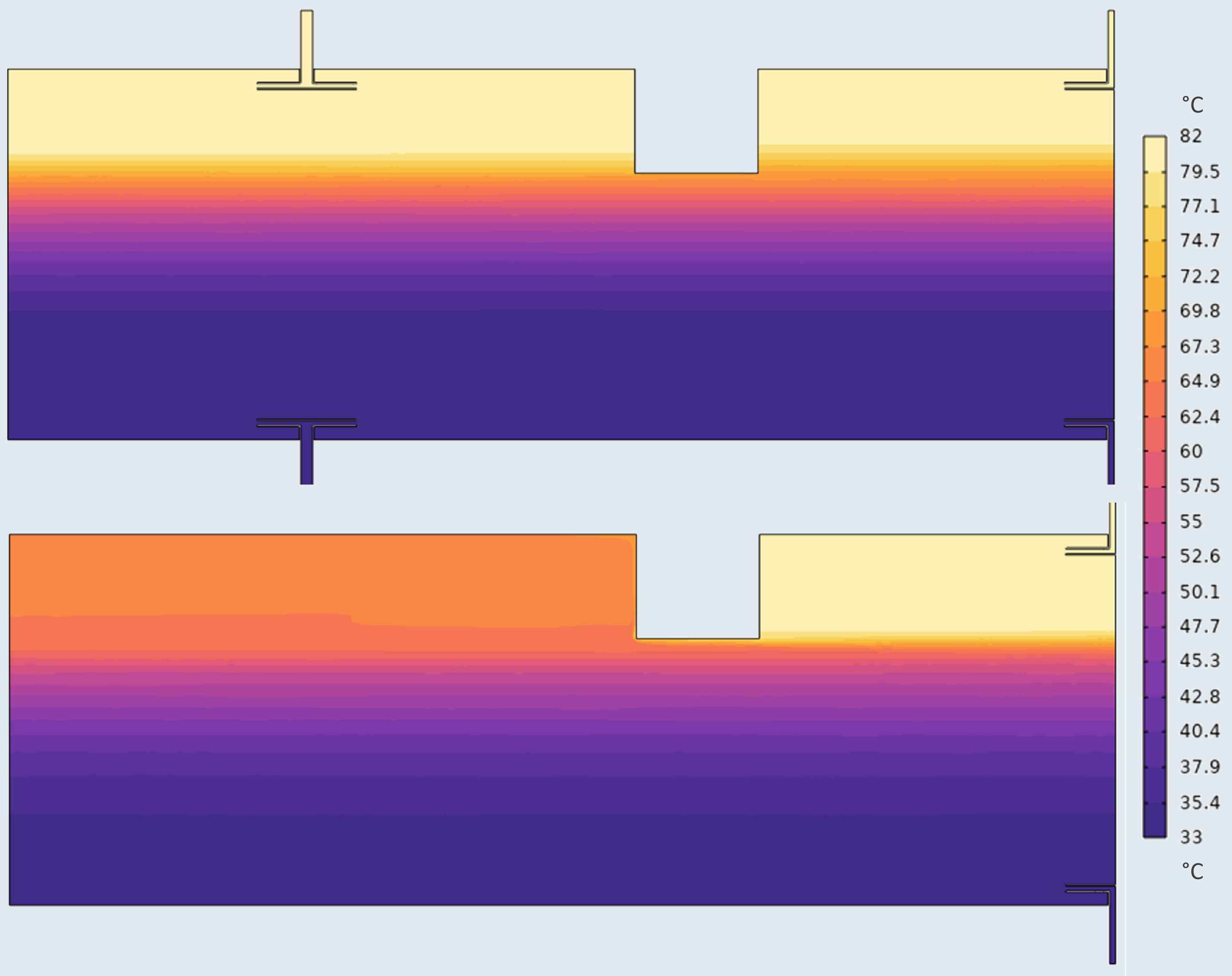

Thermal Stratification Analysis of a room-integrated large hot water storage

Conversion of a 550 m² cellar room into a hot water storage in consideration of existing building structures.

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Abstract

While common hot water storage geometries are slim and high, this work deals with the conversion of a preexisting cellar room into a hot water storage with an area of 550 m² and a height of only 2.9 m. Next to the poor area to hight ratio, the room contains columns and bearers for static reasons which complicate the generation of a good thermal stratification. A possible advantage or disadvantage is that the bearers ensure that the upper half of the storage is divided into three separate "chambers" of 36 m length and 4.9 m width, which could lead to less mixing in the storage tank but also complicate the in- and outlet positioning on the top. With the model of the cellar storage tank, we analyzed whether a thermal stratification over the whole area is generally possible. In addition, the optimal number and location for inlet devices as well as the optimal dimensions of the inlet device were investigated. For comparison purposes and to ensure the robustness of the results, we are simultaneously performing the simulations with the software Simcenter STAR CCM+ by Siemens.

