 9 Kelvin by new design

- Chilled goods
 - to -12 °C → to -4 °C
- Fruit Unit
 - to -15 °C → to -6 °C

4 Kelvin by special TEKO technology

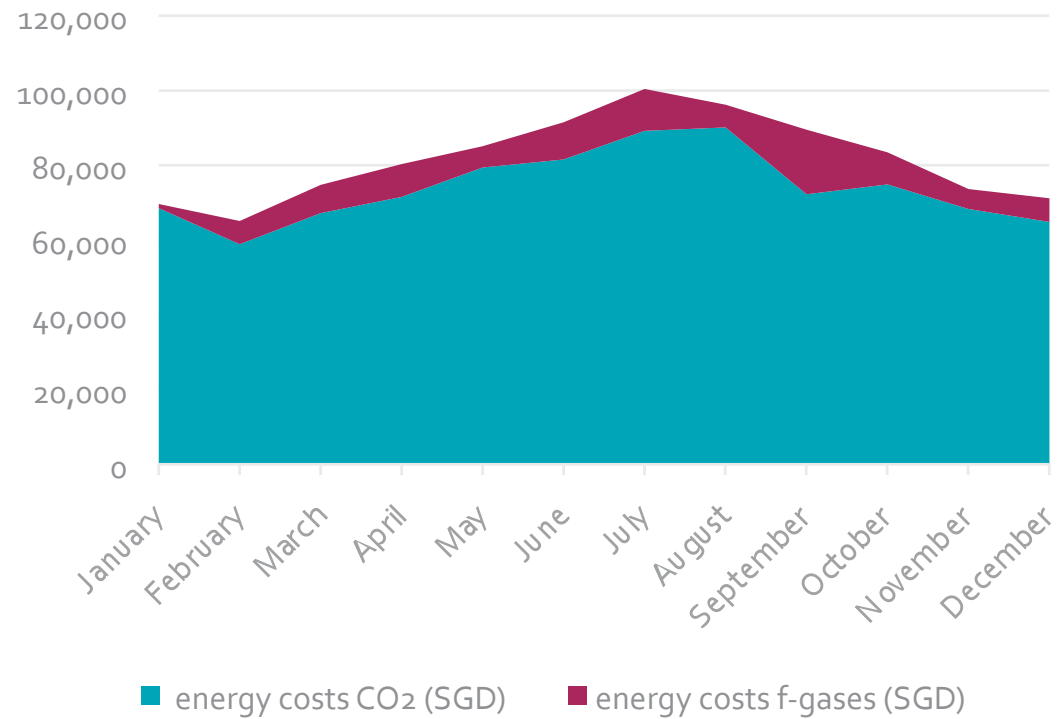
- Chilled goods
 - Additional to -4 °C → to 0 °C
- Fruit Unit
 - Additional to -6 °C → to -2 °C

Energy consumption (kWh)



Energy consumption per year

- 333.000 kWh
- 94.111 SGD
- 10 % savings compared to average 2014-2016
- With an enlargement of the area by 1,250 m²



“

*The new concept convinced me particularly by the **future viability of CO₂**. This system can withstand 20 years of operation without any restrictions.*

*Another **positive effect is the reduction in energy consumption**, which was made possible by the renewal and optimization of the system. We are highly satisfied with the result.*

”

