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Technical Article

Discover the opportunities of transcritical CO_2 with heat reclaim

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CO_2 is by nature a highly suitable refrigerant for heat reclaim. With the increasing number of transcritical CO_2 applications in supermarkets around the world, interest in taking advantage of the heat reclaim opportunity is increasing. Consequently, resilient and safe solutions are rapidly being brought to the market and returning significant energy savings to food retailers.

The heat reclaim potential depends on the climate conditions, and so far CO_2 refrigeration with heat reclaim has mostly been applied in colder climates. With new technologies, however, heat reclaim for utility water is becoming more widespread in warmer climates as well.

When it comes to transcritical systems with heat reclaim, we have only seen the tip of the iceberg. In future, supermarkets will not only cover their own heating demands by using the surplus heat of transcritical CO_2, they will also be able to deliver heat to the district energy grid. The obvious advantages are fast payback times, typically under 2.5 years, and reduced emissions that make heat export from supermarkets very attractive for all stakeholders.

There is no reason to wait – the required technologies are widely available today. This article will make the case for transcritical CO_2 solutions with heat reclaim.

Transcritical CO_2 with heat reclaim: how does it work?
Heating and cooling are two sides of the same coin. For many years, however, the cooling and heating systems have been regarded as separate systems in the supermarket.
The industry has not been blind to the opportunities of using excess heat from the refrigeration systems with traditional HFCs, but the gain has been limited and unable to match the investment. But with transcritical CO_2, the potential of the opposites can finally be fully realized in integrated heating and cooling systems.

To be able to reclaim heat in the transcritical system, one or two heat exchangers are mounted before the gas cooler of the application. A 3-way valve directs the surplus heat from the compressors into a heat exchanger according to current demand for space heating and utility water for cleaning and sanitary purposes. The excess heat, if any, is discharged.

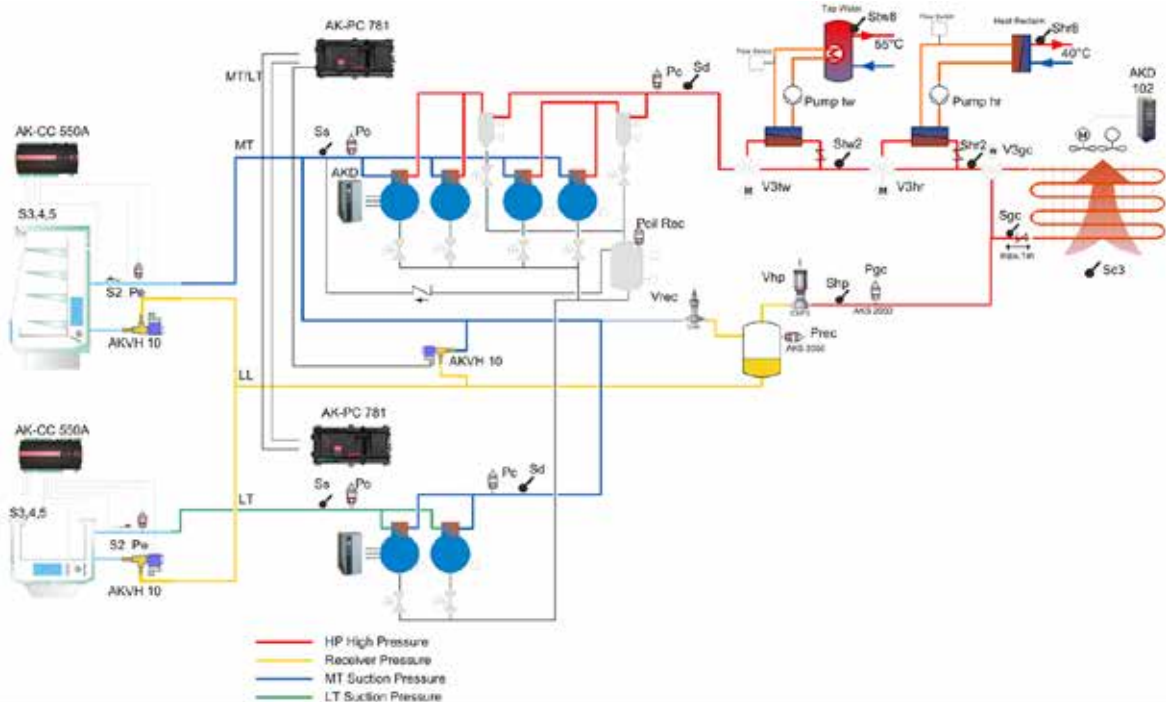

Figure 1: Example of mid-size supermarket installation with heat reclaim on the MT system.

In theory, 100 % heat reclaim from the refrigeration system provides sufficient heat to fulfil demands for space heating and hot tap water in many climates, eliminating the need for separate heating installations in the supermarket. However, reclaiming the last part of the energy is still not very efficient and therefore, the cost of relying 100 % on reclaimed heat has to be judged against alternative heat sources depending on the actual load conditions, climate and the cost of alternative heat sources.

Food safety comes first

The heating potential of transcritical CO_2 systems is so large that some retailers are dimensioning the refrigeration system after the heating demand of the store. But it is important to stress that in refrigeration solutions with heat reclaim, food safety always comes first.

A superior control strategy of temperature and pressure in the system is needed to ensure robust refrigeration and to avoid condensation of liquid in the heat exchangers. Integrating all control functions enables accurate control of the transcritical pack with heat reclaim and optimum COP at all load conditions.

Part of the energy smart grid

Supermarkets can easily fulfil their own heating demand, and they can do more than that. Supermarkets can play an important role in the smart energy grid, delivering heat to the local district energy network.