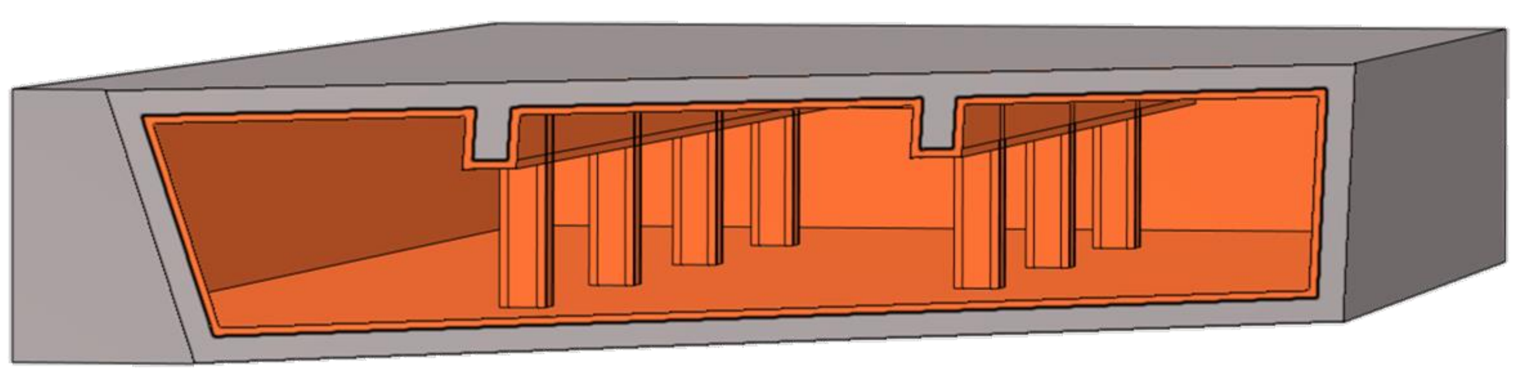

FIGURE 1. 3D-geometry of the cellar room (grey) with insulation material (orange), showing the columns and bearers

Methodology

A non-isothermal turbulent flow model was used in the COMSOL Multiphysics® Heat Transfer Module. At first, a 3D geometry was built by importing via the LiveLink™ *for* Revit®. Whereas the geometry was kept simple, the big challenge has been to deal with the size of the geometry since the room has a length of 36 m and a width of 15.5 m. In order to simplify the geometry, we created two different 2D models (lengthwise and crosswise) instead. With the use of symmetry conditions, this model was further reduced in size. The accuracy of such reduced 2D models were analyzed for a different stratified heat storage and the results agreed with preliminary experimental data, although we dealt with a few complications modeling the diffusion.

Results

The results show that due to the bearers, the installation of an in- and outlet device in every crosswise "chamber" at the top is necessary. Finally, a higher amount of inlet devices over the storage length (36 m lengthwise) does not have such a significant impact on the hottest layer generation. The average temperature in the hottest layer within the different charging processes run with a maximum temperature difference of 2 °C over time and equalize after 4 hours. Due to long charging and discharging time of several days, that's not enough to justify the installation costs for more than one inlet device per chamber. Furthermore, the in- and outlet velocities are very slow, so that no negative influence from the columns is expected. Instead, the optimized design of the radial inlet device is clearly the main target in this application case.

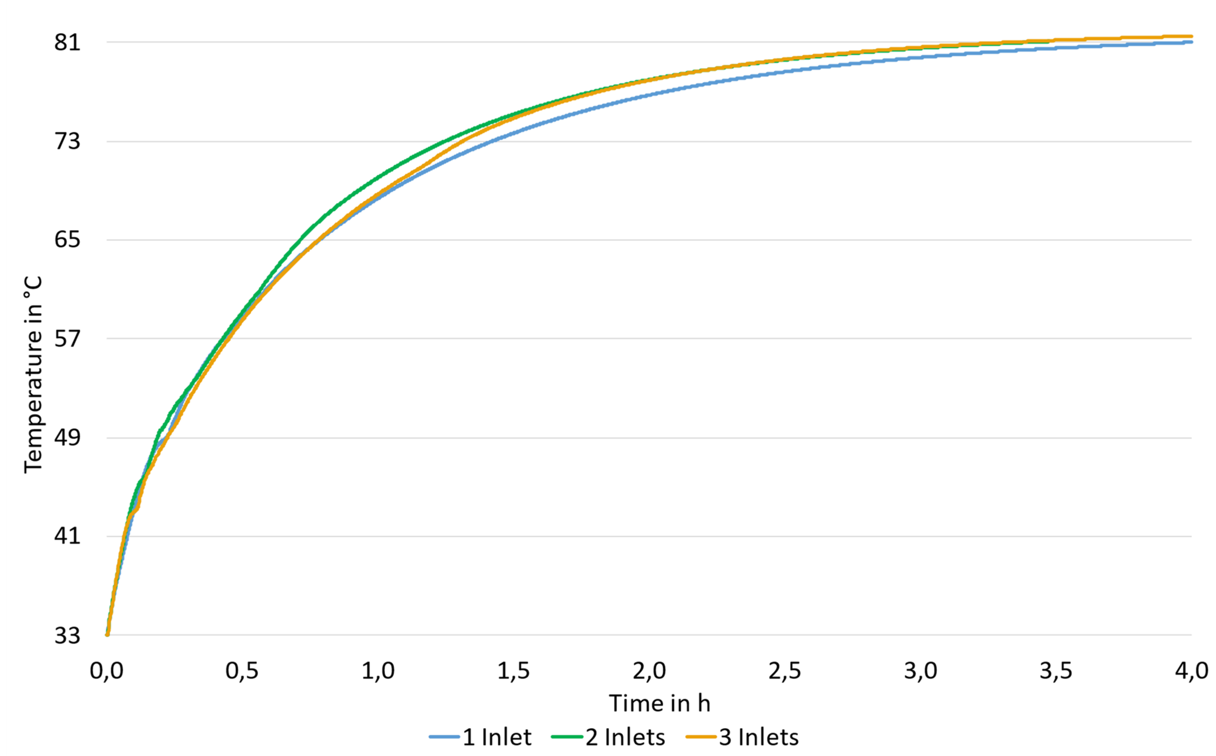

FIGURE 2. Average temperature at the storage ceiling during a loading cycle with one, two or three radial inlet devices over the entire length

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