Horizontal Living – Healthy Homes Design Competition

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REHVA announced the Healthy Homes Design Competition 2022 with the aim to encourage students in different building disciplines to design a building with increased comfort quality. The winning Team emerged "Horizontal Living" — **a concept that** addresses the challenge of energy transition, environment and wellbeing.

Today, one out of six Europeans reports living in unhealthy homes, i.e. buildings that have problems with dampness, underventilation, lack of daylight, inadequate heating during winter or overheating problems during summer. Because of this, the buildings we develop now must be ready for future challenges. By designing a new building, we have to take into account a variety of comfort parameters, sustainability challenges, social and resilience qualities.

Figure 1. Overview of the Horizontal Living building and its location in Pernis, Rotterdam.

South facade with renewables and north facade with green development

The angle of the south facade is inclined at 70° for a perfect exploitation of the winter sun. The facade consists of thermal flat-plate collectors which, in combination with a seasonal warm water storage, supply the building with heat independently. Each unit has a private loggia overlooking Pernis and the buildings small park. The development is on the north side of the building and leads to the apartments via a wooden arcade. The outer construction of the arcade is planted with climbing plants for a natural wellbeing when the residents arrive. The roof is designed as a green roof, where nature can spread as an ecological niche, also increasing the visual comfort of the occupants. The arcade serves as a community meeting place and second balcony in the hot summer months. From here, you can enjoy the Rotterdam skyline.

Outdoor and indoor spaces

The outdoor facilities are south facing to enjoy long hours of daylight, sheltered from noisy and air pollutant ship traffic. A small park to the southeast provides shade for residents to encourage outdoor living even in the increasingly hot summers. A volleyball field, urban gardening, a bicycle workshop and a common room invite you to get to know the neighbours. The building consists of 21 apartments, 2 of which are guest rooms. In hot summers, for example, the guest rooms offer protection to elderly people. All apartments can be reached barrier-free via an elevator. The interspersed rooms allow daylight from two sides and good cross ventilation. The footprint of the building is very small at 603 m².

The property is regularly flooded, with the water reaching up to 1 m, due to the increasing climate change. To make it resilient, a small dam was laid around the property. In the event of a flood, six flood protection doors are operated to protect the building

The Horizontal Living apartment

Horizontal Living is the building's design concept. Air, light and heat penetrate the building in a horizontal direction. Views are provided horizontally. The windows are placed opposite to each other to direct the wind through the building. Daylight reaches the building from at least two sides. The detailed apartment is one of several maisonette apartments. Apartments on the 4th floor are all designed as maisonettes, as the stack ventilation only extends to the 3rd floor. In this way, thermal ventilation is achieved via the difference in height of the apartment. The apartments should accommodate everything you need in a small space. Nevertheless, the feeling of space should be an airy one.

Figure 2. South elevation (top): tilted facade with solar thermal collectors and loggias; North elevation (bottom) with wooden arcade and green roof.

The residents arrive at their apartments through the arcade. Galleries in front of the apartment entrances arrange semiprivate spaces and create distance to private windows. The aim was, to have access to daylight and fresh air in every room, even in the bathroom. Common rooms are designed for maximum flexibility and as an open space. With sliding panels, the bedroom can be extended. The daylight simulation confirms a daylight factor over 2% in more than 56% of the flat.

Water as storage medium for energy transition

Electricity is the noblest form of energy because it can be converted into all other forms. It should therefore be used very sparingly and not be converted into heat. We believe that the energy transition is a matter of storage. Our concept is based on the self-sufficient production of heat by means of a solar thermal facade and storing it in a seasonal hot water storage. The roof is equipped with photovoltaic cells, which cover 83% of the building's electricity needs through the year. Water as a storage medium is available all over the world, it is non-toxic, infinitely recyclable and has a high thermal storage capacity. Compared to conventional battery storage, it has a very long service life and requires very little maintenance. By placing the storage tank inside the building, the storage losses correspond to the normal transmission that heat losses of the building envelope. The waste heat from the storage is used entirely to heat the building. The losses are thus at zero.

