Short report based on research project

Net-surplus-energy-building with power load management and e-mobility

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Bundesinstitut für Bau-, Stadt- und Raumforschung im Bundesamt für Bauwesen und Raumordnung

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1. RISE AND STARTING POINT

Sustainable buildings switch from consumer to producer by using renewable energy and energy efficient technology components. Thus, next to the building operation, the production of energy, the individual consumption and the input for mobility is subject of an integral design.

The net surplus energy building becomes an example object, on which the holistic system solutions with innovative production and storage can be developed and evaluated.

2. PURPOSE OF THE RESEACH PROJECT

In the framework of the research project "Net-surplus-energy-building with power load management and e-mobility ", the Institute of Building Services and Energy Design (IGS), Technical University of Braunschweig, is carrying out a scientific monitoring and optimization program for the single family house in Leonberg-Warmbronn (Figure 1 and 2).

Aim of the R & D project is to evaluate the energy and socio-cultural performance of the net-surplus energy standard for the single family house. The energy balance includes the building operation, household electricity and e-mobility. The focus of scientific analysis is, among others, on a high fraction of self-consumption of photovoltaic electricity. The concept takes the following aspects into account for the realization of net-surplus energy standards:

- reducing the annual final energy demand for heating and domestic hot water,
- reduction of the annual electricity demand for appliances and lighting,
- rational power generation and distribution,
- direct use of solar energy for heating and electricity, as well as for e-mobility
- storage of solar-generated electricity in thermal storage and batteries,
- Building Management System (BMS) for the control and implementation of a load management
- monitoring for performance review and optimization.

The building was occupied at the end of 2010. Since the beginning of 2011 BMS data is available which allows a detailed analysis of the energy balance, the system efficiency and the operating conditions in correlation to the use.

Energy concept

The supply for heating, cooling and electricity is designed to be a holistic energy concept with net surplus energy standard considering the building envelope and systems engineering for the building (Figure 3). Prerequisite for the reduction of the total energy demand is an integral planned solution that consistently tracks the use of solar energy.
Apart from the calculated coverage of the primary and final energy demand through the active use of solar energy, a maximum internal current use of the yield of the PV system is pursued. To harmonize the renewable supply to the coverage of the demand, for example, the terms of the heat pump is limited to daylight hours as well as power storage and intelligent power load management are object of the overall system. The batteries of e-mobility can be used as extra storage. The procedure allows a high direct solar coverage in the building and reduces the fraction of the surplus which is fed into the public grid or drawn from the grid.

Results

The primary goal of the net surplus energy standard (annual primary energy and final energy consumption) with high user satisfaction is achieved within the first two years of operation. 2011, a primary energy electricity surplus of about 80% (21,526 kWh / year) can be realized. The production exceeds the network-related share of consumption by 57.3%. 2012, this surplus descends due to the "decommissioning" of solar thermal energy and the intensive use of e-mobility. The internal current use can be increased from 18% in the first to 32% in the second year of operation. The solar electric fraction is increased from approx. 32% (2011: Power consumption 9027 kWh / a) to about 48% (2012: 11,060 kWh / a) in the total annual electricity consumption. The electricity production has exceeded the direct useable share of electricity consumption in 2011 by 82.5% and in 2012 by 67% (Figure 5).
In the two years of operation the PV system has accomplished an electricity production of about 1,050 kWh / kWp / a, the total system efficiency was just over 13%.

2011 11.202 kWh / a heat is generated and 2012 13.918 kWh / a. Here, the heat supply in 2011 was covered by 73% with the heat pump and by 27% with the solar thermal collectors. In March 2012, the solar thermal collectors were covered up to simulate the technology concept "Only Electricity House".
With the chosen dimension of 7 m^2 the solar thermal system achieved a specific yield of approx. 420 kWh / ($m^2_{Coll.}$a) in 2011.
The monthly performance factor of the heat pump increased from approx. 3 to 3.5 in the heating season 2011 to 3.7 to 4.7 in the second heating season (2012).

3. CONCLUSION / OUTLOOK

The net surplus energy standard is achieved in both of the two years of operation. As a result of the optimizations, the directly solar-electric coverage of the annual electricity consumption can be increase from approx. 32% in 2011 to 48% in 2012. This is associated with an increase of the own used PV electricity from 18 to 33%.

With the results of the monitoring, the need for further research is illustrated. Particularly in relation to the increase in own use of electricity and the development of storage capacity the R & D potential is identified. Other priorities are the evaluation of costs and review the specification for monitoring of building operation with “active functional descriptions”.