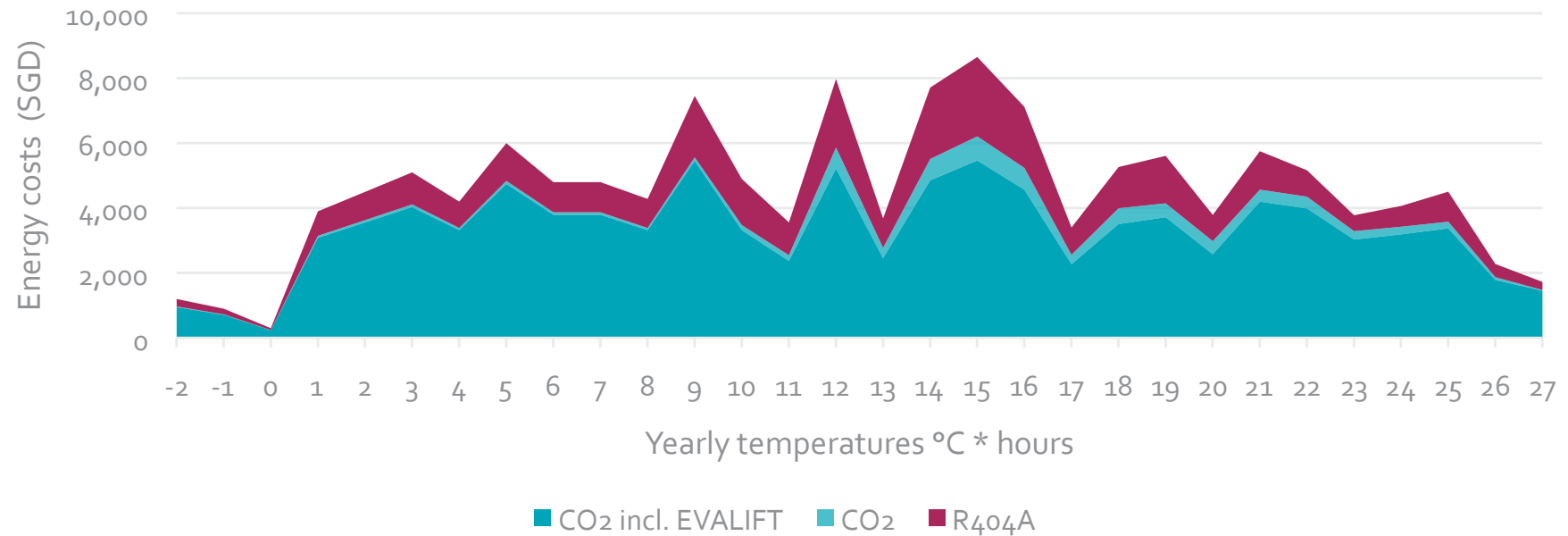
Mr. Helm / storage manager

Considered temperature zones

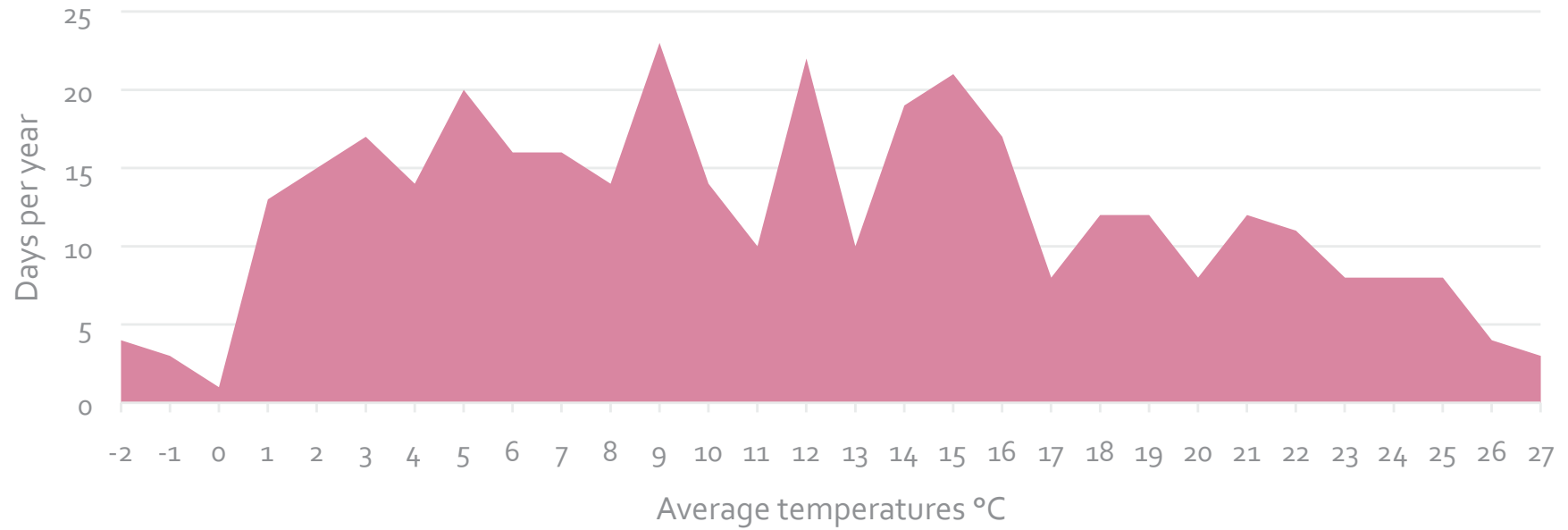
- Munich
 - Average temperature 8 °C
- Hanoi / Vietnam
 - Average temperature 25 °C
- Bangkok / Thailand
 - Average temperature 29 °C
- Singapore / Singapore
 - Average temperature 29 °C



