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Application of a novel, vacuum-insulated solar collector for heating and cooling

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Abstract

A solar collector field of 250 m^2 is being set up for cooling and adding to the heating of a building of 4000 m^2 with mixed use, which includes offices, laboratories, computing and electronics facilities, and a public area. Novel solar thermal collectors will be used, which reach excellent performances, thanks to vacuum-insulation and innovative assembly techniques. This allows the efficient operation of an absorption cooling unit. The thermal concept combines the warm and cold streams and gives priority to solar energy.

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1. Introduction

The European Laboratory for Particle Physics CERN is located near Geneva, Switzerland, on both sides of the French-Swiss border. In order to study the fundamental laws of nature, CERN has built and operates several particle accelerators. The most recent one, called Large Hadron Collider (LHC), is situated in a 27 km long circular tunnel about 100 m underground. The real estate infrastructure of the laboratory consists of two campuses with buildings of 360.000 m^2 and 130.000 m^2 on the Swiss and French side of the border. In addition, there are several smaller sites located above the underground accelerators, serving as access points and hosting infrastructure services. Each campus has its own water and electricity distribution network and district heating system.

CERN has been founded in 1954 and buildings have been added over the years as new accelerators have been built. Therefore the building stock is quite inhomogeneous and reflects the technical and energetic standard of the time of construction.

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At present, there are several new buildings being constructed each year. Depending on their location, they follow the energy norms of the host states Switzerland and France. In addition, CERN has decided to favor sustainable energy solutions. The most recent building, which is the subject of this article, will use solar energy for cooling and heating.

The next chapter shows the outline of the building and in the third chapter its thermal energy concept is discussed. A major component of the heating and cooling system is the solar collector field, which is described in chapter 4. The results of the simulation and the expected performance are given in chapter 5.

2. The Building

The building is located on the CERN campus on French territory, close to the operations centre for all CERN accelerators. Its main purpose is to house the offices, meeting rooms and laboratories for the personnel of the accelerator controls group. In addition there will be public areas for visitors, a conference room, and a cafeteria.

The building is organized in three wings comprising of 2 or 3 stories with a total surface of 3950 m^2. A view of the building and the layout of the ground floor are shown in fig. 1.

Fig. 1. 3D CAD view and plan of the ground floor

3. The thermal concept

The new building fulfils the requirements of the recent French norm RT2012. Apart from excellent insulation, it has triple-glazed windows and a fixed structure mounted outside to provide shade in summer, but still allowing day-light to enter. Heating is provided by a radiant floor, which is also used in summer to circulate pre-cooled water in order to limit the temperature in the offices and meeting rooms to 27 °C. The laboratories, the conference rooms, and the cafeteria are heated and cooled by an air circulation system. The central points for thermal energy are two water-filled reservoirs in the basement, 10 m^3 for cold water at 10 °C and 3 m^3 for warm water of up to 95 °C. A schematic diagram of the thermal energy flow is shown in fig. 2.