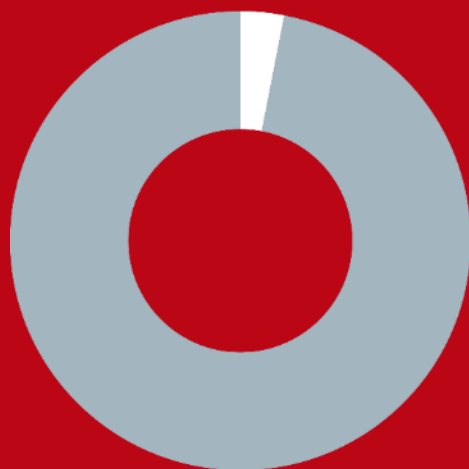


Getting to near Net Zero with the Danfoss Smart Store



Why do supermarkets **need to be energy efficient?**



3%

of the total electricity used in industrialized countries is accounted for by supermarkets. Refrigeration systems represent by far the highest share of the total energy consumed in supermarkets.



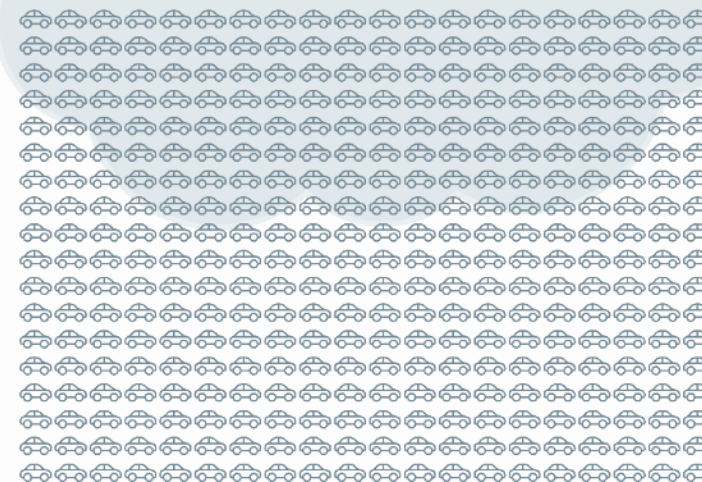
Total electricity use in industrialized

1,900

tons CO₂/year



An average-sized US supermarket emits 1,900 tons of CO₂ into the atmosphere. That's equivalent to the emissions from 360 vehicles in one year.



Environmental Investigation Agency and Shecco (2018), Technical report on energy efficiency in HFC-free supermarket refrigeration, p. 10.

Source: Supermarket case study

What Does it Take to get to Zero-Net stores



Is it possible to build a supermarket that has zero-net billable energy consumption, thermal and electrical throughout the year?

What about zero-net carbon footprint?

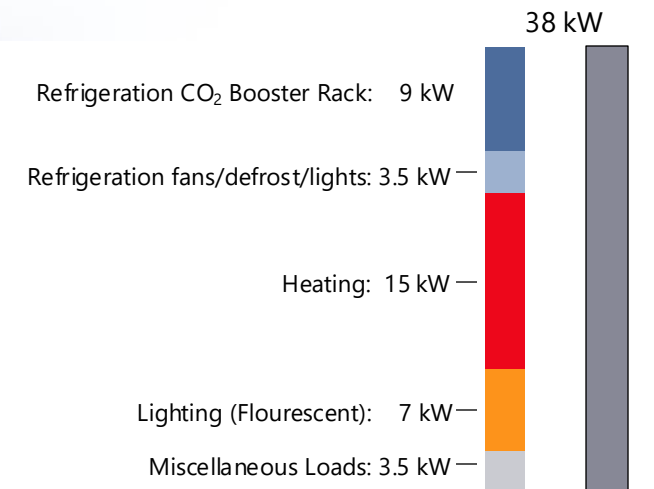
Steps to reaching Zero – Net:

- **Reduce** Consumption
- **Re-use** by Recovering Heat
- **Re-source** with Renewable Generation
- **Flex** with Demand Side Management
- **Export** Excess Heat

