CO_2 has been successfully introduced in some supermarkets but is this the answer? When leading compressor manufacturer Emerson Climate Technologies investigates the options, the industry listens

What refrigerant for supermarkets?

SUPERMARKETS are coming under increasing pressure from some quarters to move away from HFCs to CO_2, but is this the answer? What are the benefits and can they be clearly stated in quantified terms?

A new research study by compressor manufacturer Emerson Climate Technologies is designed to help end-users through the complex decision-making process when specifying supermarket cabinet cooling systems. It focuses on the refrigerant but takes into account the refrigeration system architecture and technology which have an impact on energy consumption, environment and investment costs.

The Emerson report uses data based on typical supermarket cooling loads and known compressor performance to compare the relative power consumption and lifetime CO_2 emissions (TEWI) for various systems. Realistic direct emission and refrigerant charge assumptions together with the same operating conditions throughout ensures that the comparison is valid.

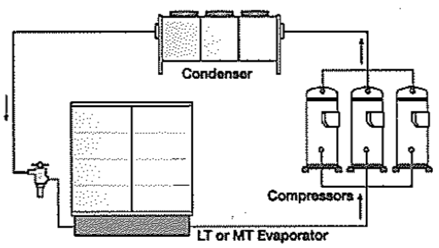
Five system types with various system, compressor technologies and refrigerants were considered. They are shown and described in Fig 1 below.

Assumptions

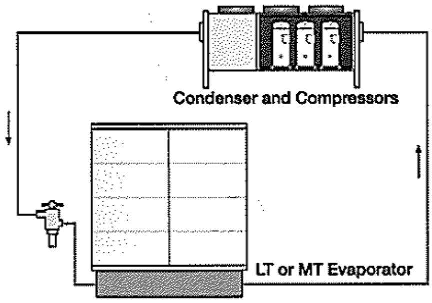
In order to provide a meaningful comparison, Emerson Climate used various standard conditions. The leakage rates chosen for the TEWI calculations were 15% for DX centralised and 10% for distributed DX. For secondary systems using factory built chillers the rate was taken as 5%. Typical charge values for the various system types have been used throughout. The cascade system (MT part) was treated as DX in this analysis.

Obviously any reduction in leakage rates for the HFC systems will have a reduction impact on the final TEWI value.

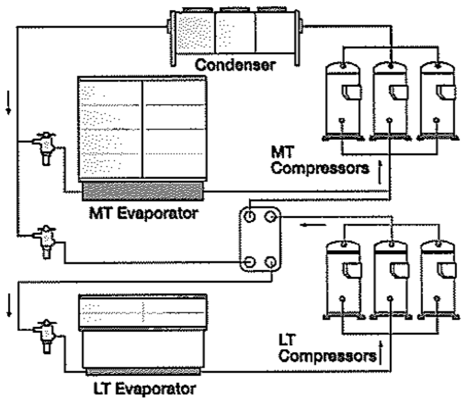
Fig 1: The five system types considered



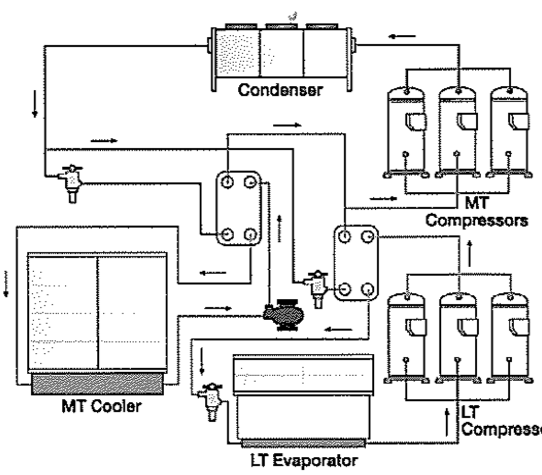
1. Centralised Direct expansion (DX) system using various HFCs (R404A/R407A/R407F/R134a) for both the LT and MT frozen and chilled display cabinets