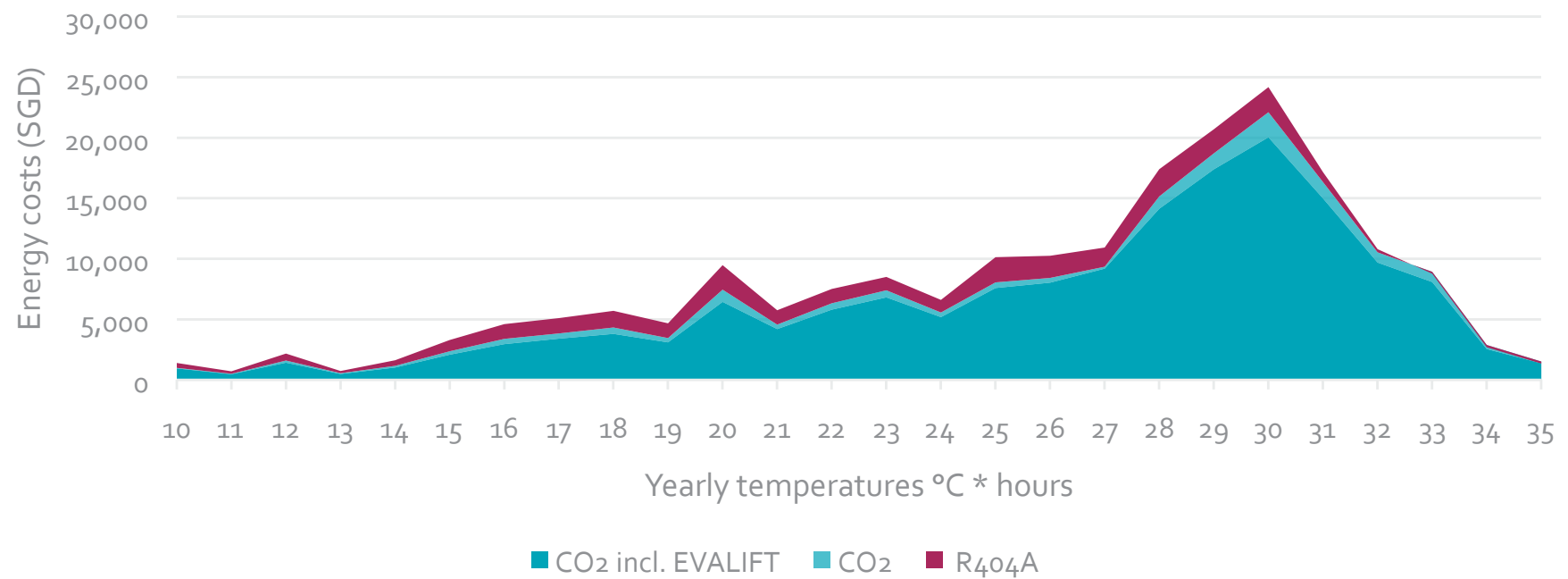
Energy costs per year in Munich (Germany)



