Ecological and Self-Sustaining Cabin

Abstract

In times of climate change and a progressively increasing world population, terms like livability, sustainability and living space are more important than ever before. To mitigate climate warming and avoid unaffordable real estate prices, alternative building and living concepts have to be found. Therefore, a group of students of the "University of Applied Science Upper Austria" created an ecological cabin [see Figure 1] that is entirely self-sustaining and regionally produced. In addition to that, the modular construction enables cost-effective manufacturing, customizable layouts and easy transportation.

Figure 1: Visualization of the cabin with ArchiCAD®

1 Introduction

The ecological and self-sustaining cabin combines innovative and longstanding building technologies to ensure physical and mental wellbeing. In order to meet these fundamental prerequisites, the project was divided into four significant issues called Construction & Materials, Electrical Energy System, Water Supply and Ventilation Technology. For demonstration purposes, the students decided to build a model of the cabin which represents technologies of the topics mentioned above [see Figure 2]. Additionally, the project team created a three-dimensional visualization by using the architecture software ArchiCAD®.

Figure 2: Model of the cabin for demonstration purposes

2 Construction & Materials

The basic material of the construction is spruce wood, because it's sustainable, regionally to get and unrivaled regarding warmth and comfort. An important demand for the construction was the modular design, which enables individual layouts for a wide range of applications. In addition to that, the single components of the cabin are easy to lift and to transport by ordinary trucks. The gross floor area of each module is 15m² and arbitrarily expandable. The thermal insulation of the outer wall consists of an ecological combination of wooden soft fiberboards and hemp. The heat transition coefficient (U-Value) of the entire wall construction is 0,21 W/m²K. Additionally, a transparent cardboard heat insulation has been installed (see Figure 3). This new type of insulation is passively using solar radiation in the winter months and acts as a shading element during the summer time. Due to these characteristics, the dynamic heat transition coefficient can reach negative values and 0 W/m²K in average. The wall construction of the planned cabin is largely similar to the model, but instead of fiberboards and hemp, cellulose fiber will be used as insulating material.

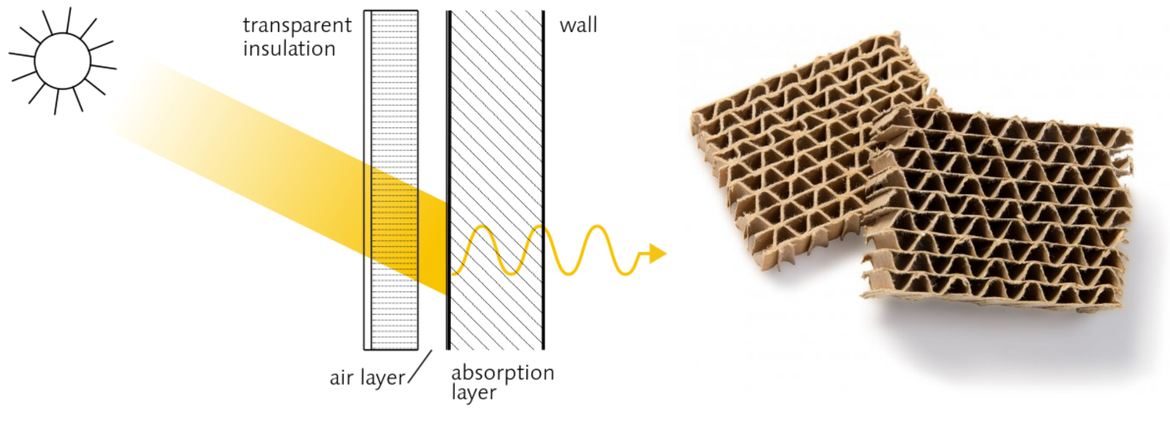

Figure 3: Transparent heat insulation (Kartonwaben-Dämmung)

3 Electrical Energy System

To ensure a self-sufficient electrical energy supply, two monocrystalline building-integrated photovoltaic modules with a total power of $100W_{peak}$ have been installed. They are connected in series and generate an output voltage of 24V (DC). The produced energy is stored in four charge controlled lead gel batteries with a total capacity of 34 Ah. In consideration of a minimum charging level of 30%, the batteries can operate a 280W infrared heating system, installed in the floor, for two hours. The DC-AC inverter enables the use of alternating current operated devices. These details only refer to the model of the cabin. The energy supply in the future cabin will be ensured by a $400W_{peak}$ solar panel which represents the sun canopy as well (see Figure 4). Additional photovoltaic panels will be placed on the roof and beside the cabin.

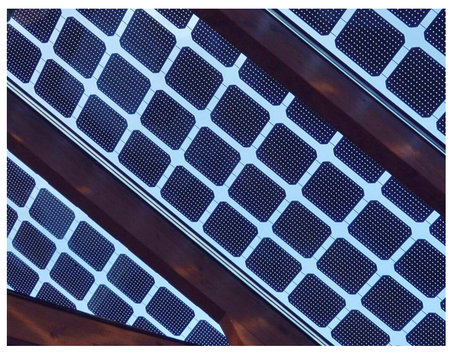

Figure 4: Solar Panel by Ertex Solartechnik GmbH

4 Water Supply

The fact that transportability is one of the basic requirements presents an engineering challenge concerning the water supply. Domestic water or sewage connection is not guaranteed for every location. Rainwater, which is collected and treated by an ecological filter system (reposition plants) on the roof, will be stored in five 200 liter water tanks that are installed in the floor of the cabin. Additional tanks can be placed outside the cabin and relieve the water heating system during the summer season. Grey water will be collected in a separate tank and (after filtering) returned to the water cycle. A modern composting toilet with integrated air ventilation is setting new standards concerning hygiene and comfort. Despite the fact that domestic water and sewage connection aren't needed, they are available.

5 Ventilation Technology

To ensure high air quality and comfortable indoor climate, the cabin will be provided with a controlled domestic ventilation with an integrated heat recovery system. Compared with manual air exchange, up to 90% of internal heat can be recovered and transferred into the incoming air. In order to keep the heat losses as low as possible, highly energy efficient windows will be installed.

6 Conclusion

The model of the cabin represents some of the essential building technology topics in the "Eco-Energy Engineering" bachelor course. In their final project report, the students came to the conclusion that the combination of sustainability, livability and space-saving design is feasible. The final construction of the cabin in cooperation with a regional carpentry will be one of our future projects. We would like to say thank you to all persons and companies which supported the project.

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