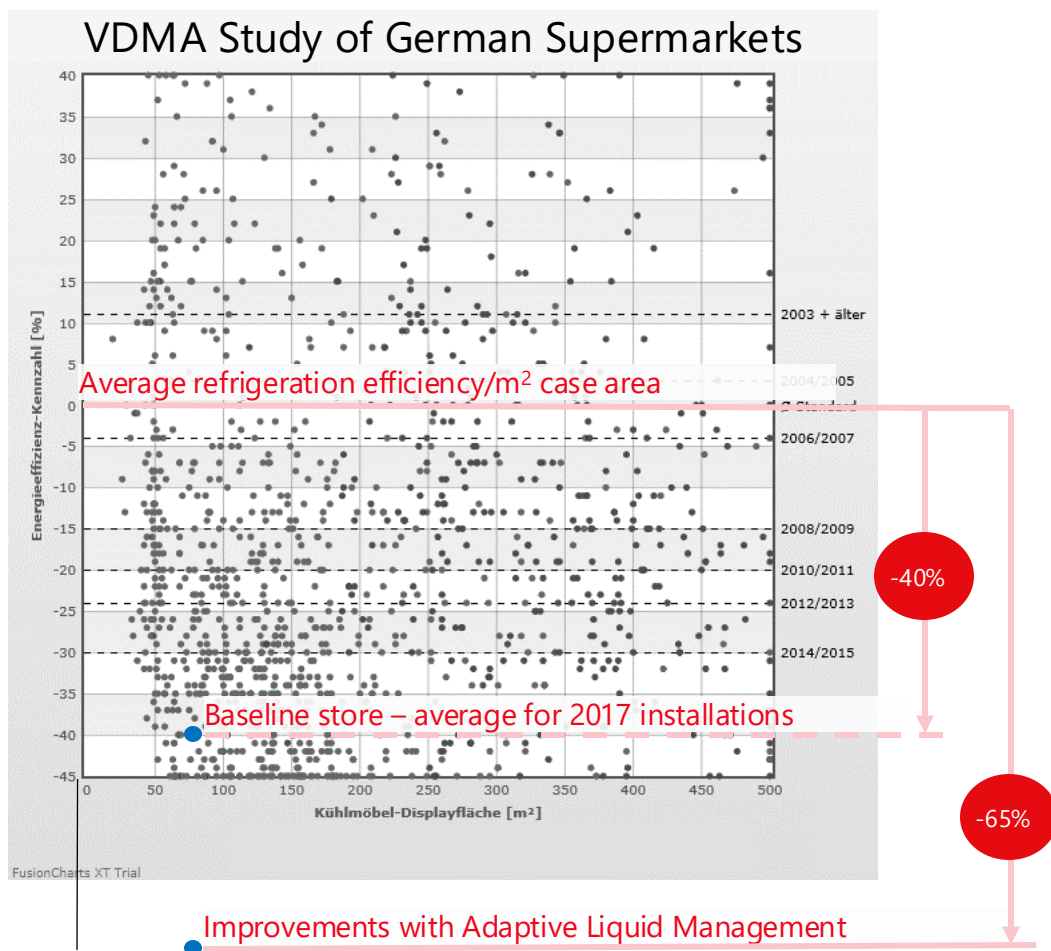


Case assumptions:

- Northern Europe climate
- 1200 m² store area
- 23 display cases
- CO₂ booster system (33/60 kW average/nominal capacity)



Reducing energy consumption; the fruit on the ground



Source: [VDMA Effizienz Quickcheck - Index \(vdma-effizienz-quickcheck.org\)](http://vdma-effizienz-quickcheck.org)

Refrigeration:

Optimized evaporator and case controls

- Reduces consumption by 25% on the baseline system
- 65% reduction on the market average

Lighting:

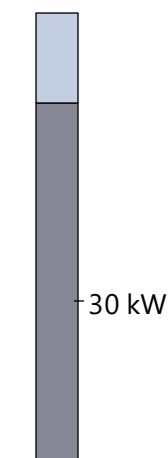
Replace fluorescent with high efficiency LED lighting reduces lighting consumption by 40%

Heating:

Low temperature floor heating or ventilation system increases system exergy, a precondition for efficient heat recovery

Auxiliary Equipment:

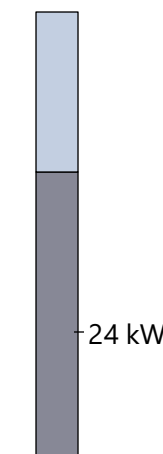
Energy Management System (EMS) with remote monitoring service allows for 30% reduction in other loads



