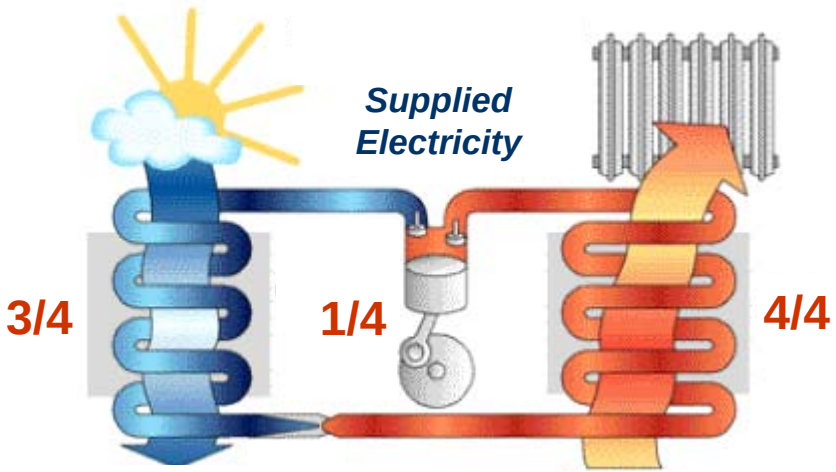
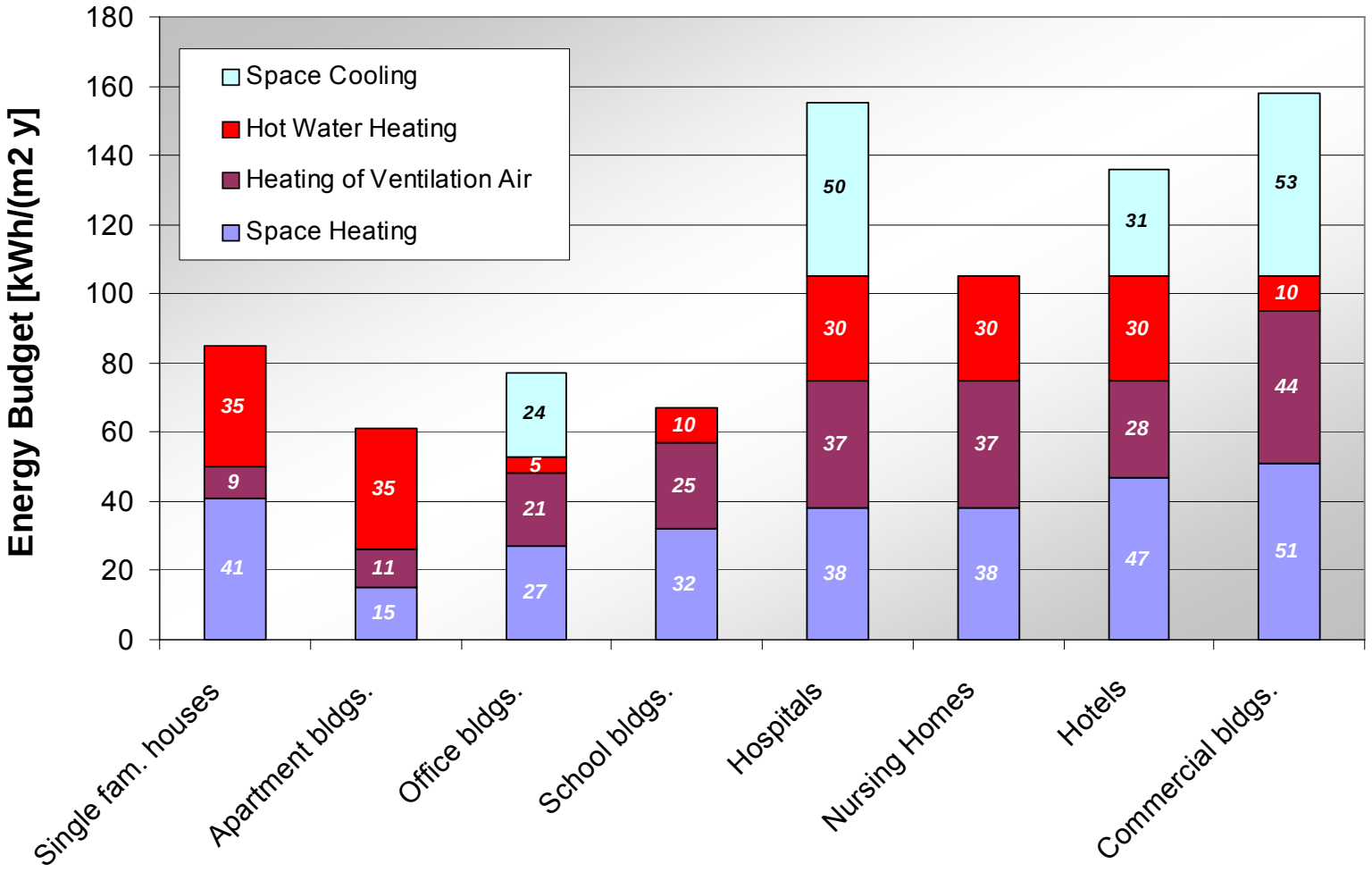
The Directorate of Public Construction and Property
SINTEF Energy Research – Dept. Energy Processes

