Sustainable Modernisation and Restoration of Historic Urban Quarters

Renewable Energy Supply as Main Objective of a Sustainable Modernisation of Historically Valuable Urban Quarters (RENARHIS)

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In the project RENARHIS (project funding id II 3-F20-11-1-038), we have developed restoration and modernisation strategies based on the model of a home building cooperative living quarter from the 1920s. The results have been documented in the form of a compendium. Main topic is the conservation of architecturally valuable assets, socially balanced living costs and a low primary energy demand by using renewable energies.

According to the 2011 census of the Federal Bureau of Statistics, roughly 26% of Germany's residential buildings have been constructed before 1948. Hence the development of concepts for the conservation and modernisation of this type of buildings is of significant economic importance. We are concerned about the preservation of the architectural and urban heritage in our country as well. To be more specific, extant buildings from the time between the world wars represent historically important urban quarters. Sustainable concepts aim at a reconciliation of the different objectives originating from monument preservation, i.e. preserving the architectural forms and variety and the substance of the buildings, and from climate protection and economic strategies, i.e. optimised energy efficiency. It is not only a conscionable use of resources and economic building modernisation but also the preservation of cultural traditions and social forms of living, i.e. the structure and the needs of the residents, which have to be considered carefully.

While preceding research used to focus mainly on new energy-saving buildings and on the renovation (retrofit) of old buildings, driven by economics, the interdisciplinary project RENARHIS was designed to deal with the following central questions:

- What can be done with historically valuable buildings where the architecture does not allow for a full-scale energetic retrofit?
- How could we make use of the special characteristics of such residential complexes to obtain an economicallyally feasible energy supply based on renewables?
- How can we maintain social living costs and how can we improve social cohesion („team spirit") within the living quarter?

An existing urban quarter in the Eastern part of Regensburg serves as a role model for the development of solutions (based on a detailed historic inventory taking) that are transferable to similar types of urban quarters of that period. The investigated quarter was established in the years from 1912 until 1926, designed as a home building cooperative complex. The home building cooperative principle with its low-budget homes has been preserved to the present day and is considered as an important objective for a future utilisation concept.

The architecture complies with cooperative principles. This is reflected in the characteristic appearance of the quarter with its economised historismic apartment blocks, arranged around green inner courtyards. The horizontal segmentation of the façades with their recurring elements, the cornices and an enclosing band of natural stone plinths symbolise the notion of solidarity and equity typical for the home building cooperative society. The lengthwise rows of apartment buildings are topped with mansard roofs, their façades are divided by pilasters and pilaster strips, and emphasised by dwarf gables.

The historic reprocessing of the building was done by reflection of details and gathering information on the construction of roof, walls and floors. A deformation-true tacheometric survey of the façades and a survey of selected flat layouts provided clear evidence of the remarkably well preserved state of the buildings.

As part of a social survey, demographic and social structures within the living complex and its surroundings were investigated both in their historic development and in their current composition. Compared to the overall town population, which itself is rather young, the neighbourhood is even younger, with more than 50% of the residents having migration background. The social structure is characterised by low income, relatively high unemployment rate and high risks of poverty.

In order to evaluate the support of an energetic modernisation of the complex, guided interviews were performed which covered 73 of the 158 households. The living quality before any measures of modernisation was in many cases adversely affected by problems with draughty windows, heating, room climate and subsequent growth of mould. Correspondingly, the need of any sort of refurbishment was reaffirmed by the residents, the overall voting being essentially positive. Letting the residents participate in the decision processes might even increase this positive attitude. Large-scale measures, involving a relocation or the installation of a new central heating, are expected to raise some opposition. Moreover, due to the high percentage of low-income persons, the transfer of costs is challenging. Accordingly, most concerns, especially of older tenants, are connected with upcoming rent increases and other additional financial burdens. This demands new models for the calculation of rent and energy costs.

A complete construction documentation with room book and analyses of building physics create the basis for architectural modernisation and energy supply concepts.

Heat losses can be reduced by thermal insulation. Historic, valuable façades, however, cannot be upgraded by exterior insulation. Hence we consider interior insulation with moisture regulating (capillary-active) calcium-silicate panels. This concept was investigated thoroughly by means of simulations, especially on details for integrated inner walls, floors, eaves, basement walls, and natural stone plinths.

