Hybrid ventilation and daylighting in a Norwegian school building

submitted by the Norwegian National Team

Several energy efficiency and renewable energy principles have been implemented in a recently refurbished and extended primary school building in Grong, Norway,. The building is located in the centre of Grong, a small town slightly north of Trondheim. The local authority's aim was to build an economical and modern school building with an attractive and healthy indoor environment and a minimal energy demand. In cooperation with the architect and the engineering consultants, SINTEF Architecture and Building Technology has developed solutions which utilise solar heat gains, daylight and natural forces for ventilation, both for comfort and energy-saving purposes.

The school building development has been included in the demonstration project MEDUCA (funded by the European Union (EU)), which is part of the THERMIE programme. Since 1997, the town of Grong has also been part of the Bruntland city network, an EU project under the ALTENER programme, which aims to reduce the environmental damage from energy consumption by implementing renewable energy sources.

The classrooms are located on the north side of the building to avoid overheating and thereby reduce cooling demand. The electricity is mostly from hydropower, with a small amount of wind power, neither of which release CO_2 into the atmosphere. The heating system is hot-water-based, and the thermal energy is currently provided by oil. However, a biomass-fuelled heat plant for hot water supply is planned sometime in the future. Biomass is considered CO_2-neutral in Norway, because the forest growth is greater than the depletion. In order to reduce the amount of air contamination, the use of low-emitting materials has been stressed.

The most evident feature of the natural ventilation system is the centrally located tower between the two wings (see

Figure 1: Cross-section through one of the wings, showing the daylighting system and the airflow path through the building – the air inlet tower, underground supply duct and exhaust tower.

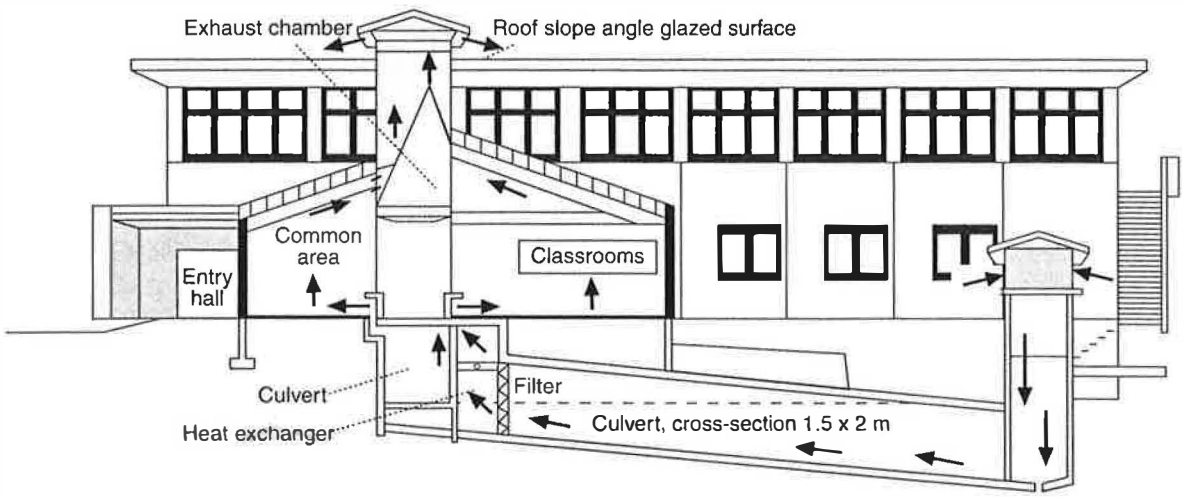

Figure 1), providing the buoyancy forces which distribute the air through the building. The air enters the building through a separate intake tower (see **Figures 1 and 2**), and is fed through an earth channel into a spinal distribution chamber in the basement. From here, the air is distributed to the classrooms as required. Exhaust air is sucked into the extract duct above the central corridor, and out through the exhaust tower.