4. BASIC DATA

Lemma

EnergyPLUS Building

Research and Project Management:

Project management:	Univ. Prof. Dr. M. Norbert Fisch Dipl.-Ing. Arch. Thomas Wilken
Development:	Dipl.-Ing. F. Bockelmann Dipl.-Ing. C. Stähr
Total costs	184.248,50 €
Rate federal government	131.128,00 €
Project duration	01.09.2011 – 01.03.2013

5. PICTURES AND GRAPHS

Figure 1: Net-surplus-energy building in Leonberg-Warmbronn

Name of the figure: Ansicht.jpg

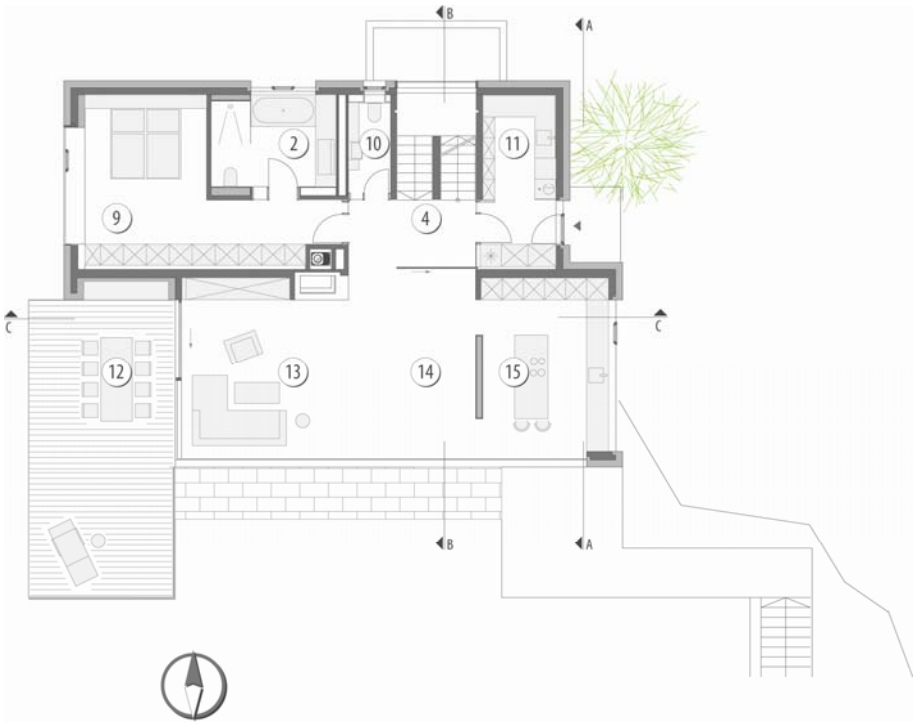

Figure 2: floor plan ground floor

Name of the figure: Grundriss.jpg

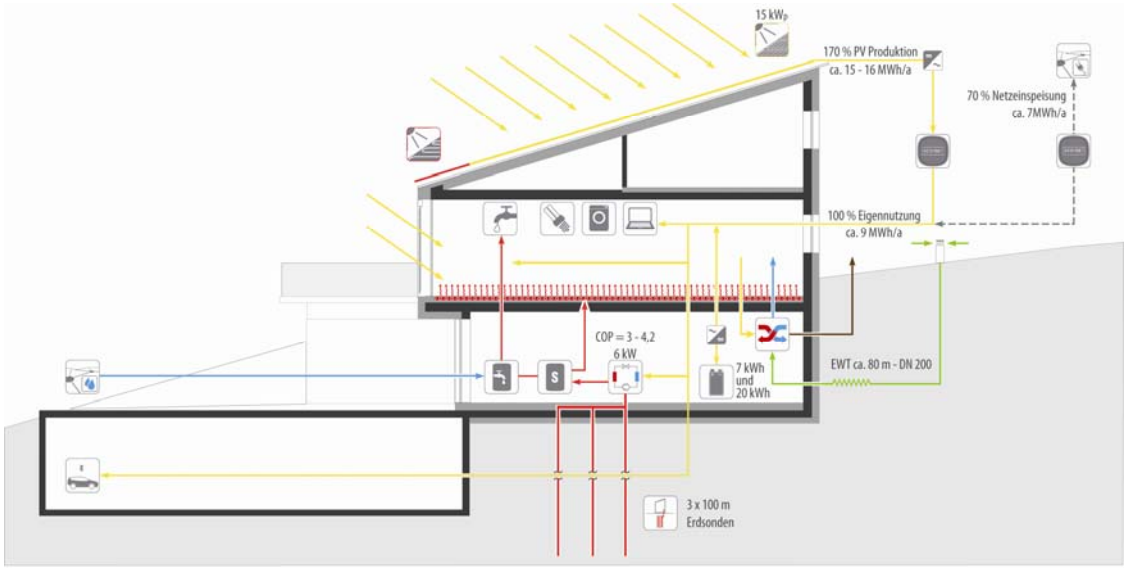

Figure 3: Energy Concept (2011)

