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PASSIVE HOUSES

Passive Dwellings in Marseille?
A Concept Study

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1. Introduction

One of the goals of the on-going, EU-funded research and dissemination project Passive-On is to extend the Passive House Standard to cooling dominated climates, especially in the Mediterranean. Within this context, the Passive House Institute investigated how extremely low energy consumption and high thermal comfort can be achieved in the climate of Marseille. By means of dynamic thermal building simulation, using the PHI's simulation program DYNBIL, a number of "First–Guess Passive Homes" was developed. For the given geometry of an end-of-terrace home, the necessary insulation levels and possible cooling options were investigated.

2. Goals to achieve

What kind of building does the term Passive House designate in a Mediterranean climate? Passive Homes in Central Europe are characterized by the fact that they provide high comfort in both winter and summer at affordable cost without the need for a conventional heating (or cooling) system, thus consuming only very little heating energy. In Central Europe, this requires a ventilation system with heat recovery, which can also be used for the distribution of a space heat power of approximately 10 W/m^2. A significant cost reduction can often be achieved when compact heat pump units are used. Foe Southern Europe, the idea of using the heat pump also for cooling brings up interesting perspectives. In this case, the unit could still heat the DHW with its waste heat and at the same time deliver approximately 7 W/m^2 of cooling power to the house.

We were therefore looking for a building that fulfils the following conditions:

- The aim of an extremely low energy demand for heating and cooling shall be reached cost-efficiently. This means that the focus must be to improve the quality of components which are needed anyway, such as the building envelope, instead of introducing additional technological systems.

- The daily mean heat load, determined by means of dynamic building simulation, is below 10 W/m^2.

- High thermal comfort in winter. Without radiators, the temperature difference between the operative room temperature and the average surface temperature of the windows must not exceed 4 K. Drafts due to leaky building envelope must be avoided, too.

- Good indoor quality. This means that a controlled ventilation, but non necessarily with heat recovery, is required.

- High thermal comfort in summer. As a well-tried criterion for comfortable summer conditions, we require that the room temperature exceeds 25°C in no more than 10% of the ours of the year. Ideally, this should be achieved with purely passive means. Using a low power cooling device on the order of 7 W/m^2 might be permissible, though: The energy consumed will probably be small, and the additional investment will be near to zero. As a matter of fact, Passive Homes will have to compete with standard building that are equipped with cheap though inefficient split units, and they should be able to better overall comfort.

As a starting point, we used an existing, verified dynamic building simulation model for end-of-terrace Passive Homes that have been built in Hannover-Kronsberg in 1998. The houses have 120 m^2 of living area. The building envelope is extremely airtight (n_{50} = 0,6 h^{-1}) and free from thermal bridges. A mechanical ventilation system with 110 m^3/h airflow volume is installed. The average internal heat gains are assumed to be 2,5 W/m^2 of living area. IN a hot and sunny climate, solar control us inevitable: Venetian blinds reducing the solar gain coefficient by ca. 80% are installed which are gradually closed at indoor air temperatures from 23 to 25°C.

A detailes description of the building geometry and of the performance oft the original Hannover buildings can be found in [Feist 2005].

3. Climate

Climate date from [ASHRAE 2001] for Marseille were used. They represent a typical year which does generally not contain extreme weather conditions. The average annual ambient temperature in Marseille is 15°C. The average monthly temperature of the climate data set ranges from slightly above 5°C in winter to around 25°C in summer (Figure 1).

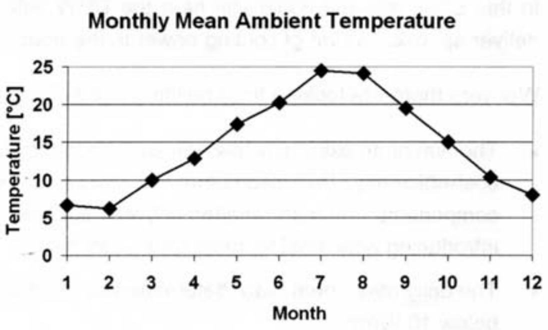

Figure 1: Average monthly temperatures

Figure 2 shows that, in winter, it is generally sunny with no more than two or three overcast days in series. The minimum temperature is –4°C, the minimum daily average is 0,4°C. Thus, building designs which make use of solar energy may be functional here.

Abundant solar radiation il also present in summer. The maximum temperature is 34°C, the hottest day has an average of 27,1°C. IN summer, protection from solar radiation is obviously an important issue. During the hottest days, the temperature drops to 25°C in the night, but in most cases 20°C are reached. Night ventilation may therefore be an option. If different conditions apply (e.g. ambient temperatures above 25°C during summer nights in city centres), the results may change substantially.

4. Results from the Thermal Simulation

4.1 Insulation

Insulation of the building envelope is not only advantageous in winter, but also in summer. During hot periods, the reduction of transmission loads helps to keep the building cool, whereas during cooler periods in summer, an efficient reduction of the indoor temperature is possible by means of window ventilation.