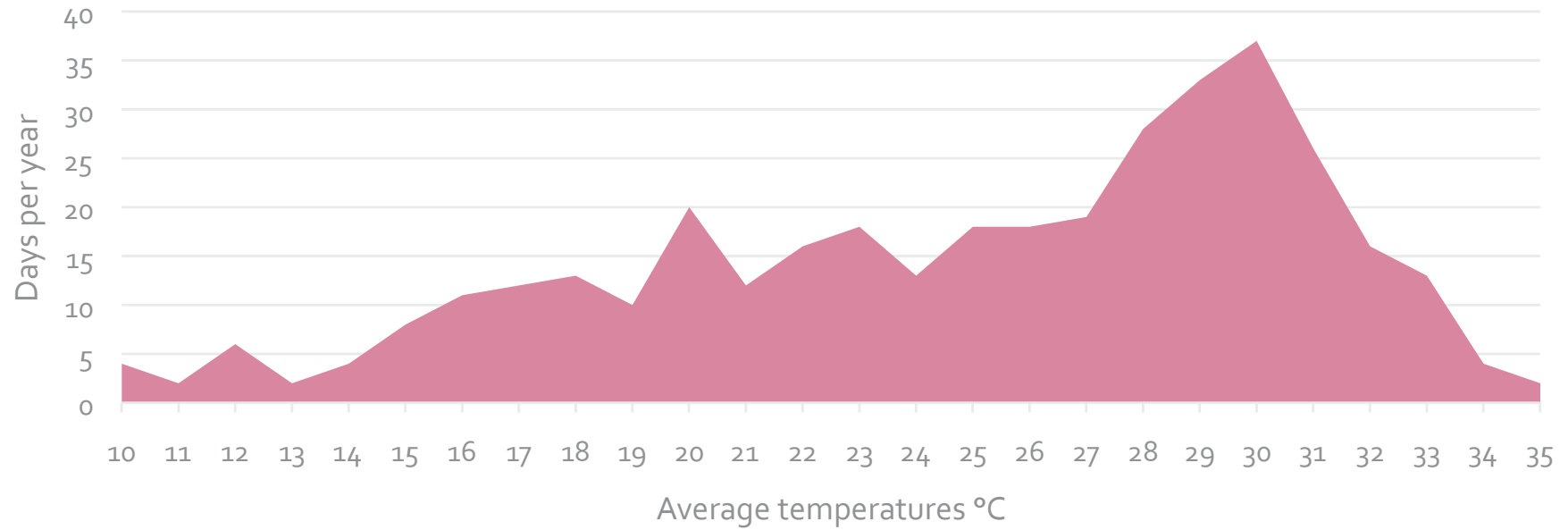
Munich (Germany)



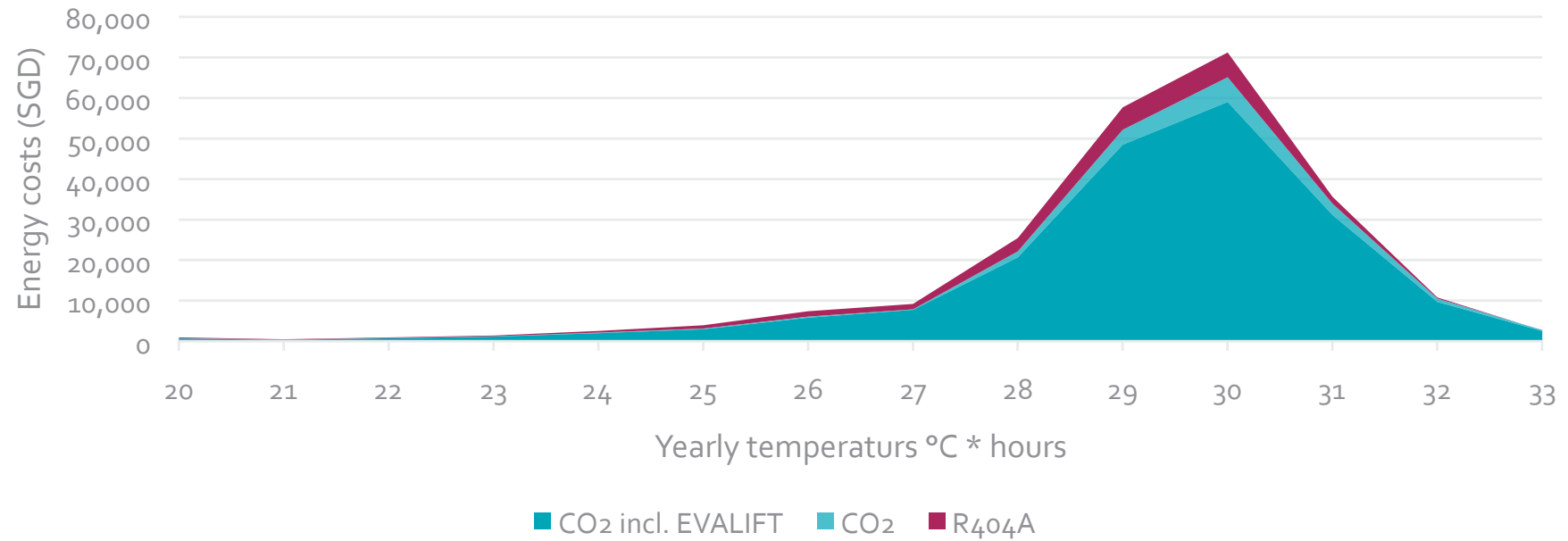
Energy costs per year in Hanoi (Vietnam)



