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# Sustainable architecture: its technologies and prospects

**R. Špaček†, H. Hasenritter‡, W. Friedl* & L. Šíp†**

Slovak University of Technology in Bratislava, Bratislava, Slovakia†
Independent Architect, Kempten, Germany‡
Independent Architect, Adelzhausen, Germany*

ABSTRACT: Analysis of a constructed *passive house* and research into the technologies of it now prove that this build type is being applied by architects and engineers to achieve highly thermally insulated structures with low energy consumption. Energy economy is thus much preferred over any other approach. This concept is based on European directives, as well as on the increasing price of energy. However, dealing with ways of building the passive house requires seeking sustainable solutions. It also requires a higher level of knowledge by both designer and user, so that the opportunity to achieve sustainability is present throughout the building process; the use of the structure; and that its destruction and disposal also can be included and evaluated in the design process. Therefore, the aim is to develop instantly useable criteria and solutions for both architects and engineers of the structures.

## INTRODUCTION

In the course of the next 10 years, a *zero energy* standard will be almost compulsory for all newly-built structures in European Union countries. European legislation has followed this objective for a long time now - and systematically. A passive house combined with intelligent technologies and the use of renewable energies complies with this prospective European standard as early as today.

In teaching architecture, the following of the line of authenticity and identity is of essential significance. The use of alternative energy sources through technology innovation is presented in different ways within *green* architecture. Typical is the combination of active (technological) and passive (architectural) forms of use of alternative energy. Technologies enter the architectonic expression of the built work. The active components are visible and typical for such an architectural piece of work [5][10][11]:

- the technology that is using alternative energy resources is visible;
- the technology forms the architectural concept;
- architecture with typical high-tech expression;
- conflicting modern technologies and traditional façade materials;
- expressional bewilderment.

Brussels, June 2010 - European Directive on the Energy Performance of Buildings - EPBD 2010

Figure 1: The Brussels Directive.

### Nearly Zero Energy Building

From 1st January 2019, all public buildings will have to be built as nearly net zero structures. From 1st January 2021, all built structures will have to be constructed to this standard [1][2].

By 2020, the passive house standard will have to be compulsorily introduced to all newly-built structures in Europe.

Architects and engineers gradually will need to better understand that a passive house or a nearly zero energy building does not only mean energy saving (i.e. saving of heat and thus saving of such energy carriers as wood, gas and oil). It is also about the sustainability of the selected building materials, of operational and life cycles of the structures and their impact on the environment during their construction, their use, their demolition and disposal.

| PASSIVE SYSTEMS | | ACTIVE SYSTEMS | | |
|---|---|---|---|---|
|  | + |   | = | Zero Energy Building |
| PASSIVE HOUSE | | Use of renewable energies | | |

Figure 2: The principle of the nearly zero energy building.

The Missing Sustainability Criteria for Passive Houses and Zero Energy Buildings

Neither the zero energy building nor the passive house considers the holistic approach to sustainability. Students' education should be markedly aimed at this holistic perception of sustainability.

Evaluation of the sustainability of both passive house and zero energy buildings should include other primary and secondary areas. Within the secondary area, it is important to consider the parameters apart from the user. That is, for instance, the quality of urban planning and design.

Within the primary area, which is dependent on the user, the parameters directly influenced by the builder and architect should be considered. That is, for instance, the use of built-in energy. Sustainability cannot be evaluated without considering its lifelong use. Thus, the decision for sustainable architecture includes a much wider spectrum of issues than we have thought so far [3][4].

| | |
|---|---|
|  | Secondary sustainability: An example of missing sustainable urban planning and design  Architect *What else can I make more optimal on the shape of the building? Finally, it will still look as if it is my fault.* |

Figure 3: The architectural puzzle.

In 2009, the whole European architectural community remarkably joined this trend. In September, organised by the European Economic and Social Committee, days of energy efficiency took place in Brussels. In that time, a seminar on Architecture and Sustainability was organised by the European Council for Architecture (ACE). Culmination of the whole seminar was the introduction of a publication called Architecture and Sustainability - Declaration and Policy of the Architects' Council of Europe.

The ACE fully supports that it is the responsibility of architects and architecture for quality of life in the future. Architecture should be environment-friendly and energy-efficient. Terms such as *Low carbon society*, *Energy efficient Europe* have appeared. The ACE, through national organisations, has gathered and addressed 480,000 architects, and it is expected that, so far, local initiatives will become a general paradigm.

The new aesthetics of architecture is being discussed. If the effort for all new structures built after 2020 with zero energy standards becomes real, then this may become a challenge for our present graduates. The teaching methods of sustainable architecture head towards a new paradigm relating architecture to technology.

Example of Green Sustainable Architecture - the Green Passive House to *Plushouse* Standard

The author explains the principle of sustainable architecture such as the *Plushouse* certified in Germany and built to passive house standard [6-9].

The example serves as a methodical aid helping to teach architecture students at the Faculty of Architecture, Slovak University of Technology (FA-SUT) in general and, more deeply, at the Institute of Sustainable and Experimental Architecture.