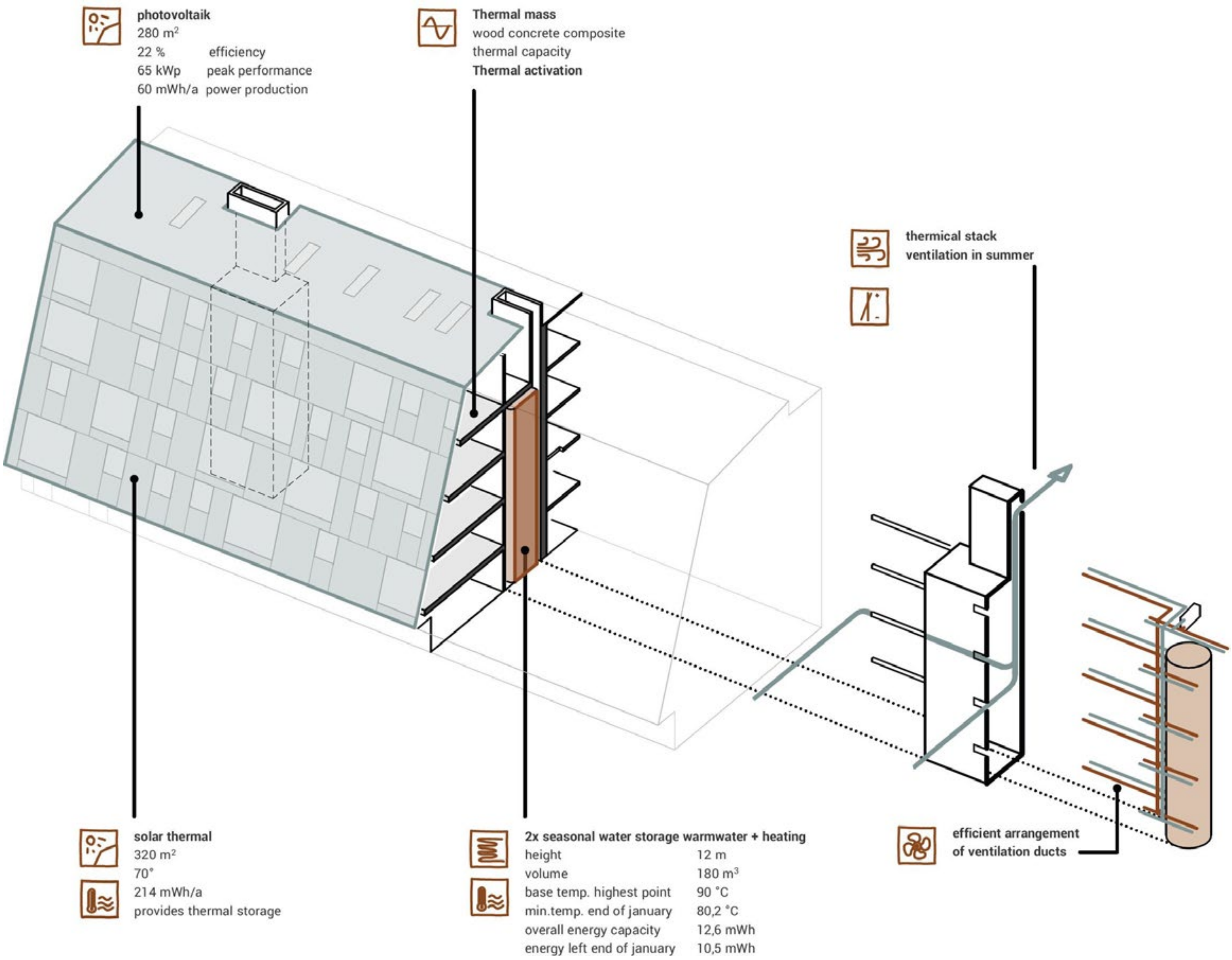

Figure 3. Axonometry with the different functions of the seasonal warm water storage and thermal stack – for storing heat energy and creating thermal ventilation through the storage stack in summer.