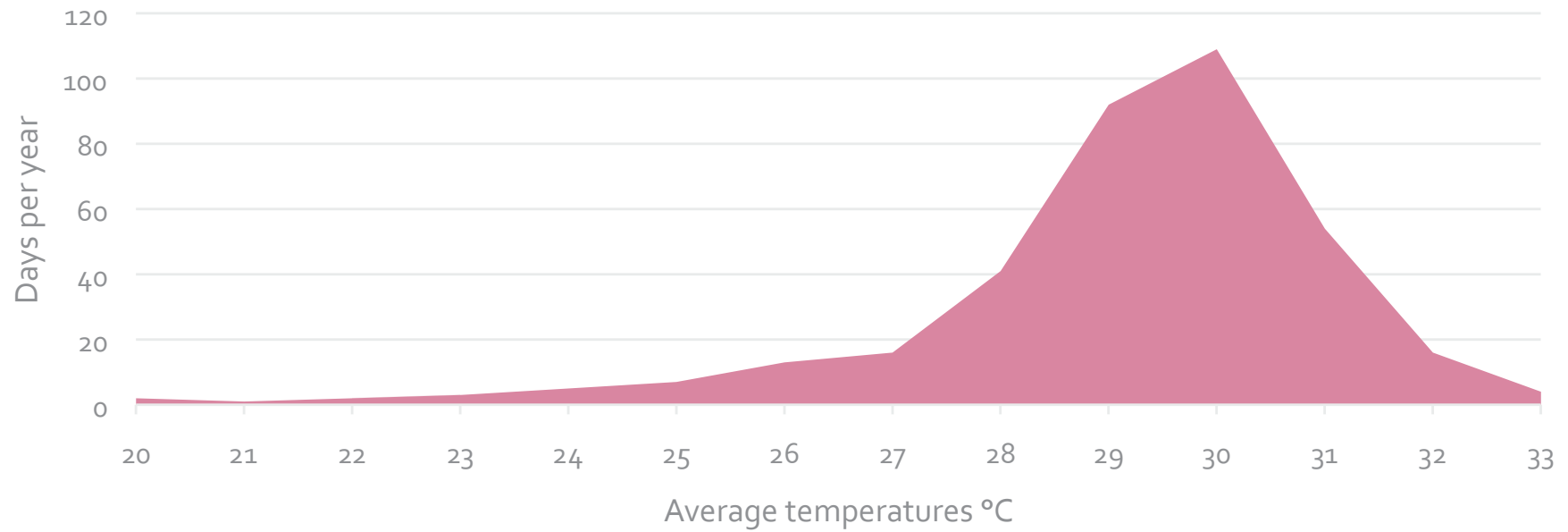
Hanoi (Vietnam)



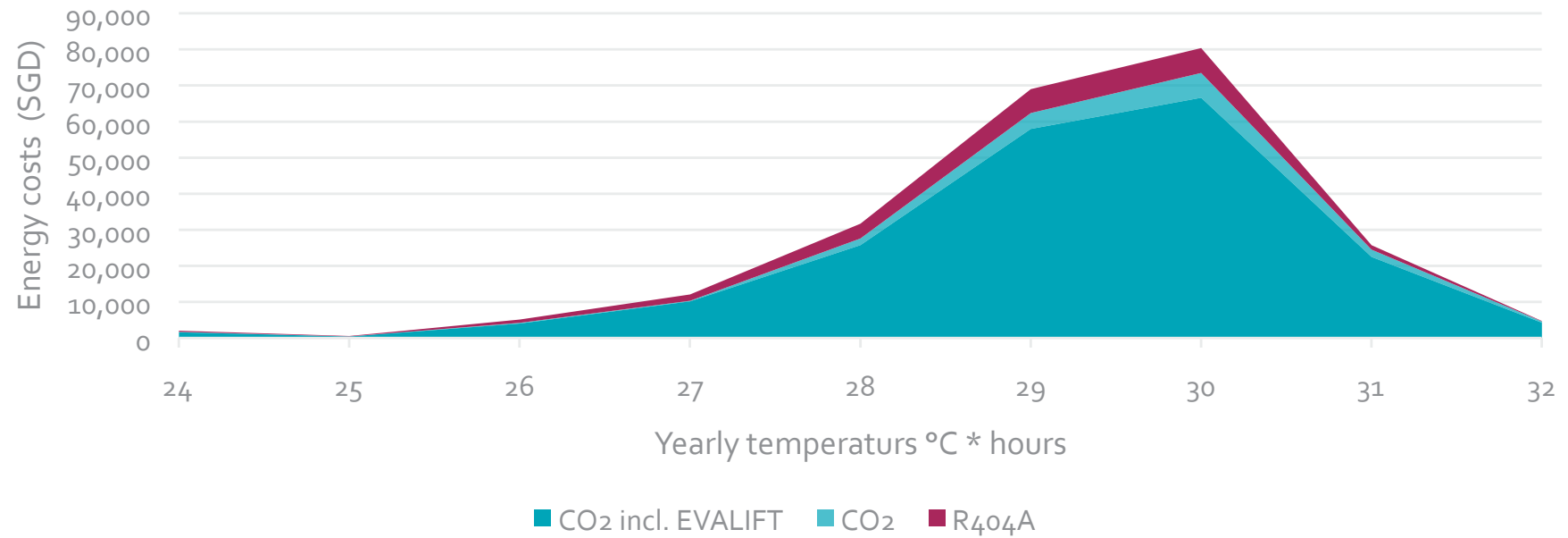
Energy costs per year in Bangkok (Thailand)