The plus standard is reached by a quality perimeter envelope, effective technologies of heat distribution and ventilation, and by use of alternative energy resources. However, sustainable architecture is not restricted to only energy reviews; it is inevitable to take into account the life cycle of the structure. The process starts with urban design and continues with material selection, structural systems and technologies of the building processes. Currently, we develop the so-called *Green Passive House* evaluation system that enables us to assess sustainability in a complex way.

The plus energy house is built in the way of the passive house and realised for a family with three children in the inner city of Augsburg (Germany). In relation to the annual demand for heating, the two-storey house with a heated cellar produces an annual surplus of about 35%. Another unique aspect is the benchmark for balanced assessment of negative primary energy in hot water, heating and technological electricity. This *negative value of primary energy* is reached by use of biomass in combination with solar support of heating and photovoltaic equipment. When we succeed in increasing sustainability of a passive house, namely by its long life cycle in combination with ecological building materials, we can speak about the Green Passive House.

Figure 4: Views of structures: © www.architekt-friedl.de

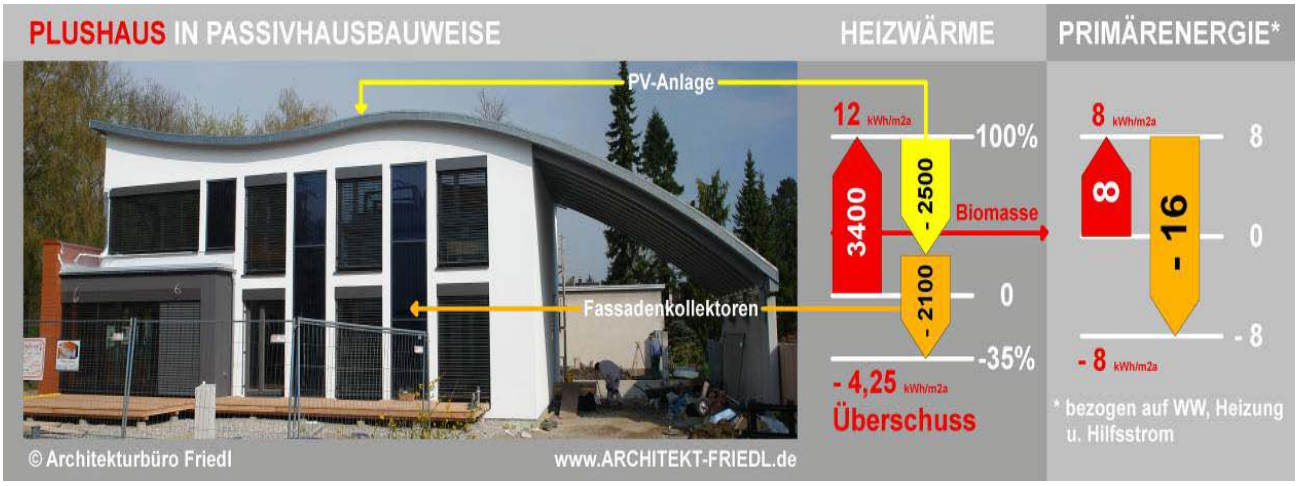



Figure 5: *Plushouse* built by the way of the passive house: © www.architekt-friedl.de

Increase in Primary Sustainability

- *Plushouse* standard as a special type of Passive house (related to heat-requirement per year);
- *negative parameter of primary energy* (related to warm water, heating and auxiliary current);
- *flexible photovoltaic*, following the curved roof;
- widespread collectors at the facade for solar heat production;
- Green roofing in visible parts of the roof;

- insulation of the roof with cellulose fibres;
- use of rainwater for toilet and garden;
- biomass for heat-requirement for covering peak-loads;
- high heat protection by massive construction method;
- interurban position with connection to public local traffic and transport.

Characteristic Values

| | |
|---|---|
| • Passive House Planning package (PHPP): heat-requirement per year | 12 kWh/(m²a) |
| • Energy reference plane | 273.26 m2 |
| • Pressure test n50 | 0.2 h-1 |
| • U-value *thermal cover* | 0.08 bis 0.16 W/(m²K) |
| • Openings | (g-Wert: 61%) 0.71 bis 0.76 W/(m²K) |
| • Heat recovery | 88% |
| • Biomass as an energy carrier for peak-loads | Pellets (Biomasses) |
| • Solar heat quantity of the facade collectors | 2 461 kWh/a |
| • Savings by generation of solar electricity | 2 135 kWh/a |
| • Parameter of primary energy: warm water, heating, auxiliary current and current used in the house for living | + 48 kWh/(m²a) |
| • Parameter of primary energy: warm water, heating and auxiliary current | + 8 kWh/(m²a) |
| • Savings by generation of solar electricity | - 16 kWh/(m²a) |

Viewing the balance: => *Negative* - 8 kWh/(m²a)