CO_2 Heat Pumps for Heating and Cooling of Non-Residential Buildings



Proposal for New Building Codes (2006)

Energy Demand in Buildings – Total Energy Budget [kWh/(m²y)]



Heat Pumps for Heating and Cooling of Non-Residential Bldgs.

- The annual heating demand is covered with high energy efficiency
  - Seasonal Performance Factor (SPF*) > 3-4
- A large share of the annual cooling demand is supplied as a by-product of the heat production from the heat pump or covered by free cooling:
  - Sea water
  - Ground water
  - Energy wells in rock – thermal energy storage

$$* \text{SPF} = \frac{Q_{\text{delivered}}}{E_{\text{supplied}}}$$


Norsk Hydro, Vækerø

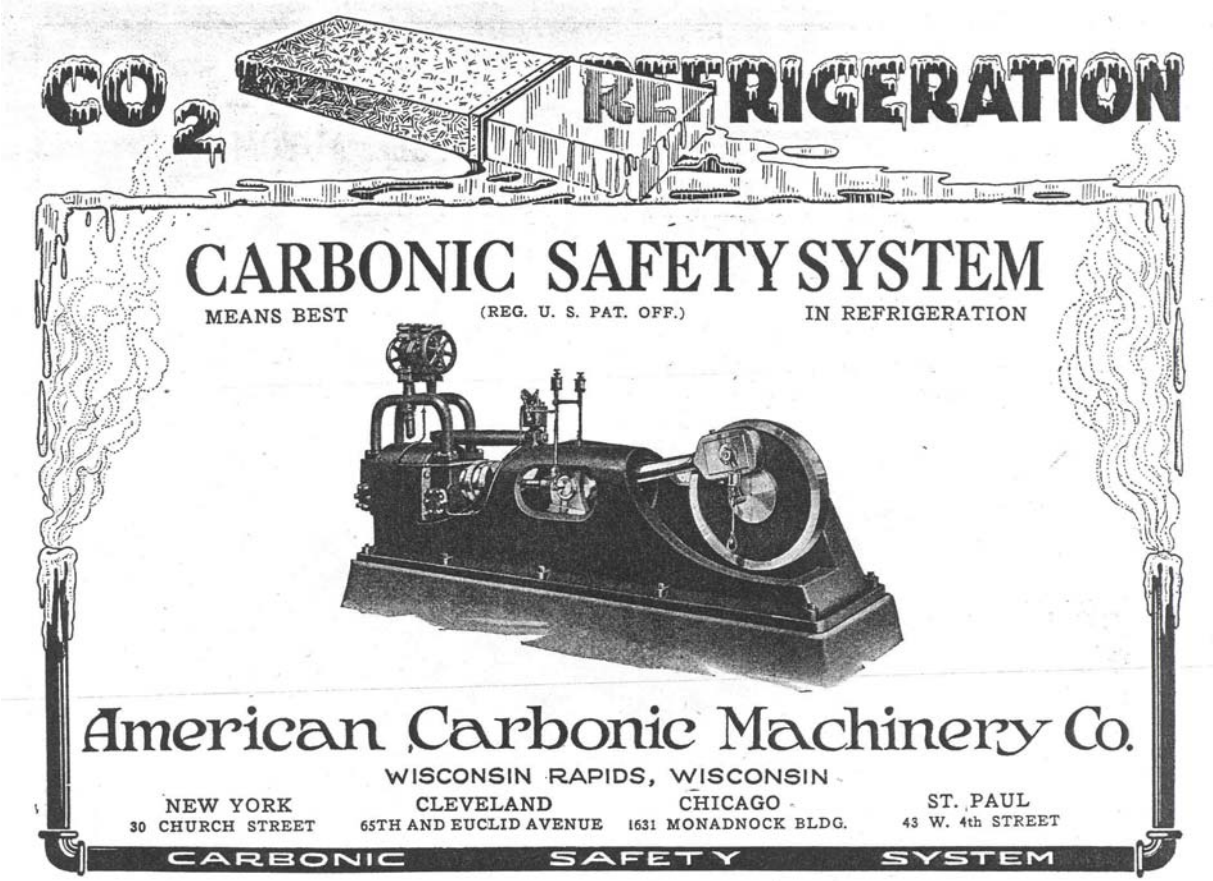

Ericsson-bygget, Asker


Alnafossen kontorpark, Brynseng

Nydalen næringspark, Nydalen

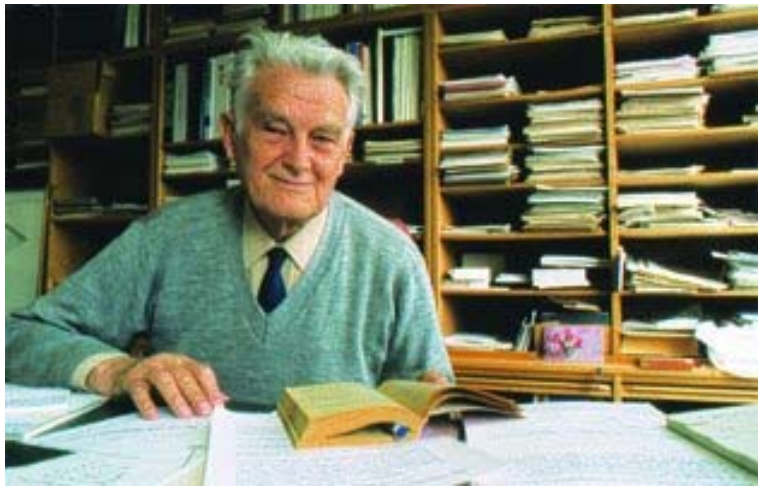

Lena Terrasse. Melhus

CO_2 Used as a Working Fluid

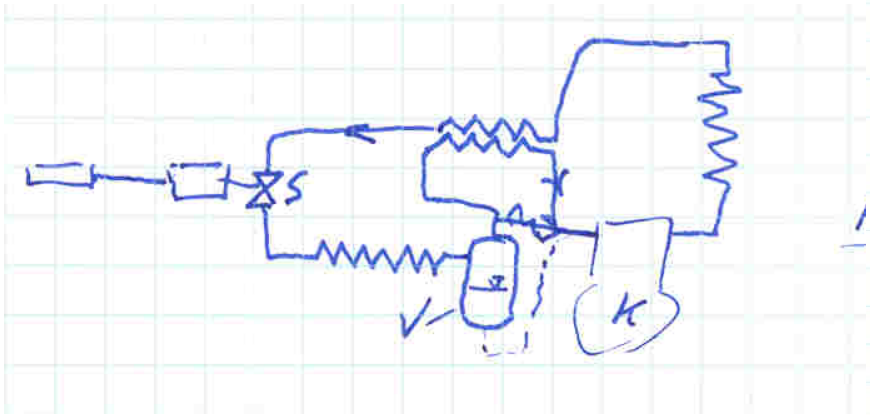


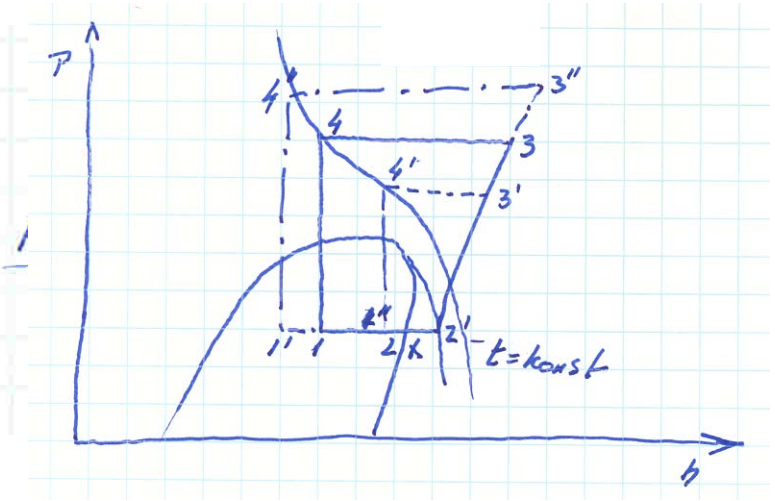
- CO_2 (R744) used in refrigeration and AC systems up to approx. 1950