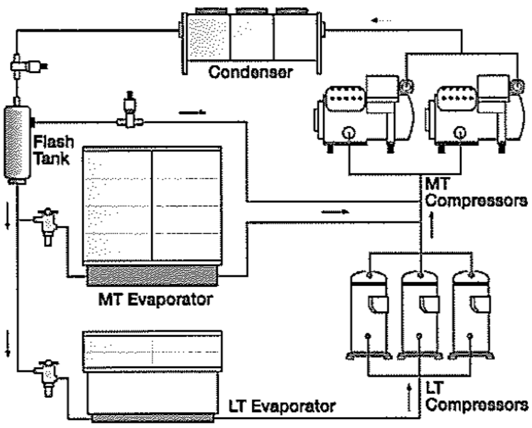
2. Distributed DX systems for LT and MT, utilising HFCs and a compressor/condenser housing located close to the frozen and chilled display cabinets



3. Cascade systems, where the LT has a separate circuit that discharges its heat into the suction stage of a DX MT system. The refrigerant options include R744 (CO_2) for LT and various HFCs for the MT



4. Secondary systems, where a secondary refrigerant distributes the MT cooling around the supermarket. The LT operates in the same way as the cascade system. The refrigerant options include R744 for LT and R290 and HFO for MT



5. CO2 Transcritical (T/C) Booster system

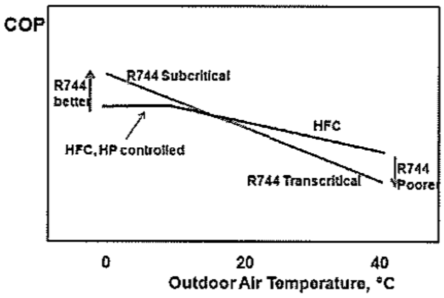


Fig 2: COP trend with outdoor temperature

A condensing temperature of 25°C was used to represent average UK operating conditions.

For R744 lower pressure drops and better heat transfer properties reduce the compressor "lift". The R744 head pressure was allowed to float down to a temperature well below 20°C to enable a transcritical system to operate in conventional mode.

With all these benefits taken into account, the R744 booster system was able to reach the same average COP as a typical reciprocating DX centralised system.

This is the usual comparison, says Emerson Climate, and in the analysis it is assumed that the R744 transcritical system would consume the same amount of power per year as an R404A DX centralised system with reciprocating compressors.

Fig 2 shows the COP trend with outdoor temperature. It indicates that the transcritical system must be operated in subcritical mode for a substantial number of hours in order to offset the low efficiency at high outdoor air temperatures.

Findings

These are shown graphically in Fig 3 and 4. Emerson Climate point out that the values are built from actual compressor performance data except in the cases of R290 and HFO where realistic COP estimates based on known performance characteristics have been used.

Emersonn Climate says that HFOs were not considered as a DX type refrigerant due to their high cost and the fact that like R134a they require significantly more compressor displacement.

Investment cost

Emerson Climate maintains that comparative information can be built up from known component cost data and by making realistic assumptions about the installation cost differentials.

While the report recognises that factory assembly reduces installation cost for distributed systems and chillers, more site work is required for central plant, cascade, secondary and transcritical systems.

Compressors and other components for R134a are significantly larger than those for higher pressure refrigerants and this has been factored into the final result shown in Fig 5.