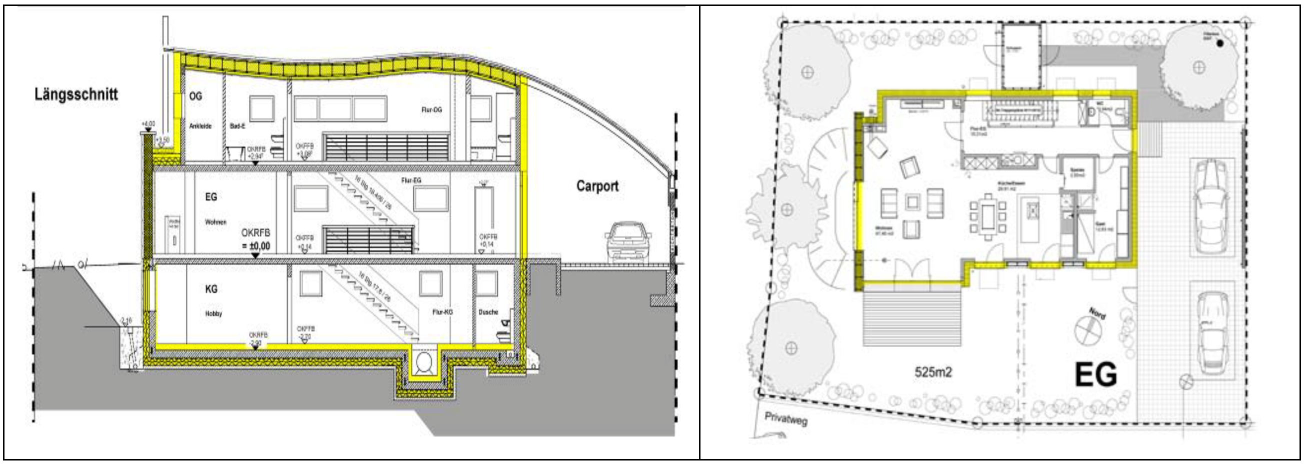



Figure 6: The plans.

Concept of Ventilation

Figure 7:

Dimensioning:

main ventilation: 173.1 m$^3$/h
rated volume flow: 225 m$^3$/h
conditioned area: 281.60 m$^2$/h
rated air change: 0.3 1/h

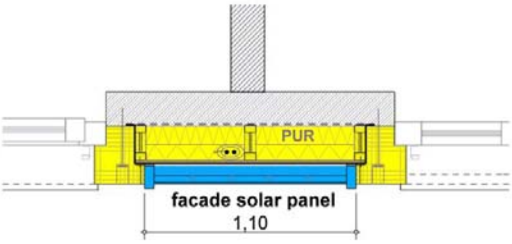
ventilating system device:
rate of heat appropriation: 88% certified
maximal power consumption: 0.30 W/(m$^3$/h)

Heating-Conception

<table>
<tr><td>Figure 8<br><br>To cover peak-loads, a self-activating pellet-primary-oven is used. This facility gives up to 95% of heat-energy to the cache by using medium-heat water.<br><br>5% of the energy is radiated directly from the oven to the living-room. An automatic loading system has been developed to accommodate an increase in user demand. The well-filled pellet-stock in the basement can last for many years.</td><td><br>pellet-primary-oven</td></tr>
</table>

Components for Energy Production

*Facade-Collectors for Solar Heat Production*

<table>
<tr><td>Figure 9<br><br>13.8 m² effective solar-thermo facade-collectors have been integrated into the architecture concept of the passive house. Therefore, considerable effort was necessary to resolve constructive and technical issues.<br><br></td><td></td></tr>
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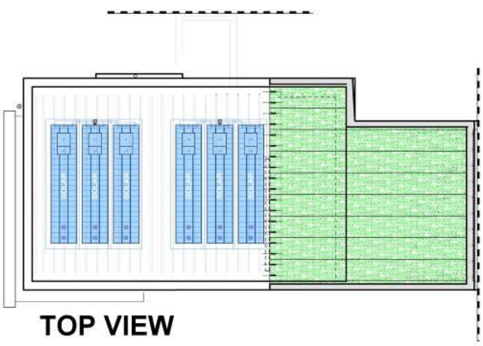
*Solar Power System - 2.4 kWp*

<table>
<tr><td><br><br>Figure 10<br><br>Solar power system with 2.4 kWp output. In visible parts of the roof an extensive green-roofing system was realised.</td><td>Photovoltaic modules, which are flexible and integrated into the roof insulation, are another special feature. These modules match perfectly the course of the more-dimensional curved roof and convert solar radiation energy directly into electricity.<br></td></tr>
</table>

CONCLUSIONS

The *Passive house* should always be the model for sustainable architecture [12]. It should be equipped with active components for obtaining energy. In that way the zero or plus standard can be reached. The *Green Passive House* additionally takes into account user-dependent and user-independent parameters. In the process, it is important to strive for long life-cycles of the passive house. The application of sustainable building materials to good ecological recyclability is the precondition. Sustainability is also related to the architectural quality of structures, their project design and urban planning and design.

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