Building physics was also investigated concerning the moisture dynamics in order to prevent growth of mould in the rooms and condensate water in the building components. The full programme includes:

- Photo documentation and thermographic analyses of the building (outside and inside)
- Material analyses (core extractions, moisture measurements)
- Measurements of room climate and user behaviour

- Thermal calculations and hydrothermal simulations of details: thermal bridges in walls, jointing details of wood beams, basement ceiling, windows with and without capillary-active interior insulation
- Calculations of energy demand to derive the necessary insulation thickness
- Measurements on sound insulation and concepts to improve the wooden beam floors
- Fire protection

Following on the knowledge of the construction documentation and analysis of the physical building an architectural modernisation concept was developed which should ensure a sustainable treatment of the existing building stock.

This includes:

- proposals for the modernisation of floor plans that match the present-day living standard
- principles of controlled domestic ventilation
- risk assessment for beam heads with respect to wood moisture
- review of current research in the field of solar-active color coatings
- representation of the essential construction details in due consideration of the requirement for fire, sound and moisture protection

In the course of the work on the complex it turned out that the existing layout structures can be adapted to present-day requirements with little effort. The densification of the building blocks through the expansion of attics can be implemented in many areas, without changing the historical structure of the dormer windows. To this end, the glass surface of the dormers must, however, be increased, which is achieved by appropriate configuration of the roof. Furthermore a private outdoor area, desired by many residents, can be provided – despite the complete absence of balconies in the façade – by appropriate use of the courtyards.

A particular challenge was the implementation of the interior wall insulation, regarding the beam heads of the wooden beam ceilings. Only on the basis of detailed physical analysis and simulation for this detail point, a constructive solution could be found which can be implemented without risk to the beam head. This includes, among other things, a component tempering in the lower part of the walls and a recess in the interior insulation in the ceiling connection. This ensured that sufficient heat is conducted to the beam head to protect it from excessive moisture content and the associated risk of mould. This detail demonstrates an example of the guiding principles of sustainability by connecting the energy savings objective with a secure and improved building durability via a suitable insulation design.

An energy supply concept, adapted to the architectural and infrastructural situation, should contain also ecological objectives, such as resource care or reduction of CO_2-emission. Suitable energy sources were identified w the help of a potential analysis and the energy requirement was determined for different modernisation measures based on the DIN 18599 as well as on a detailed heating load calculation.

From the results two different supply variants were developed and evaluated in detail:

- Solar thermal plant with pellet boiler as heating support and most possible insulation of the building cover
- Combined heat and power unit (CHP) based on a renewable fuel in combination with reduced insulation

The solar thermal plant convinces with low investment costs and a fully developed system technology. The thermal part substituted by the solar thermal plant is almost carbon dioxide free and relieves the supplementary boiler system. The second variant (CHP) shows higher flow pipe temperatures which can be connected with every heating system. According to the principle of cogeneration of heat and power (CHP), heat and electrical energy are provided, which can be used up in the urban quarters and leads to a decentralized solution which is ecological and sustainable.

The operation of a CHP in historical buildings is beneficial and can be used as compensation strategy, if the energetic modernisation of the building cover is only possible to a limited extent. Moisture regulating conservation measures in form of wall heating panels were also examined and integrated into the concepts.

The supply variants must stand up to a detailed performance auditing. Rents above the local standard shall be excluded. For the performance auditing of the individual energy supply variants static and dynamic calculation methods are available. The economic assessment of the building modernization measures was conducted following the annuities process according to VDI 2067 - 1. A calculation tool based on the VDI 2067 was designed. With the determined net heat production costs the different supply variants can be compared.

The evaluating method “costs of the saved kWh" was applied to the economic assessment of the insulation. The investment costs are compared to the energy costs saved by the planned measures.

Financial supports of modernization measures were introduced and the issue was discussed, that the tenants profit of the rehabilitations, the investors, however, finance these.

The results of the work packages were documented in form of a guide and also can be transferred to other cooperative living quarters and ensemble structures of the 19th and early 20th centuries.

Project Information

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