The Directorate of Public Construction and Property

CO₂ Heat Pumps for Heating and Cooling of Non-Residential Buildings

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

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- Space Cooling
- Hot Water Heating
- Heating of Ventilation Air
- Space Heating

- Single fam. houses
- Apartment bldgs.
- Office bldgs.
- School bldgs.
- Hospitals
- Nursing Homes
- Hotels
- Commercial bldgs.
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

\[ * \text{SPF} = \frac{Q_{\text{delivered}}}{E_{\text{supplied}}} \]
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 (CO₂)
Summary of Main Properties and Characteristics

- Low critical temp. (31.1°C) – high critical pressure (73.8 bar)
  - Heat rejection at supercritical 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, stable → safe fluid
CO₂ 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 CO₂ 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
**CO₂ 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 CO₂ heat pump

- CO₂ technology developed at NTNU-SINTEF, Trondheim
- Shecco Technology™ has exclusive licence rights to the CO₂ technology patents
Integrated CO₂ 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

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**CO₂ Heat Pumps in Non-Residential Bldgs.**

*Environmental Benefits – Technical Benefits/Challenges*

- CO₂ – 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！