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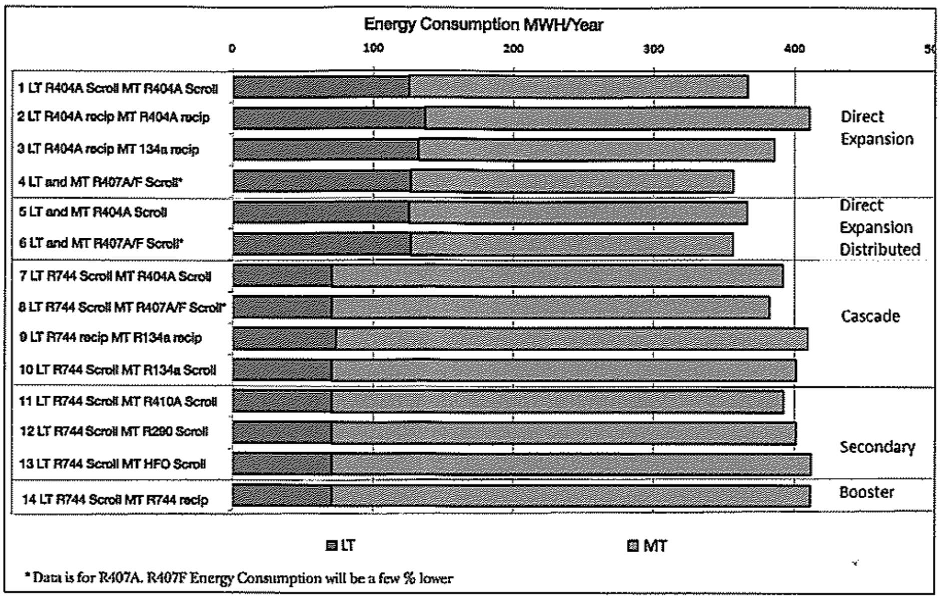