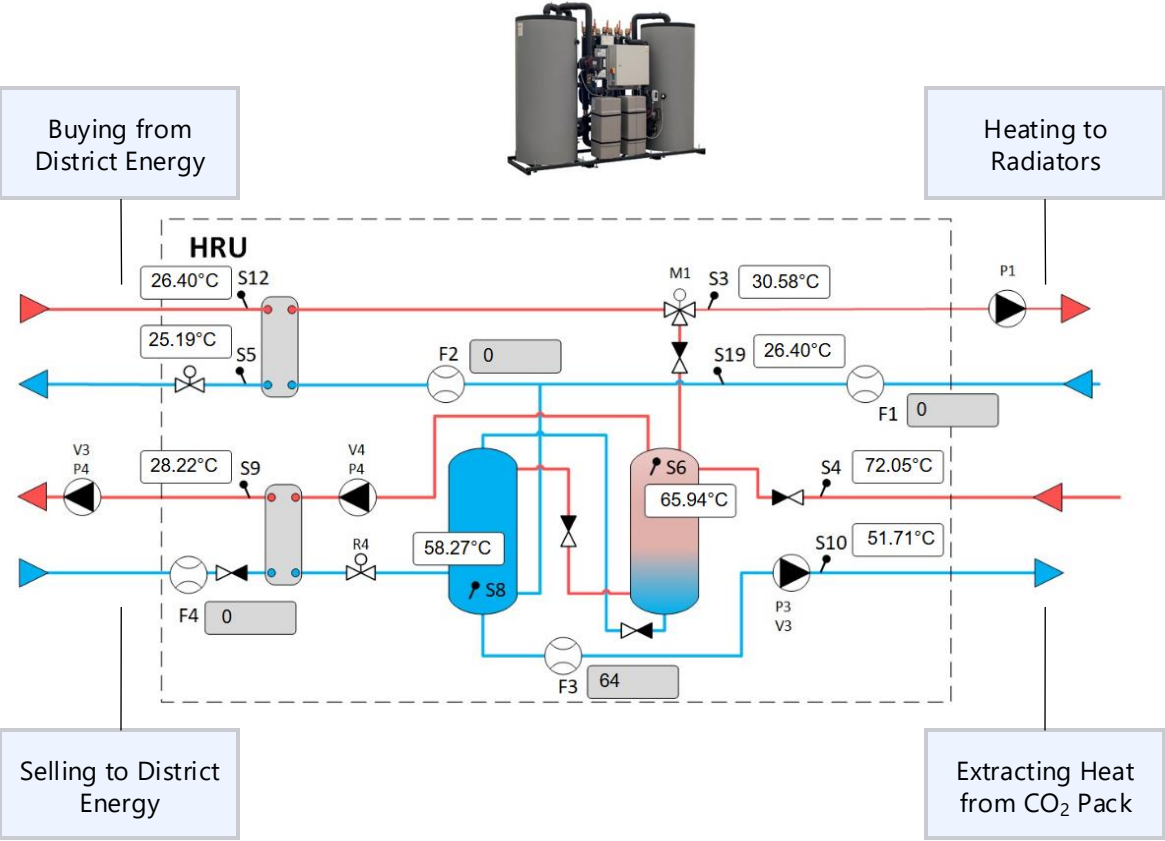
Onsite Energy Generation, PV is the way to go



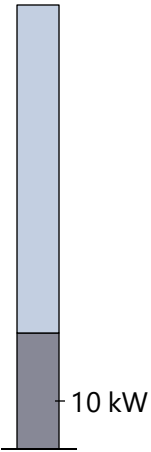
- Photovoltaic solar generating panel combined with a Lithium Ion battery technology can provide 5 to 10 kW on average
- Coincident with increased refrigeration loads in the summer months
- A solar array covering half of the roof, 600 m² provides annually: 53,000 kWh or 6kW average (24/7/365)
(346 x 1,65 m² panels, 700 kWh/m² annual solar radiation, 16,7% efficiency, 75% performance ratio)
- Energy arbitrage systems can be used to:
 - Optimize energy expense
 - Reduce carbon footprint



Heat Recovery covers the heating demand, and more...