Comfort strategy for Winter and Summer

The heating strategy is structured as a graduated concept. Due to the living spaces' consistent orientation towards the south, the glazing catches the low-lying winter sun, and the high thermal mass of the built-in materials stores the solar heat and releases it with some delay. A component activation located in the ceiling provides the residents with a pleasant basic temperature (21°C). If the residents want an individual temperature, e.g. in the bathroom (23°C), this is achieved using wall heating. The mechanical ventilation system supplies them with fresh air. The ventilation strategy in summer is optimized for different cases. Controlled windows provide residents with sufficient fresh air. At night, the building is cooled down by cross-ventilation and the coolness is stored in the thermal mass.

If the shipping traffic in the north disturbs the air and noise, the residents can switch from natural ventilation to stack ventilation. Fresher and less noisy southern air comes into the apartment and the exhaust air is transported away through the storage shaft to the north. The thermal lift in the chimney is controlled by a regulated heat exchanger with the excess of hot water, which will be available in summer. The building envelope was designed close to the passive house standard. Strict southern orientation, compact design, minimized thermal bridges and a highly insulated building envelope.

The aim was to keep the buildings CO_2-emissions to a minimum. Basically, there is always a conflict of objectives with positive timber construction and a high thermal mass of the building. This was achieved using a demountable hybrid wood-concrete ceiling. The outer walls are made of a timber frame with wood fiber insulation.

Further design information

To calculate the storages, the heating requirement (25.2 kW) and the hot water consumption (1720 ℓ/day) of the building were determined. The heating degree days and the collector yield Rotterdam serve as the data basis. The result is the solar coverage (118.2%) and the usable storage energy content in the respective month. The solar thermal area has a surface of 320 m² and produces overall 78.82 MWh/a

Figure 4. Section through one of the maisonette apartments; visualization of the heating, ventilation and smart control strategy.

heat energy. The two storages are 12 m in height and have a diameter of 2.6 m. The overall storage volume combined is 180 m³. That corresponds to an overall energy capacity of 12.6 MWh. Looking at the cold month of January, the warmest layer of storage water has a temperature of 80.2°C and the storage has a remaining energy content of 10.51 MWh. This means that the buffer is great enough to have no shortage of thermal energy even during dark doldrums in winter. The heating requirement was determined by using an assumed heating load, which is based on the requirements of passive houses (with a factor of 1.3 as a buffer, using the storage design sheet). 40 ℓ/d and person were assumed to determine the hot water consumption. Since the building is equipped with passive cooling, no additional cooling energy is required.

The ventilation, the auxiliary energy, and the energy for electrical devices and light are included as electricity consumption. The ventilation energy was calculated with the peak performance of the two ventilation devices (2 kW) and 3 months running time. The auxiliary energy was assumed to be 3% of the thermal energy. The demand for electric appliances and lighting was calculated from public data for the households in the building. The photovoltaic system was determined using the global radiation at the Rotterdam location and the peak performance of the modules. The total energy consumed results from the required thermal energy (0), the required electricity (37.58 kWh/ m²a) minus the electricity production of the photovoltaic system (31.2 kWh/m²a). This means that the annual average energy requirement is only 6.43 kWh/m²a (**Figure 5**).