Name of the figure: Energiekonzept.jpg

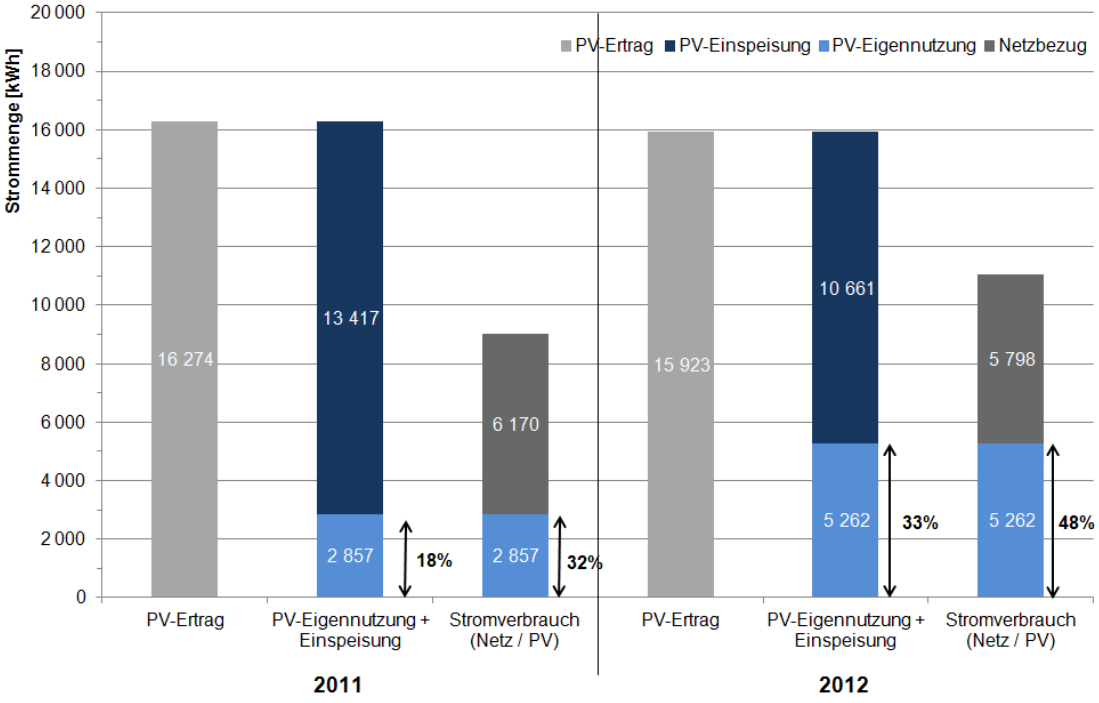

Figure 4: Annual balance of electricity / final energy and own shares in comparison (2011 and 2012)

Name of the figure: Jahresbilanz_Strom.jpg

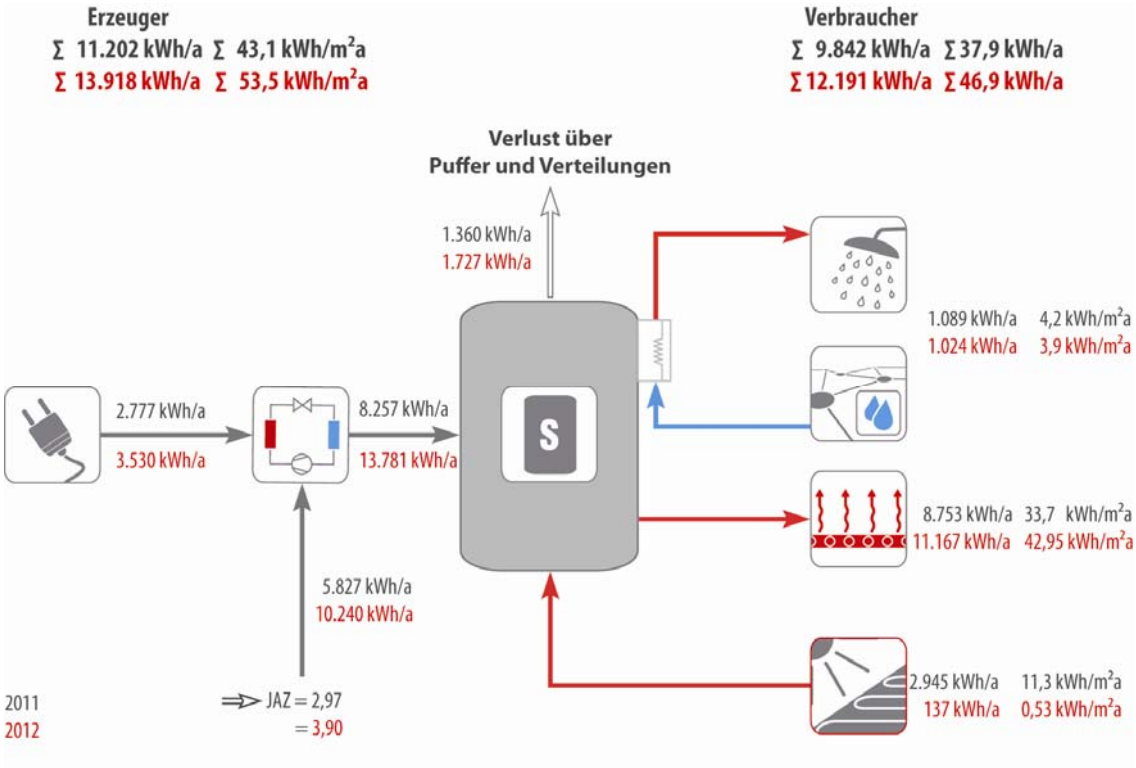

Figure 5: Heat Balance 2011 und 2012

Name of the figure: Wärmebilanz.jpg