SUSTAINABLE REFURBISHMENT OF MUSEUMS

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Summary

A group of researchers from 5 German universities, along with several German museums, works on the development of retrofitting strategies for museum buildings. The overall aim is to provide the necessary indoor climate, as required due to preventive conservation, with a minimum energy demand. The German Maritime Museum in Bremerhaven serves as the first scheme project for the implementation and validation of their ideas.

Keywords: Museums, Preventive Conservation, Retrofitting, Energy Efficiency, Innovative Materials

1 Background

In Germany a multitude of museum buildings need to be retrofitted within the next years. The complexity of these projects lies within the necessity of meeting the requirements of various disciplines: How to provide a steady indoor climate, necessary for preventive conservation reasons, against the background of fluctuating numbers of visitors and the aim of lowering the energy demand, in order to cut both, costs and carbon emissions, in a, almost certainly, listed building?

To answer questions like this, engineers from 6 major German universities formed a research group, funded by the Federal Ministry of Economics and Technology. The group's overall intension is to escort museums through the difficult process of refurbishment by developing and implementing new refurbishment strategies. These will be validated by measurements, the results published in order to enable planners and museums to apply them on other projects.

2 General Procedure

2.1 Present Situation of Museum Buildings

First investigations of building structure, plant service facilities and energy consumption of the participating museums, among them the Deutsches Museum in Munich and the Deutsches Schiffahrtsmuseum (German Maritime Museum) in Bremerhaven, show U-values typical for the respective construction period. The resulting energy consumption values (heating and electricity) per square meter net-ground area are shown in Figure 1.

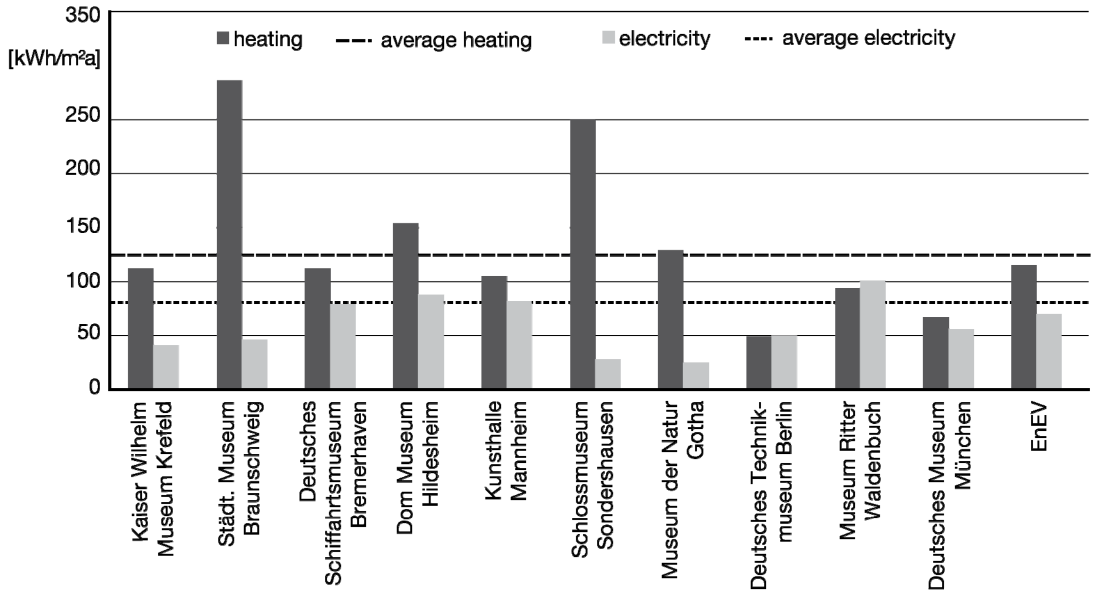

Fig. 1 Energy consumption (heating, electricity) of selected German Museums

In comparison to the energy demand requirements according to the Energy Saving Ordinance (*Energieeinsparverordnung - EnEV*) [1], the results concerning electricity meet perfectly. The heating demand of the examples however is in most cases higher than the reference value. Some recently refurbished museums on the other hand, e.g. the Deutsches Technikmuseum (Museum of Technology) in Berlin, go below the legal limits.

These investigations are accomplished by measurements of room air temperatures, surface temperatures, heat flow rates, relative humidity, illumination level, and CO_2 concentration (Figure 2).

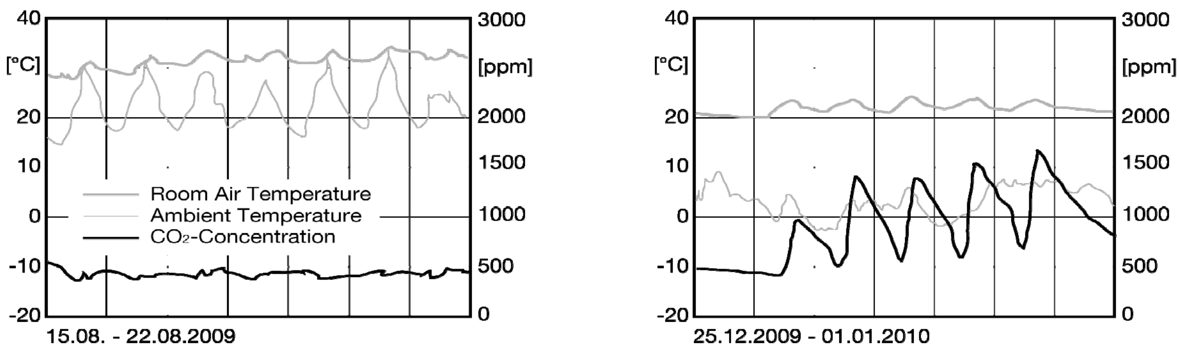

Fig. 2 Room Air Temperature and CO_2 Concentration in the microelectronic department of the Deutsches Museum in Munich in comparison to Ambient Temperature

2.2 Thermal Building Simulation and Validation of Refurbishment Strategies

Calculations of the buildings' energy demand based on DIN V 18599 - Energy efficiency of buildings [2], are justified by the above mentioned measurements and used as a basis for the validation of suggested refurbishment measures.