- Heat recovered from the CO₂ refrigeration system covers 30 -50% of the heating demand without raising discharge pressures
- Raising the discharge pressure by 10 bar increases exergy (useful energy) by 50% with only a 20%(1,2 kW) increase in rack energy consumption.
- Regulating the discharge pressure, the entire heating demand should be met.



...the system is transformed to a power station



*Fitness Center, Augustenborg, Denmark heated via Danfoss HRU
in a COOP supermarket*

- In areas with district heating or in conjunction with multi-use buildings, apartments, offices, shopping centers the store can become a heating station
- Using the full 60 kW installed refrigeration capacity, drawing on ground or air source heat, and raising the discharge pressure the system can provide up to 70 kW of additional heating

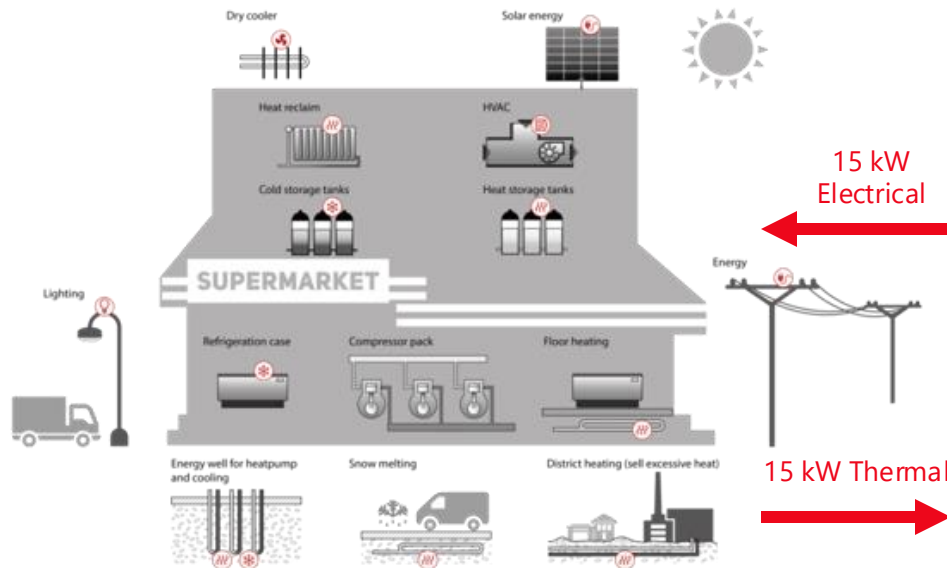
→(70kW +60°C water)

- Heating is needed year round, even in the summertime...

with only 35% utilization we reach zero-net energy!



In the end, doing more with less!



- A Zero-net billable energy supermarket is possible
 - Energy efficiency
 - Onsite generation and storage
- Energy arbitrage enables optimization of the energy bill
- Further potential to use supermarkets to balance the grid
 - Fast Frequency Reserve
 - Peak Load Shifting
 - Seasonal Buffering

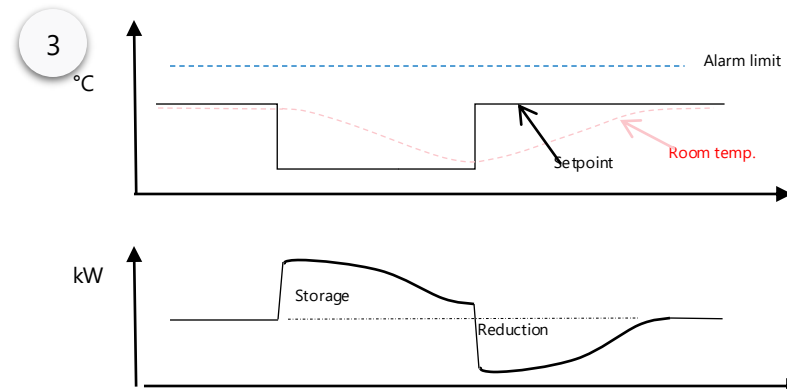
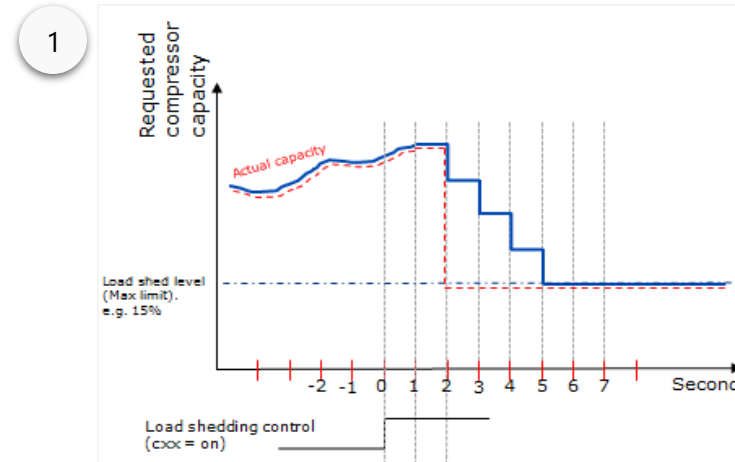
...Helping to reduce carbon footprints!