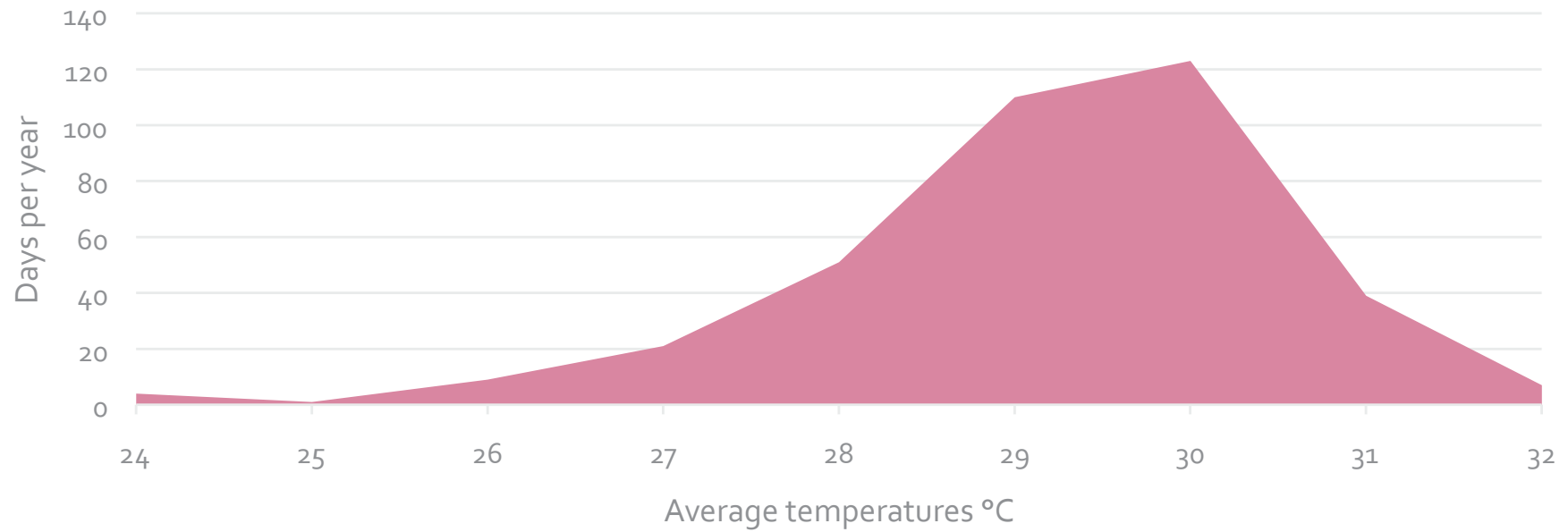
Bangkok (Thailand)



Energy costs per year in Singapore (Singapore)



Singapore (Singapore)



Energy costs per year (SGD)

Place	CO ₂	R _{404A}	%
Munich	105.608	136.382	29,14%
Hanoi	175.507	202.260	15,24%
Bangkok	209.056	230.418	10,22%
Singapore	209.262	231.326	10,54%

