Summary Report

Material Moisture Monitoring of Highly Insulated Wooden Frame Building Components from the Efficiency House Plus with Electro Mobility in Berlin

within the frame of the research initiative „Future of buildings“

Performed on behalf of
the Federal Institute for Building, Urban Affairs and Spatial Development (BBSR)
in the Federal Office for Building and Regional Planning (BBR)

Duration of the project:
27. July 2011 to 31. March 2017

The summary report has
5 pages with text and
6 pictures

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Occasion / Initial situation

The „Efficiency House Plus with Electro Mobility“ was built for research projects in 2011 within the frame of the research initiative „Future of buildings“. The aim of this project is an experimental investigation of the correlation between the design and usage of the building with the focus on the heat – and moisture behaviour of the building envelope. This is a quality assurance measure of the building envelope. Additionally it should be a foundation for further development in the technical building equipment and evaluate the highly insulated building envelope for a wide application.

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Subject of the Research Project

The hygrothermal behaviour and durability of the highly insulated building envelope as well as the indoor climate were investigated in a measurement program with 58 different measurement sensors over a period of 4,5 years (picture 2 and picture 3). The different uses of the building during the measurement period between January 2012 and September 2016 included the usage by two different "test families" and three periods of usage as a public exhibition.

The measurements were focused on

- an IR-thermography after completion of the building as a thermal building inspection
- the influence of the erternal climate on the internal climate with statements on comfort and about the heat protection in the summer
- the U-value of the opaque external walls
- the material moisture in the external building boards of the wooden framed panels of the external walls, the material moisture of the floor above the crawl space as well as the material moisture of the flat roof within the area of PV-elements and outside the area of PV-elements
- the natural convection within the loose-filled insulation of the NNO-fassade, investigated with material moisture profils as well as temperature profiles within the insulation
- the question: are hygro-thermal conditions for mould growth verifiable,
- how are the hygro-thermal climate conditions within the crawl space.

To investigate in these points it was necessary to install 52 different sensors within five frames of the prefabricated wooden framed elements of the exterior building components. These sensors measured the temperature, the relative humidity, the heat flux or the material moisture. The measuring equipment was completed at the building site in Berlin during the construction progress. Due to the building useage as well as due to the building process, there were restrictions on the position of the sensors.

The high thermal insulation standard of the opaque external building components were demonstrated through measurements with an IR-thermography camera. These measurements detected small thermal bridges across the joint between the floor and the external wall, relevant for measurements about natural convection within loose filled insulation in the external wall, see picture 4. Connections of steel components and highly-insulated building components made of wood are relevant heat bridges.

The external temperatures within the ventilated space of the NNO fassade were 1.2K to 2.3K higher in the measurement period than in the reference year of the EnEV relative to the annual mean value. In the hottest summer months the monthly mean values of the external temperatures were 3,6K to 4,3K higher than the values of the EnEV.

The ventilated layer between the black fassade elements and the highly-insulated wooden framed elements of the NNO-external wall, as well as of the SSW-external wall don't prevent a temperature rise of the wooden framed elements. This heating caused by radiation contributes to the overheating of the interior air in hot summers. The highest overheating was detected in the flat roof in the area with PV-elements. The monthly temperature mean values measured in a layer about 90mm below the upper surface of the highly-insulated flat roof were in the area of PV-elements higher by 4 Kelvin, see picture 5. The temperature maxima differ up to 12 Kelvin in both areas, see picture 6.

The highest measured temperatures on the exterior claddings of the wooden framed elements were 47°C on the ventilated SSW-exterior wall and 60°C within the above mentioned layer in the flat roof. (picture 7). The monthly mean value of the temperature amplitude damping were 10,4 in August 2015 (min: 3,0; max. 16,4).

The protection against summer overheating has not been complied during the use of the building for exhibitions in two of four summers. An effective night ventilation is to guarantee independence of the useage of the building.

The mean values for the U-value of the opaque NNO-exterior wall and the SSW exterior wall were 0,094 W/m^2K at maximum. These values were calculated with measurement values of the winter months. The results were lower than the calculated U-value of the planning process with 0,10 W/m^2K.

The good ventilated crawl space had a low moisture load compared with the ventilated space within the NNO-fassade. The measured moisture load of the interior air was low. The mean value of the indoor air humidity was 28,6% RH in February 2012 and was in 12% of the whole year lower than 30% RH.

The high surface temperatures on the exterior cladding of the wooden framed elements due to radiation, the low temperature difference between the inner and the outer cladding of the wooden frame elements of 17 Kelvin at maximum, the low moisture content within the indoor air and the inside vapour barrier with s_{di}>100m are the reasons of the low moisture transport within the external walls with s_{de} = 4,5m. No relevant moisture transport due to natural convection or vapour diffusion are expected within this boundary conditions in a cellulose insulation of 360mm thickness and a density of >55kg/m^3.

The measurement results of the external walls did not reveal material moisture or mold fungus affected by natural convection or air leakages. Investigations of the high insulated floor element above the crawl space also showed no risks for moisture damages.

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The hygro-thermal measurements in the opaque building envelope and in the crawl space of the Efficiency House with Electro Mobility show a good standard in terms of heat and moisture protection. The protection against summer overheating should be improved. The influence of a dark coloured surface of an opaque building envelope made of wooden framed elements on the summer overheating of the indoor climate should be considered in the planning process. The arrangement of photovoltaic elements should be optimized, so that an overheating of the underlying wooden frame element due to radiative heat transfer is avoided.

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Key Data

Short title:	Material-Moisture-Monitoring of the Efficiency House Plus with Electro Mobility in Berlin
Researcher / Project manager:	Dr.-Ing. Katrin Riesner (Project Manager, Researcher of all project phases) Dipl.-Ing. Detlef Krause and Peter Nagel (installation of the sensors)
Total cost:	94.928,15 €
Ratio of the federal subsidy:	100%
Duration of the project until:	31. March 2017

Pictures:

Picture 1: „Picture 1 – Photo EHPmE.JPG“

Photo with the roadside view of the Efficiency house plus with electro mobility in Berlin

Picture 2: „Picture 2 – Ground floor plan.bmp“

Ground floor plan with the location of the sensors and the measurement equipment

Picture 3: „Picture 3 – First floor plan.bmp“

First floor plan with the location of the sensors and the measurement equipment

Picture 4: „Picture 4 – Detail building base.bmp“

IR-thermography picture of the insulated wooden frame with sensors in the NNO-external wall

Picture 5: „Picture 5 – Monthly temperature mean values within the insulation_2013.bmp“

Monthly temperature mean values of the exterior air temperature, the indoor air temperature as well as of the temperatures within the insulation of the flat roof, of the external walls and above the crawl space for 2013

Picture 6: „Picture 6 – Monthly temperature maximum values within the insulation_2013.bmp“

Monthly temperature maximum values of the exterior air temperature, the indoor air temperature as well as of the temperatures within the insulation of the flat roof, of the external walls and above the crawl space for 2013

Picture 7: „Picture 7 – Temperatures within the insulation_07.2015.bmp“

Indoor climate and outdoor climate as well as temperatures within the insulation of different building components for the first week of July in 2015