CO_2 Used as a Working Fluid



- Reintroduced by professor Gustav Lorentzen (1915-1995)
- First patent on a transcritical CO_2 system in November 1988





Carbon Dioxide (CO_2)

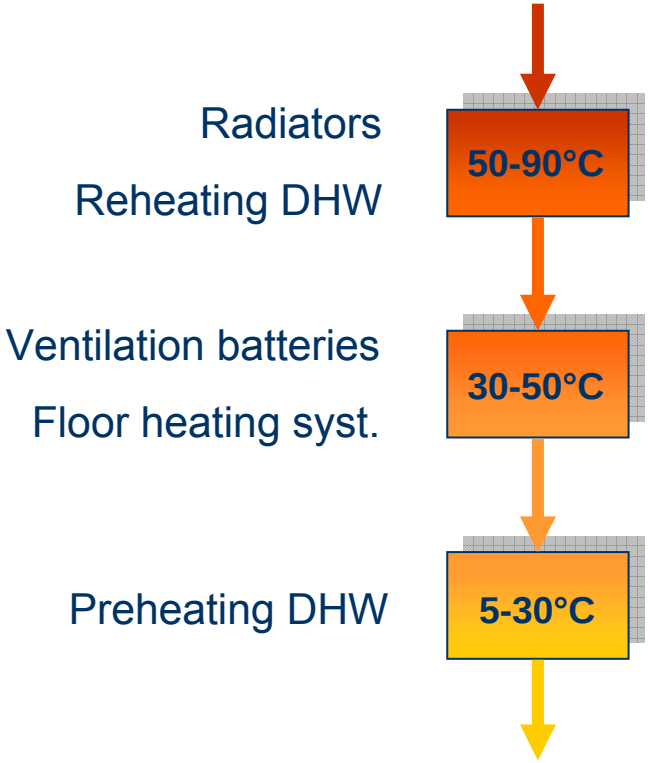
Summary of Main Properties and Characteristics