The calculation of the life cycle was calculated for a balance according to DIN EN 15978 (**Figure 5**). Life cycle phases A-D were included. The supporting structure of a conventional building made of reinforced concrete and brick was compared with our building. Ökobaudat.de served as the data basis for the life phases of the materials. ■

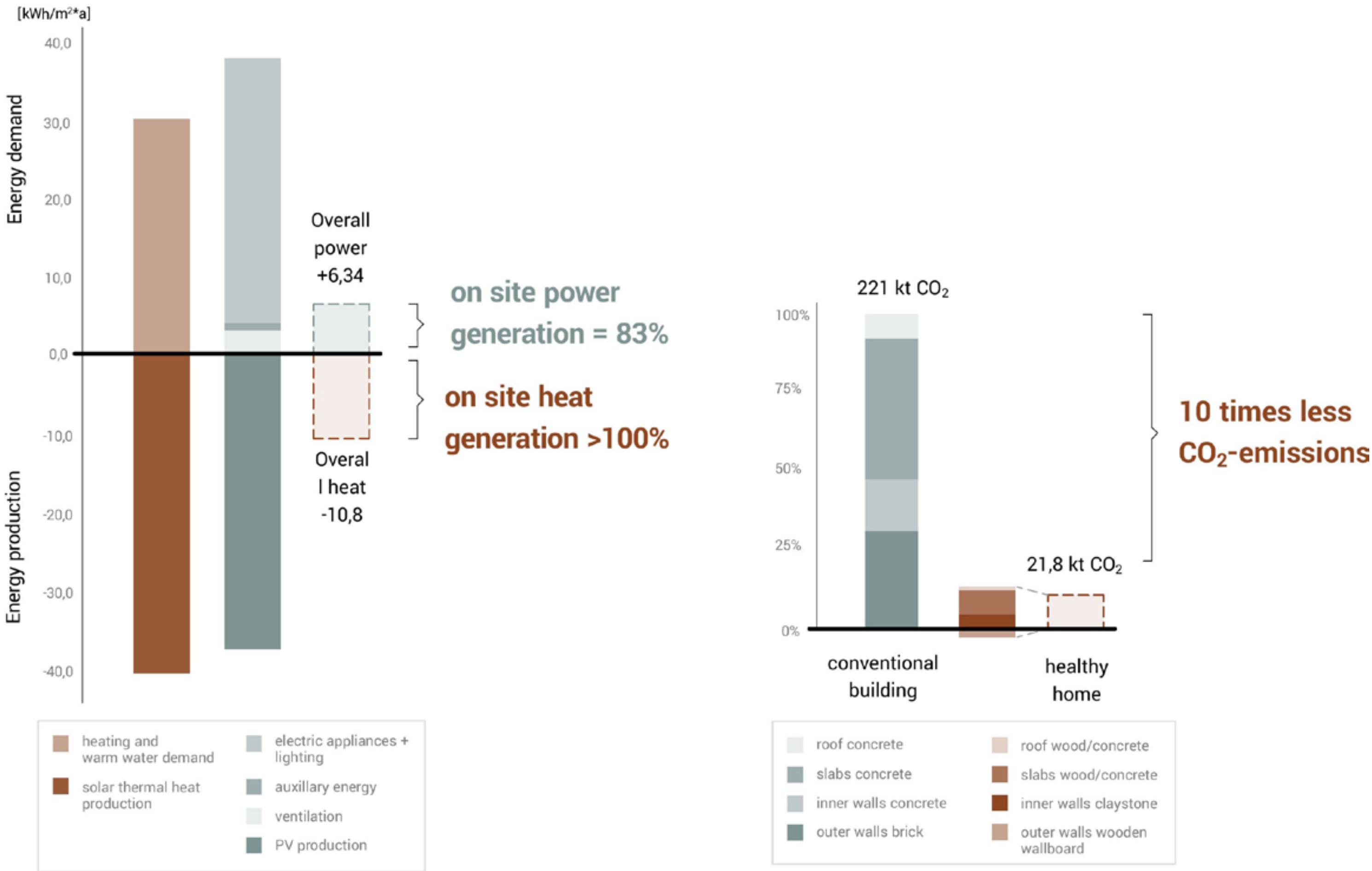

Figure 5. Comparison of energy demand and production (left) – the building is independent from supplied heat energy due to the seasonal warm water storage; comparison of CO_2-equivalents of the load bearing structure of a conventional construction and the Horizontal Living project (right).