- CO₂ Unit
 - 156 kW to= -6°C / 25 kW to = -33°C
 - 135 kW to= -4°C
 - $t_{GK} \text{ ta} + 2K$
- R₄₀₄ Unit
 - 156 kW to= -6°C / 25 kW to= -33°C
 - 135 kW to= -4°C
 - $t_c \text{ } 20^\circ\text{C min} < \text{ta} + 13K$

Energy costs per year (SGD)

Place	CO ₂ incl. EVALIFT	CO ₂	Saving to CO ₂ %	Saving to R404A %
Munich	98.305	105.608	9,59%	38,73%
Hanoi	161.176	175.507	10,25%	25,49%
Bangkok	192.831	209.056	9,27%	19,49%
Singapore	193.209	209.262	9,18%	19,73%

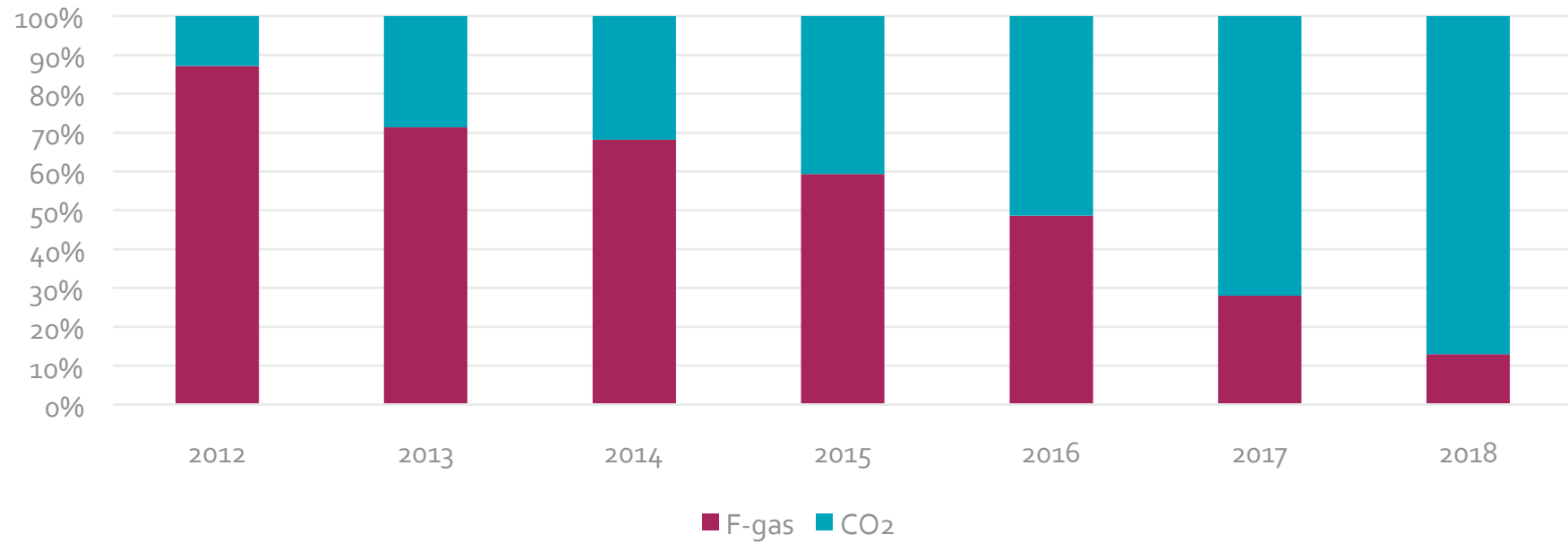
- CO₂ incl. EVALIFT
 - 156 kW to= -2°C / 25 kW to = -33°C
 - 135 kW to= 0°C
 - tGK ta +2K
- CO₂ Unit
 - 156 kW to= -6°C / 25 kW to = -33°C
 - 135 kW to= -4°C
 - tGK ta +2K
- R404 Unit
 - 156 kW to= -6°C / 25 kW to= -33°C
 - 135 kW to= -4°C
 - tc 20°C min < ta+ 13K

Conclusion

- CO₂ is a natural refrigerant
- CO₂ is an efficient refrigerant
- CO₂ shows its performances in northern regions as well as in Asian regions
- CO₂ can be even more effective by using technologies like EVALIFT or ejectors
- CO₂ technology is sophisticated

→ Installers and engineers have to be trained on CO₂

Installed TEKO Units



Series production at TEKO





Thank you for listening!

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