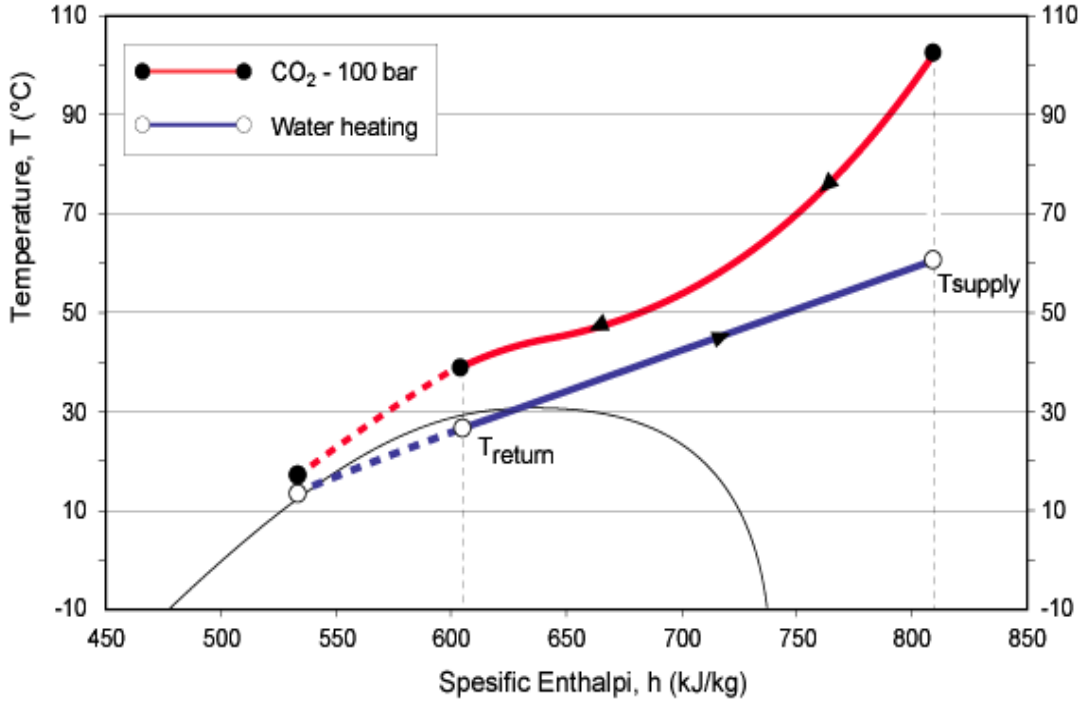
CO_2

- **Low critical temp. (31.1°C) – high critical pressure (73.8 bar)**
  - Heat rejection at supercritial pressure → transcritical heat pump cycle
  - High pressures at evaporation and heat rejection (25 to 150 bar)
- **Moderate molar weight (44.01) – very high gas density**
  - Compressor volume only 10 to 25% of conventional compressors
  - Small dimensions on heat exchangers and tubing
- **Favourable thermophysical properties**
  - Excellent heat transfer → low temp. differences in heat exchangers
  - Low pressure ratio → high compressor efficiency
- **Other properties**
  - ODP=0, GWP=0 → no negative impact on the global environment
  - Non-flammable, non-toxic, odourless, inert, stabile → safe fluid

CO_2 Heat Pumps in Non-Residential Bldgs.