Refurbishment measures providing the required indoor climate by minimizing the overall energy demand are combined to refurbishment strategies that will be put into practice. The resulting indoor climate as well as the energy consumption will be monitored in order to validate the implemented refurbishment strategies.

3 Pilot Scheme: Energy Refurbishment of the German Maritime Museum in Bremerhaven

The German Maritime Museum in Bremerhaven plays a major role within the project as it is going to be the first pilot scheme to be realised. Its energy optimization is going to be an outstanding example for energy optimized museum buildings in Germany, with a high influencing potential.

3.1 Situation

On 8500 m² the history of German nautical history is presented. The museum itself dates back to 1975 (Figure 3) and is the last major oeuvre of the German architect Hans Scharoun. In 2000 the museum was extended for the first time by Berlin based architect Dietrich Bangert. Now a second extension is necessary, which will be carried out by the same architect.

Fig. 3 German Maritime Museum in 1975 [3]

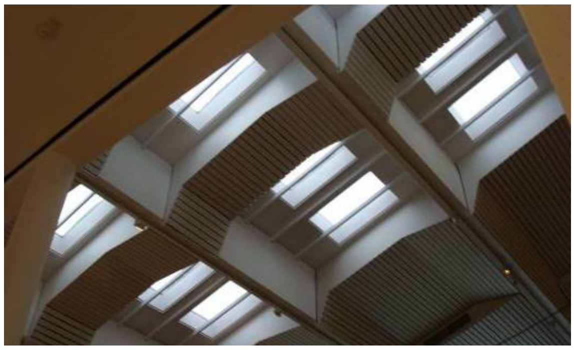

Fig. 4 Size of roof lights, reduced over the years

3.2 Energy Concept and Retrofitting Strategy

The integrate energy concept, focusing on retrofitting measures, power supply, conservation and exhibition concept, merges the existing parts with the extension.

3.2.1 Building Specific Retrofitting Measures

In order to achieve low primary energy consumption, energy losses caused by transmission and ventilation have to be minimized. Relatively easy to achieve for the museums newly built parts, this is quite challenging for the historical part by Hans Scharoun.

Due to monument preservation requirements, the necessary thermal insulation will be realised by applying vacuum isolation panels underneath the existing clinker façade, which had already been substituted once. Thus the original appearance of the building can be preserved, along with an optimised interior climate and minimised energy losses (Table 1).

3.2.2 Power Supply and Plant Service Facilities

The planned extension of the museum by nearly 50% of the existing area requires a new energy supply concept for the whole building.

Tab. 1 U-values of existing building part, built by Hans Scharoun, before and after retrofitting

Building Component	**Existing Building** W/(m²K)	**Retrofitted Building** W/(m²K)
Roof	0,57	0,1
Exterior Wall	1,16	0,2
Floor Plate	2,50	0,2
Windows	1,40	0,9
Roof Lights	2,70	1,1

The basic component will be district heating, supplied by the local waste-to-energy facility. It will cover the heating demand and operate the absorption refrigeration machine. Peak loads will be met by a compression refrigeration machine. In addition to the local electricity supply, roof integrated PV elements will produce electrical energy.

An air change rate of 2 will be provided by an air conditioning plant with a heat and humidity recovery efficiency factor of 75%. In combination with low temperature heating and high temperature cooling systems, integrated into the refurbished floor construction, the reduced air change rate offers a high energy saving potential.

3.2.3 Exhibition Concept

The new exhibition concept combines preventive conservation requirements in accordance with international standards, comfortable indoor climate conditions and a reduced energy demand for heating, ventilation and lighting.

One important aspect is the increase of illumination by natural daylight. The use of daylight was reduced over the years by partially closing the original roof lights (Figure 4). By their intended reactivation the solar gains, required by the energy concept, can be provided. However the protection of materials like paper, textiles, photographs and paintings is essential. So a triple-glazed window with a U-value of 0,6 W/(m²K) and a g-value of 0,25 is projected. The band-pass filter of 405 nm promises high protection, especially for sensitive materials like lignin and cellulose.

3.3 Outlook

Going to be realized until 2013, the German Maritime Museum will have an overall end energy demand of approximately 80 kWh/(m²a) for heating and 40 kWh/(m²a) for lighting and cooling.

References

[1] Bundesministerium für Verkehr, Bau und Stadtentwicklung (Federal Ministry of Transport, Building and Urban Affairs). *Energieeinsparverordnung 2007 – EnE:V2007 (Energy Conservation Regulations 2007*

[2] Deutsches Institut für Normung (German Institute for Standardization). *DIN V 18599. Energetische Bewertung von Gebäuden (Energy efficiency of buildings)*. Beuth. Berlin 2007

[3] Deutsches Schiffahrtsmuseum Bremen, 6.3.2010, http://www.dsm.museum/Homepage DSM