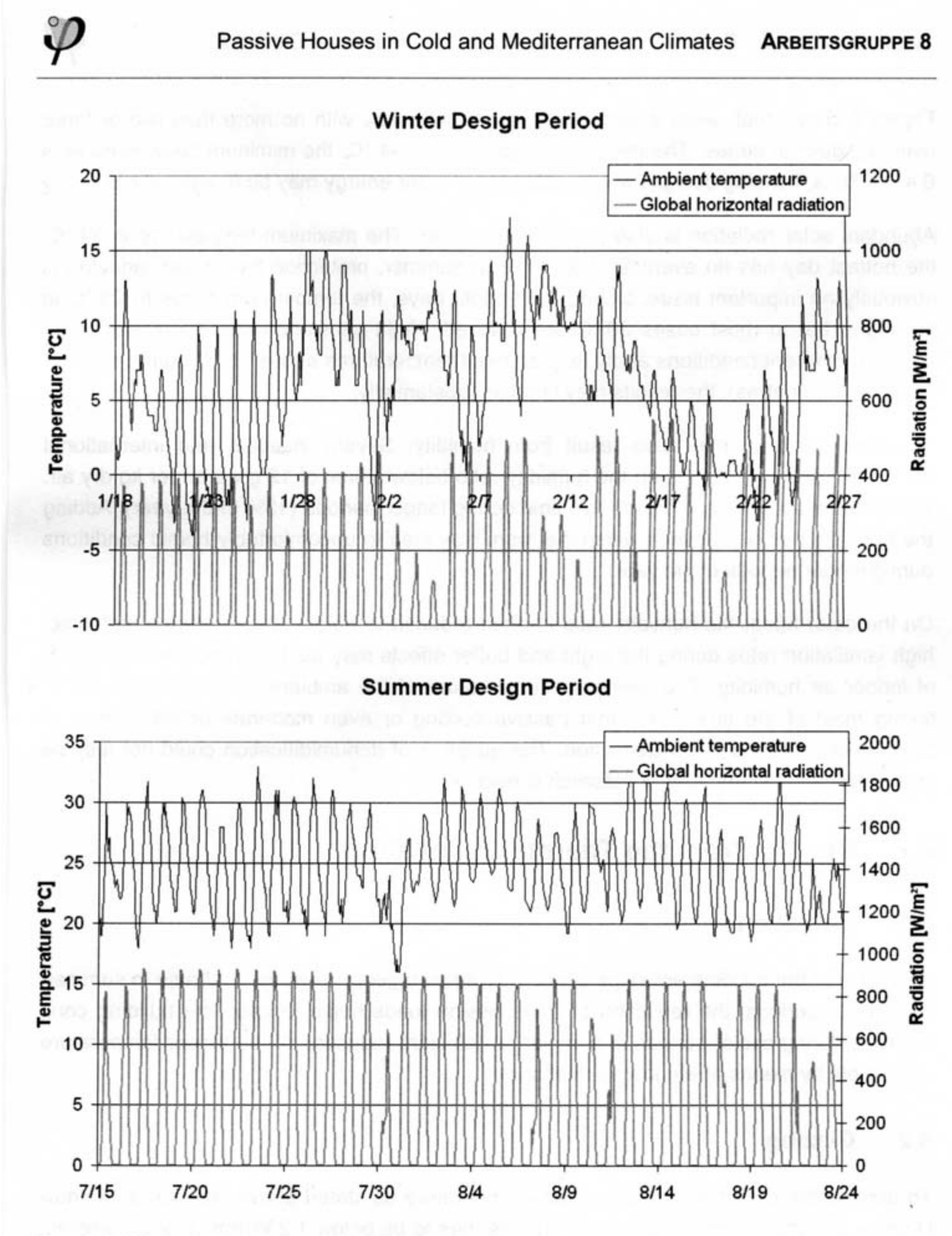

Figure 2: Winter and summer design periods

4.2 Glazing

To achieve the minimum window surface temperature as stated above, the overall window U-value, including frame and thermal bridges, has to be below 1,2 W/(m^{2}K) for an ambient temperature of –4°C. The thermal comfort would be comparable to a triple-glazed Passive House window in Germany. This can be achieved with either triple glazing in a (German) standard window frame or with an insulating frame and double glazing. Standard window qualities will not be sufficient.

Double glazing, as compared to triple glazing, resulted in a very similar heat load but in a slightly lower consumption. Assuming a location where there is not too much shading of the windows, it seems to be advantageous to use double glazing, which is also cheaper, in Southern France.

4.3 Heat Recovery

If no heat recovery is present, insulation thickness of 25 cm and Passive House quality window frames were required in order to limit the heat load to 10 W/m^2. If, on the other hand, a 75% efficiency heat recovery was present, standard windows frames and insulation thicknesses between 10 cm (floor) and 18 cm (roof) were sufficient.

4.4 Night ventilation

One possible means of keeping the summer temperatures within the comfort range is night ventilation. In the example, at room temperatures above 23°C the heat recovery of the ventilation system is switched off, resulting in higher ventilation heat losses and thus cooling the building. Depending on the respective climate and indoor conditions, the windows were assumed to be opened at room temperatures between 22 and 25°C. This resulted in an average window air change rate slightly above 1 h^{-1}.

It was found that better insulation also provides better thermal comfort in summer. The variants that use heat recovery (with highly efficient DC ventilators!) have better summer climate than the variants that use better insulation instead of heat recovery. The reason appears to be that short-term peak temperatures around noon have less effect if more of the heat flows into the building is dampened by the thermal mass and the phase shift of the exterior envelope.

In this example, the fraction of hours which exceed a temperature of 25°C was about 17%. By using more elaborate shading and ventilation patterns it will probably be possible to reduce this value below 10%.

4.5 "Supply air cooling"

In an alternative approach, instead of using the windows for night ventilation, the air temperature of all zones is kept below 25°C by an active cooling system. Similar to the results for night ventilation, the cooling load and the energy required for cooling both are reduced if the insulation level is improved and/or if a ventilation system with highly efficient heat recovery is present. The cooling load stays below 7 W/m^2 in all investigated cases. The (useful) energy which is required to operate the cooling system in summer is a lot lower than the heating energy required: It ranges between 3 and 5 kWh/(m^2a).

Such a system would also be capable of providing dehumidification of the supplied air.

5. Acknowledgments

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6. References

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Source: 10. Internationale Passivhaustagung 2006 - Tagungsband, S: 293