Heat Rejection Process in a Temperature-Enthalpy Diagram

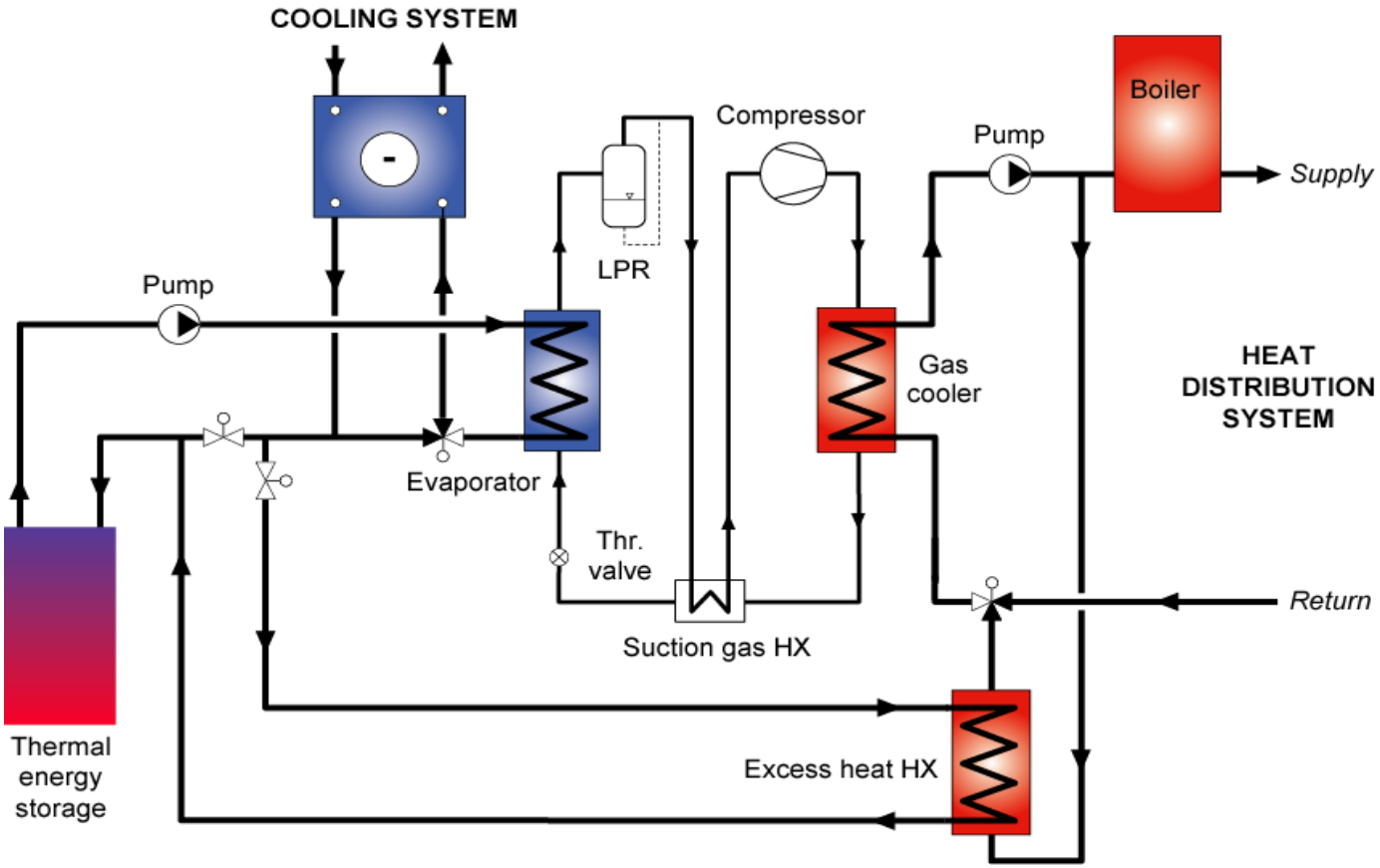




Falling return temperature in the heat distribution system **increases the COP** for the CO_2 heat pump ⇒ **Serial connection of heat loads at falling temp. levels**

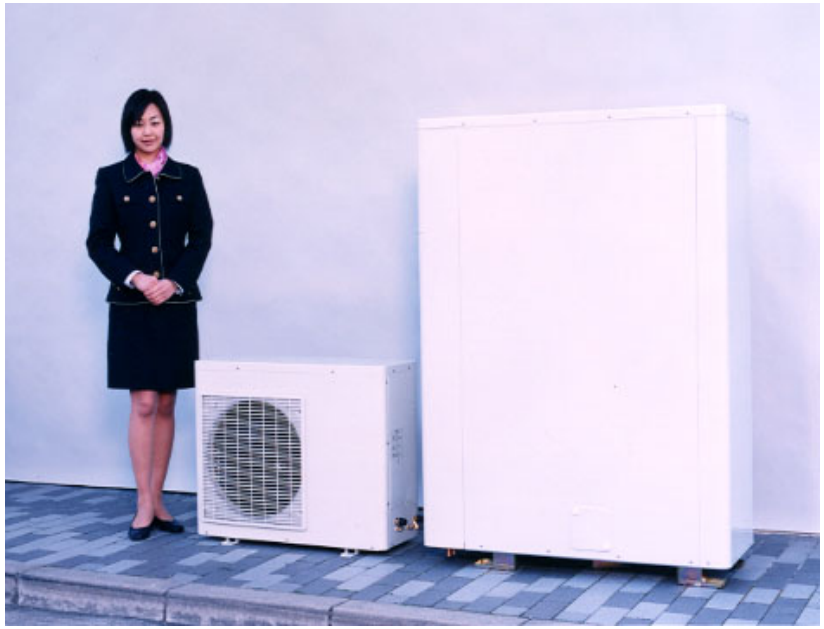
Example of CO_2 Heat Pump System

Combined Heating and Cooling – Use of Thermal Energy Storage



CO_2 Heat Pump Water Heater

Manufactured by Denso Corporation Ltd., Japan (2001-2002)



- Hot water heating
- Ambient air as heat source
- 4.5 kW heating capacity
- 85°C hot water temperature
- The world's first commercial CO_2 heat pump

- CO_2 technology developed at NTNU-SINTEF, Trondheim
- Shecco Technology™ has exclusive licence rights to the CO_2 technology patents

Integrated CO_2 Heat Pump

"EcoCute" – Manufactured by Denso Corporation Ltd., Japan

- Space heating & hot water heating
- Ambient air as heat source
- 6.0 kW heating capacity
- 65/90°C hot water temperature
- 200.000 units sold in 2003/2004

- CO_2 technology developed at NTNU-SINTEF, Trondheim
- Shecco Technology™ has exclusive licence rights to the CO_2 technology patents

CO_2 Heat Pumps in Non-Residential Bldgs.

Environmental Benefits – Technical Benefits/Challenges

- CO_2 – environmentally benign and safe
- May achieve higher SPF than conventional heat pumps
  - Requires a relatively low return temp. in the heat distribution system
    - *Serial connection of radiators and ventilation batteries is required*
    - *The operating time of the ventilation system is a critical parameter*
    - *A large hot water demand is favourable*
  - Possible to increase the energy efficiency by applying special system design and components, e.g. replacing the throttling valve with an ejector
- No temperature limits when supplying heat
  - Can supply heat to high temperature hot water systems (<95°C)
  - Can supply heat to high temperature radiators (80-90°C)

讲座完毕

谢谢您！