Types of Demand Side Management

What kind of flexibility do we have in the supermarket?



1. Load shedding / FFR (compressors)
2. Defrost shifting
3. Thermal storage
4. Rail-heat /Anti-sweat heaters
5. Light dimming
6. HVAC



Danfoss Smart Store ADC

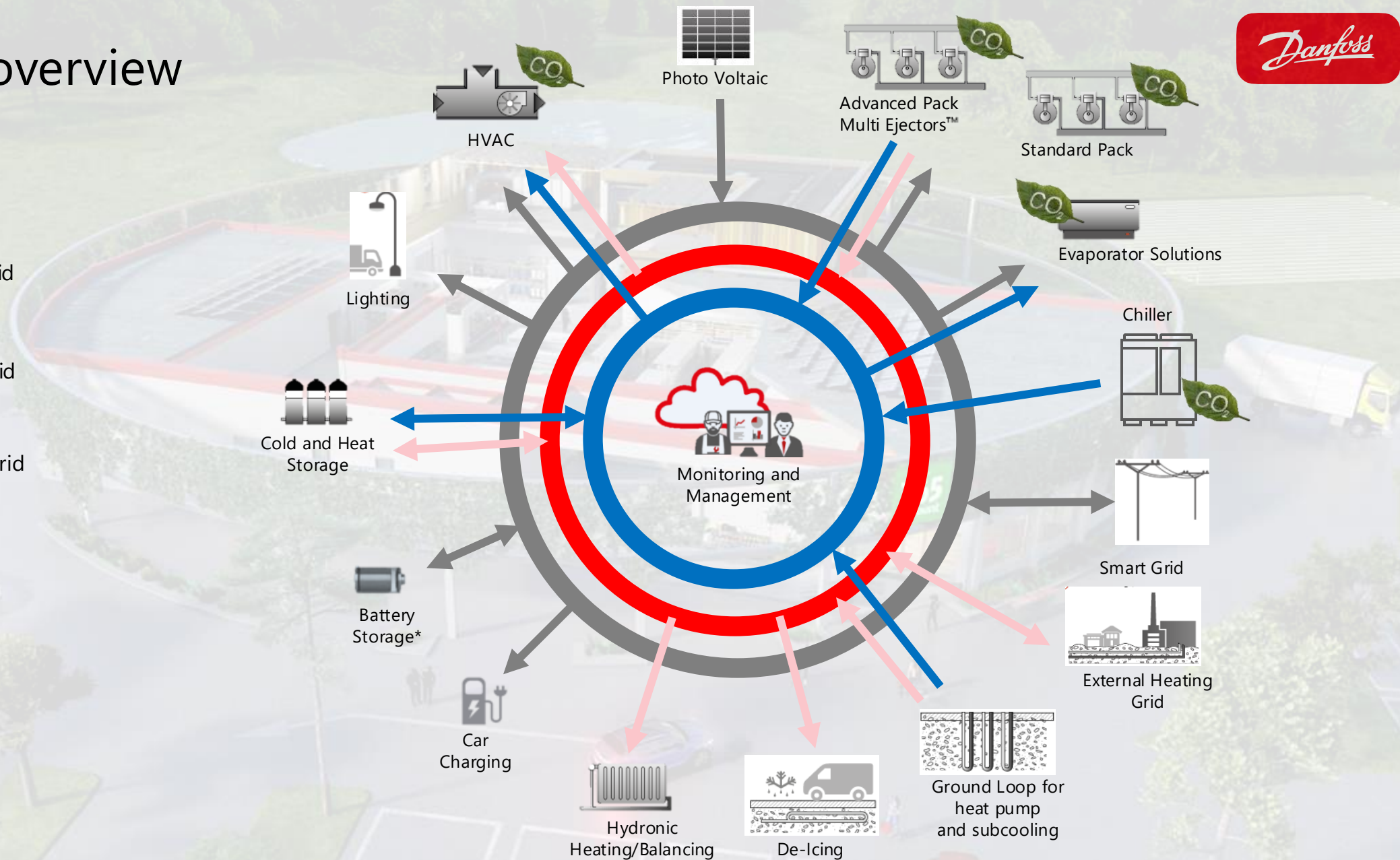
Location: Danfoss' headquarters in Nordborg, Denmark