Fig 3: Annual Electrical Energy Consumption

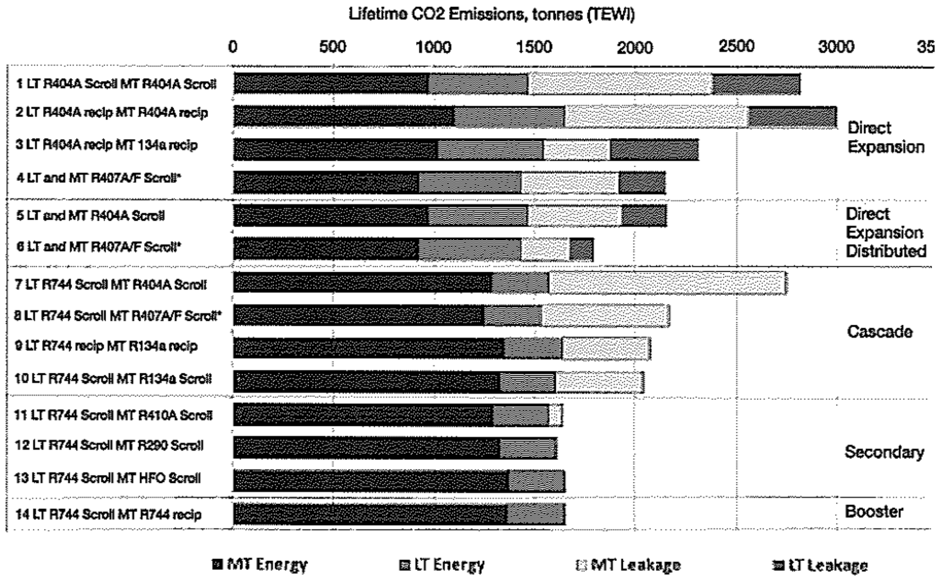

Fig 4: Lifetime CO_2 emissions

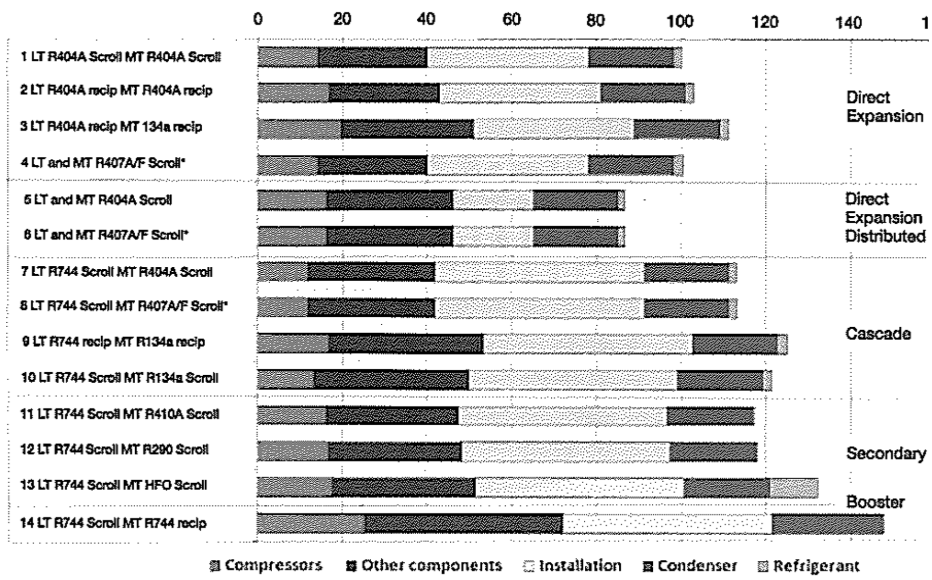

Fig 5 : Relative build cost for the various system types

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Conclusion

There is no outright winner in the report with the best solution being down to individual preferences and application type. Except in cases 12 and 13 the options analysed are based on today's availability.

Looking at the report, DX is the best for energy efficiency especially if the close coupled version can be effectively applied. Although not shown, it is easy to see that by using one of the newer reduced GWP HFCs such as R407F and reducing emissions by 50%, from 10% to 5%, the DX distributed is the best solution for the environment. This type of system also wins on investment cost and for smaller commercial systems it provides the best 'all round' choice.

For lifetime CO_2 emissions (TEWI), the R744 (CO_2) transcritical system appears a winner if applied in such a way that the annual energy consumption is equivalent to a reciprocating DX system.

This is the usual target for designers of these systems, says Emerson Climate, and is only achievable with very careful design and control. The report points out, however, that R744 transcritical will continue to incur a cost penalty for the foreseeable future. Secondary systems could also be a good alternative.

With improved containment, the cascade solution with lower GWP HFCs on MT, such as R407F, is senn to be highly competitive in terms of both emissions and cost, together with relative simplicity.

Concerns over the possible changes in legislation, increasing carbon tax and the need to be "seen to be green", are driving changes in the industry.

The report takes the view that short term measures such as simplistic legislation can work against the overall objective of emissions reduction, especially if there is insufficient industry engagement. Significant investment is required in order to bring the R744 costs even to the levels shown here, it says.

According to the report, each of the alternatives to the R404A centralised systems will see technology and service pushed to the limits of leakage reduction, building energy integration and heat recovery. Not least, it sees the need for effective monitoring to ensure design energy performance is delivered and sustained over time.

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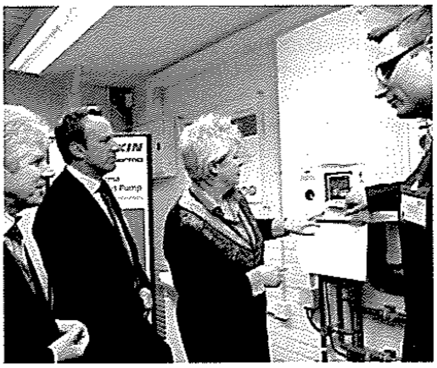
Daikin training in East Anglia focuses on renewables



DAIKIN UK and West Suffolk College have joined forces to open a training centre in East Anglia to help increase the uptake of renewable energy heating solutions in the region.

The opening of this centre of excellence is the latest regional training centre to be established in the UK as a result of partnerships between Daikin UK and vocational training colleges.

The facility will enable heating and plumbing contractors within East Anglia to benefit from customised product training.

More than £12,000 worth of Daikin Altherma products has been installed within the facility along with £15,000 worth of Daikin VRVIII heat recovery equipment.

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