Energy-efficient supermarket uses daylight and ground cooling

EnBau

The new discount supermarket in Rastatt wants to be exemplary in terms of energy efficiency
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Discount stores and food chains generally construct their supermarkets using standardised architecture and furnishings. Although energy efficiency and indoor comfort are issues that are taken into consideration, they are not quite at the top of the priority list. However, that could soon change, as a project from Aldi Süd shows. With its new store in Rastatt, Germany, the discount supermarket chain is testing its “energy saving store of the future”. The building energy concept is indeed remarkably innovative, whereby the discount supermarket chain wants to save 50% of its energy relative to standard supermarkets. This is only possible by sensibly combining numerous individual measures relating to the cooling, refrigeration units, building envelope and building services technology. In addition to excellent thermal protection, they are relying on greater daylight illumination, lighting control, efficient refrigeration units and heat recovery and, in particular, a sophisticated, geothermally based heat and cooling generation system. This makes it possible to dispense with the conventional supply systems used today such as gas-fired boilers and air conditioning systems. Aldo Süd intends to incorporate those concept components that prove themselves in the pilot project into its standard building specifications when building new supermarkets or refurbishing existing ones.

Building summary

Project status	Evaluated
Location	Rastatt, Baden-Württemberg
Completion	August 2010
Inauguration	September 2010
Building owner	Aldi Süd Rastatt GmbH
Gross floor area	1,825 m^2
Gross volume	9,054 m^3
Usable floor area (according to EnEV)	1,675 m^2
A/V ratio	0.56 m^2/m^3
Key aspects	Heat insulation, Glazing + windows, Daylight planning, Daylight systems, Optimised lighting, Ventilation + heat recovery, Regenerative + passive cooling, Thermo-active building element systems, Heat pump, Combined heat and power generation, combined heating and cooling, Heat / cold storage, Control technology, operational management, building automation

Project description

Aldi Süd constructs or refurbishes around 100 stores each year in Germany, whereby it consistently relies on a uniform quality standard that is reflected in both the architecture and the system technology used in the supermarkets. Energy efficiency and comfort have long been issues addressed by the store developers. According to Aldi Süd, the utilisation of waste heat from the commercial refrigeration systems is just as much standard as the ventilation systems with heat recovery and the comprehensive energy monitoring. With its new store in Rastatt, Aldi Süd once again intends to increase the energy efficiency of its supermarkets by a considerable and exemplary amount, whereby it is endeavouring to achieve primary energy savings of 50%.

Research focus

At frequent intervals, the data from more than 200 sensors and measuring devices are transferred daily to the Fraunhofer Institute for Solar Energy Systems where they are evaluated. This is because the operation of the supermarket is being analysed and optimised as part of a two-year scientific monitoring phase. A central aspect is concerned with evaluating the innovative CO_2 cooling system and the interaction between the different components under varying operational conditions. Also important is the control of the pressure and temperature levels on the high-pressure side of the system. The same applies to the temperature levels of the thermally

activated concrete slab and ventilation system, since they have a considerable impact on the energy efficiency and thermal comfort in the supermarket. The thermal coupling with the ground is being analysed in terms of energy-related and economic criteria in order to evaluate the additional investments required for constructing the geothermal system. The daylight system and the daylight-dependent artificial light control are being analysed and optimised to improve the energy efficiency and to achieve optimal visual comfort for the customers.

Building / Renovation concept

The new building has been designed and constructed as a very energy efficient building. Although from the outside it looks almost identical to Aldi Süd's standard stores, there are considerable differences in terms of the system technology used and the building structure. The supermarket has facades made of highly insulated precast concrete panels and an innovative roof structure made of glued-laminated timber trusses. The daylight is provided by 28 skylights that are evenly distributed above the sales space. The triple glazing used for these skylights is furnished with a frit pattern in the inter-pane cavity, which reflects the direct solar radiation and enables views of the sky. The timber roof cladding is visible and enables excellent light distribution in the room. Low thermal bridging and airtight construction were ensured during the planning stages. A blower door test showed that there are less than 0.5 air changes per hour.

Energy concept

A central element of the building's energy concept is the monovalent and geothermally supported CO2 compressor pack. It is designed to supply the entire heating and cooling, enabling other heat generators or air conditioning systems to be entirely eliminated. Specifically, the system provides commercial cooling at three different temperature levels: in the chiller cabinets and freezers in the sales area, in the cold stores in the storage area and for ambient cooling. In addition, it also provides space heating.

The ventilation with heat recovery provided as standard by ALDI was optimised in terms of the air volume and efficiency. The air volume is controlled in accordance with the CO_2 to achieve the hygienically minimum air volume. Heating and cooling is provided via a thermo-active floor slab in the sales and storage areas and via underfloor heating in the recreational area. The supply air is also pre-heated and pre-cooled via the compressor pack system. The individual sub-systems have to be adapted to the refrigeration pack during both their design and operation to enable its maximum possible use.

The operation of systems with CO_2 as the heating or cooling medium is not without problems. An important aspect in ensuring the high efficiency of CO_2 systems is to avoid trans-critical operation. With high external temperatures, the cooling medium is therefore cooled as much as possible. Compared with other cooling media, carbon dioxide has a lower critical temperature of 31 °C. This is a decisive factor for its energy efficient processing, since above the critical point carbon dioxide can no longer be liquefied, even under greater pressure. In addition, the temperature with which the carbon dioxide is released from the heat exchanger is decisive for the energy efficiency. The lower the temperature, the higher the achievable coefficient of performance, which measures the energy efficiency. It is intended to achieve this by integrating a borehole heat exchanger, which has lower heat sink temperatures, into the compressor pack system. In winter the borehole heat exchanger will be used as a heat source for a heat pump switching system integrated within the compressor pack system. In order to ensure that the borehole heat exchanger is cost effective and remains operational in the long term, the ratio between the heat removal and heat influx for the ground has to be balanced out across the year.

Performance

Information on this subject will become available as the project continues.

Optimisation measures and possibilities

Further information will be provided on this during the course of the project.

Construction costs and economic viability

The final construction costs have not yet been determined. However, based on the new energy concept, the operational costs for the building services systems have been calculated to be around 35% less than for a standard store.

Further information will be provided on this during the course of the project.

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	
Heating energy demand	82.00
Overall primary energy requirement	79.60

Measured energy consumption data (in kWh/m²a)	
Site energy for heating and domestic hot water (dhw)	18.50
Total source energy	516.60

Implementation costs

Costs of implementation in €/m²	
Construction (KG 300)	718
Technical system (KG 400)	332

These figures represent established costs
Net construction costs (according to German DIN 276) relating to gross floor area (BGF, according to German DIN 277)

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