Systems overview



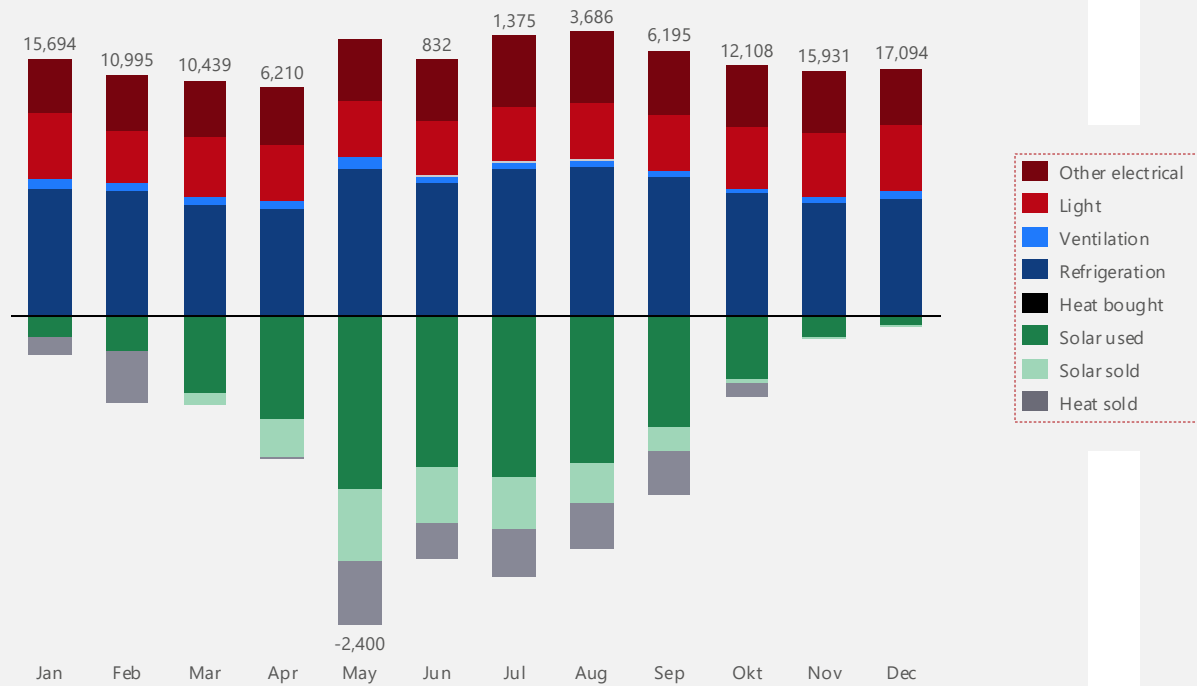
-  Cooling Grid
-  Heating Grid
-  Electrical Grid



Net of Electrical & Thermal energy the Smart Store consumed 58% less than the benchmark store in the COOP 365 portfolio