Before entering the classrooms, the air is filtered and warmed by the heat recovery system and an additional heating element, if required. In wintertime, the underground duct also serves as a preheating chamber, using heat from the earth to warm the cold incoming air. Similarly, it also cools the warm air in the summer. Cooling can also be achieved by cross ventilation using open windows and vents. Assisting fans are placed both on the supply and extraction side to provide satisfactory ventilation on days when the buoyancy forces are insufficient. Calculations have shown that the electricity consumption for fans can be reduced by some 90% compared to a conventional balanced mechanical ventilation system. The heat recovery system, with an expected efficiency of 55-60%, extracts heat from the air leaving the exhaust tower, adding it to the fresh air in the distribution chamber. A water-glycol mixture in a pipe loop carries the heat in-between. Solar energy entering the exhaust chamber through the glazed roof will add useful heat to the heat recovery system during spring and autumn, and will also increase the buoyancy forces. The fresh air supply to the classrooms is individually controlled by sensors for CO_2 and temperature.

In the school building, the ventilation exhaust air chamber (see **Figure 1**), has a glazed roof and walls towards the classrooms allowing natural light to enter through the space and into the classrooms. The control system, which reduces or turns off the electric light when the daylight level has reached a certain level, enables reduced electricity consumption of around 25%. Several natural ventilation design issues, such as shallow-plan spaces, tall slim windows, and the use of atrium and sun spaces, are also important for daylight utilisation.

A monitoring programme is due to be carried out next winter, which will include measurements of energy, ventilation and lighting performance, as well as qualitative studies. This school building in Grong is the first in Norway to utilise daylight and natural forces for ventilation in such a conscious way. However, similar principles are now being implemented in several other Norwegian schools.

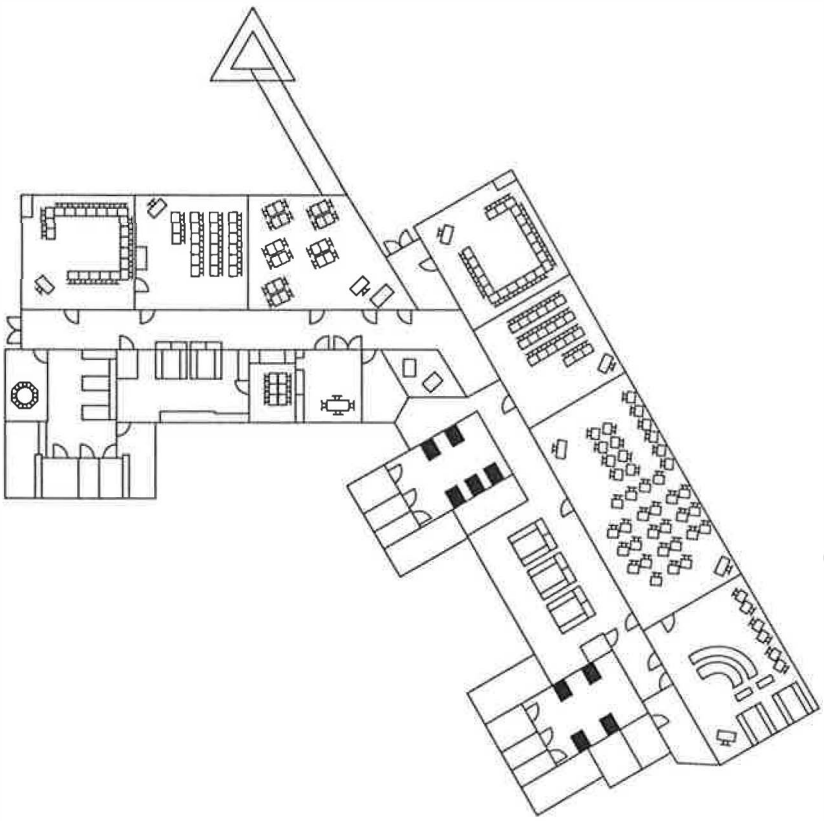

Figure 2: Plan of the two new wings, including the triangle-shaped intake tower.

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