With only minor investments, the supermarket can be connected to the local district energy network and the supply of reclaimed heat can generate yet another revenue stream from the store. The first experiments with grid integration in Denmark have returned pay-back times of 1-2 years due to special subsidies; without subsidies, the pay-back time is still short, estimated 3-4 years.

In many markets, the lack of business models and current regulation still inhibit a more widespread interest in transferring the surplus heat from the supermarkets to the district energy network.

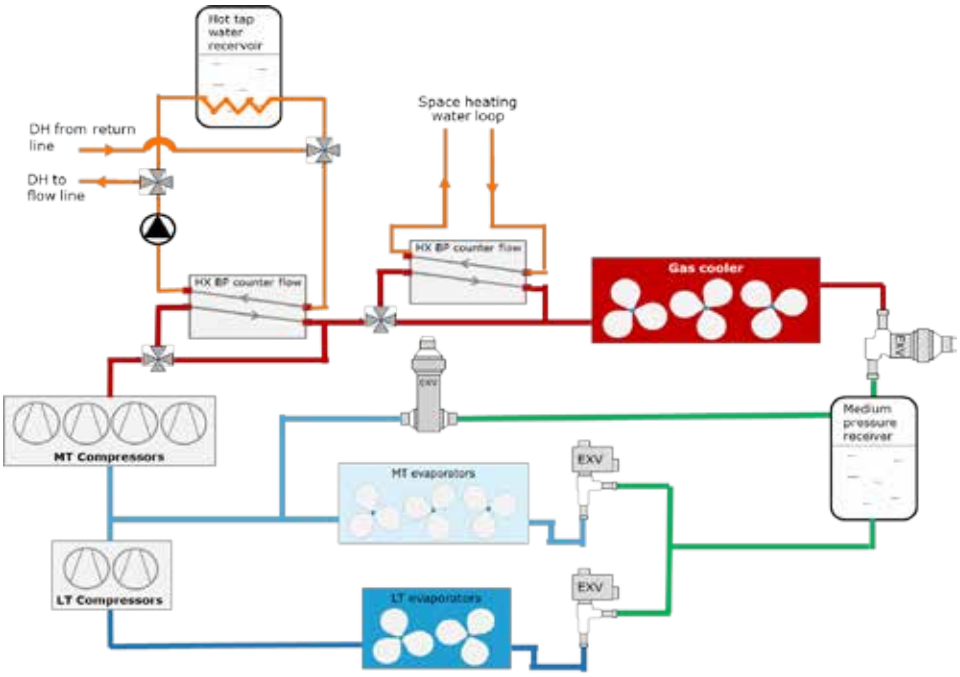

Figure 2: The concept of the CO_2 Transcritical system with heat reclaim and connection to district energy network

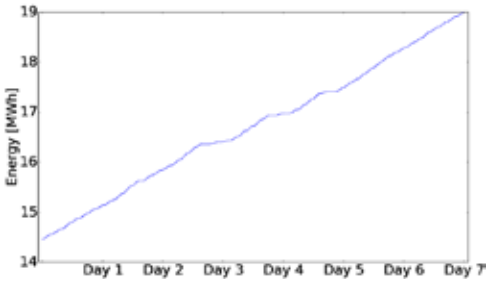

Figure 3: Accumulated energy exported to the district energy network from Danish supermarket

CO_2 competencies required to be successful

Technology and components for natural, low GWP refrigerants for supermarket applications are readily available today. But to harvest the full potential of the sustainable solutions, the general level of know-how needs to be raised through increased education and training.

With the thousands of installations worldwide, the skill base in CO_2 refrigeration with heat reclaim is growing. This goes to secure that a high level of design and installation quality is maintained in order to make the most of the opportunities for safe and efficient Transcritical systems with heat reclaim.

Cooling and heating work beautifully together

Transcritical supermarket applications with heat reclaim are very suitable for improving the overall refrigeration system performance. It is a highly efficient and resilient solution that provides simultaneous heating and cooling by recycling waste heat energy within the store.

More than 2,000 installations across Europe and in other parts of the world have shown that the traditional CO_2 weaknesses in refrigeration applications such as high temperatures and pressures can be turned into profitable advantages when adding heat reclaim to the systems. In fact, the operational costs can be reduced by more than 20 % by replacing conventional heating sources with heat reclaim, and the pay-back time of the heat reclaim installation is typically short, less than 2.5 years. At the same time, huge carbon savings can be made when the system is installed and maintained correctly.

Month	Store Gas Savings[1] (£/month)		Pack Electricity Penalty[2] (£/month)	Net Project Savings (£/month)	Cum Project Savings (£)	Simple Payback Period (Years)
Sep-14	1,892	-	231.94	1,660	1,660	3.26
Oct-14	2,456	-	117.06	2,338	3,998	2.71
Nov-14	3,985	-	952.54	3,033	7,031	2.31
Dec-14	4,104	-	665.10	3,439	10,470	2.07
Jan-15	4,012	-	450.42	3,561	14,031	1.93
Feb-15	4,427	-	491.40	3,935	17,966	1.81
Mar-15	3,818	-	169.71	3,648	21,614	1.75
Apr-15	2,547	-	269.23	2,278	23,892	1.81
May-15	2,230	-	403.56	1,826	25,718	1.90
Jun-15	1,470	-	359.73	1,111	26,829	2.02
July-15	967		368.93	967	27,795	2.14
Aug-15	791	-	693.84	97	27,892	2.33

Figure 4: Savings and pay-back time month by month in British supermarket fitted with Transcritical CO_2 + heat reclaim

Danfoss leads the development of solutions and components for CO_2 refrigeration and offers a wide range of products specifically designed for CO_2 transcritical systems. Furthermore, Danfoss provides training, design tools and consulting services to promote the use of CO_2 and to support the development of forward thinking solutions in all parts of the value chain.