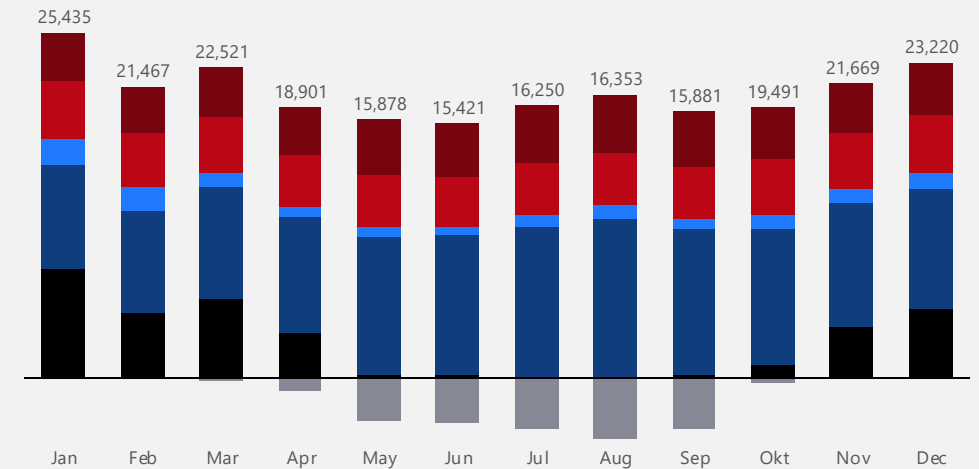


- Smart Store - Net energy **98 MWh** (11kW annualized average)



- 35% (77,5 MWh) of consumed electricity produced by solar PV
- Additional **22 MWh electricity was sold** to the grid
- All heating was recovered** from the refrigeration system
- Additional **23 MWh heat was sold** to the Sonfor

- Benchmark Store - Net energy **233 MWh**



According to AK-Centralen monitoring service, the Benchmark store is a top performer in the COOP-365 portfolio of stores across Denmark

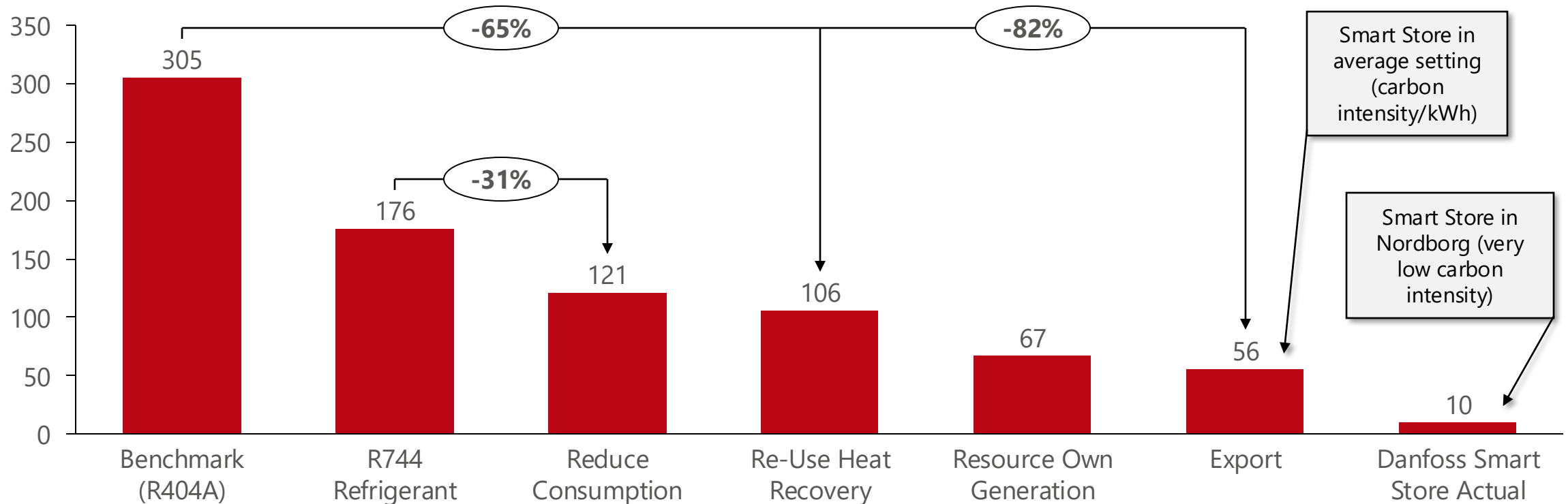
- Additional 32 MWh heat bought from Sønderborg Varme

Decarbonization path of a Smart Store

Refrigerant Options, Control Optimization and Heat Recovery



Tons CO₂eq/annum*



*Based on average global carbon intensity of electricity generation (470g/kWh) and natural gas heating (220g/kWh).
Actual figures for Nordborg vary as all power is via sustainably sourced PPA's



Thank you



Hans Matthiesen
Senior Director, Global Application Development Centers

hom@danfoss.com