Refurbishment and CO2-neutral heat supply to a 1950’s residential complex

EnEff:Stadt

The objective of the project is to modernise and refurbish the building for low energy optimisation with the target value of a primary energy requirement for heating and domestic water heating at least 50 % below the permitted value for a new building. The residual heat required should be generated such that CO2-neutral energy supply is guaranteed. The building structures are to be preserved and modern layout solutions are to be implemented.

West view of already refurbished buildings 35-41. On this side of the roof the PV system has been installed.
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Settlement summary

Project status	Realisation
Location of local community	München, 81669 München-Haidhausen Au, München, Bayern
Developer, organizer	GWG Gemeinnützige Wohnstätten- und Siedlungsgesellschaft mbH
Settlement	Urban perimeter and block developments
Utilisation type	General living
Settlement size	6.624 m²
Gross floor area (BGF, according to German DIN 277) before	13.044 m²
Gross floor area (BGF, according to German DIN 277) afterwards	16.428 m²
Residential space before refurbishment	6.513 m²
Residential space after refurbishment	9.338 m²
Industrial, commercial area afterwards	149
Number of accomodation units before	140
Number of accomodation units afterwards	0,47
SOI (Site Occupancy Index)	0.63
FSI (Floor Space Index)	2.03
Age structure	1949-1957 Nachkriegsjahre
State of construction and refurbishment	Poor state of construction, in urgent need of refurbishment
Heating system	Before refurbishment: Individual stoves (wood, gas, oil, electrical), after refurbishment: Central heating with radiators (gas-motor operated compression heat pump with ground water use)
Ownership structure	Renting through municipal building society
	New buildings, Refurbishment, Residental buildings, Urban concentration,

Project themes	Integrated energy concepts for buildings, Optimising building envelopes, Optimising building technology, Local heating and cooling networks, Renewable energey sources, Centralised + decentralised energy supply, Optimisation of operations, Energy management systems, Heat and cold storage

Project description

The residential complex in the Munich quarter Haidhausen/Au built in 1955, now in need of refurbishment, consists of four 3 and 5-storey buildings with cellars and unused top floors. The 149 existing apartments house a total residential space of approx. 6,513 m², whereby the apartments are sized between 40 m² and 65 m². The apartments have two, three and four rooms.

Objective

The objective of the project is to refurbish the four buildings to a primary energy requirement for heating and domestic water heating at least 50 % below the permitted value for a new building. The additional residual heat required is to be generated or compensated using renewable energy sources so that, in total, no additional CO2 emissions are released, thus guaranteeing a CO2-neutral energy supply.

Energy efficient refurbishment

Small and very small apartments primarily oriented to one side with trapped rooms will be combined to form larger apartments. The re-organisation of the layouts, the addition of balconies and wheelchair accessibility with lifts guarantee demand and future-oriented accommodation. The addition of one storey to each building, and a new building above the exit of the underground car part built as part of the project will create an additional 15 rented apartments. The total number of apartments will be reduced to 123. With an addition of approx. 1,974 m² of residential area, the total residential space after completion of the measure will be approx. 8,107 m². In addition to this, a medical practice with a usable floor area of approx. 164 m² will be built in the residential complex. The careful redensification preserves the established qualities. The redesigning of the residential complex in conjunction with the structural and energetic renovation of the existing buildings guarantees long-term rentability.
A resol rigid foam (weber.therm plus ultra, maximum thermal insulation WLG 022) insulation system will be installed in the outer building walls. Vacuum insulation is planned for the façades facing the road. The windows will be triple-glazed for thermal insulation and fitted in high-efficiency frames. The cellar ceilings will be insulated with vacuum insulation plates installed in the floor screed of the ground floors.

Heat supply

Until now, the apartments have been heated with individual coal or gas-fired stoves. Some apartments contain electrical heaters. Some apartments also have gas-fired central heating systems. The domestic water is also heated decentrally, primarily using gas-fired continuous-flow heaters.
The future heat supply of the four refurbished existing buildings and the new buildings will be provided by a heating centre to be built between house 33 and house 41. Connecting the heating centre to the district heating supply (steam network) of the Munich Municipal Utility Company would be too expensive and complicated as a result of the local conditions. Instead, the geothermal energy close to the surface is to be used to heat the apartments. Ambient heat at a low temperature level will be made available for heating via a heat pump. Geothermal energy is to be used via direct thermal use of ground water.
High quality mechanical energy is required to drive the thermodynamic cyclical process in the heat pump. For consistent low-exergy use (LowEx approach), the waste heat which is inevitably created in providing this high-quality energy should used for heating. Therefore, the current project incorporates a compression heat pump driven using natural gas. These pumps are generally better than electric compression heat pumps in terms of primary energy requirements. The compression heat pump driven by a gas motor used to transport the ground water will be built specially for this project.
In order to use heat pump without excessive primary energy, the temperatures on the heating water side must be as low as possible. On one hand, this requires a low demand for thermal energy for heating, which is implemented via the excellently designed thermal insulation of the buildings. On the other hand, surface heating systems (e.g. wall heating, underfloor heating) or large and powerful radiators are required. For control technology reasons, radiators are to be used for this project.
An additional gas condensing boiler will guarantee high supply temperatures of the heating circuits in the planning case, and to cover the peak load. This combination allows optimised operation of the gas motor heat pump. To reach the objective of a CO2 neutral residential complex, some of the heat is generated via a solar

thermal tube collector array.
The domestic water heating system concept is optimised to ensure that both the LowEx approach is optimally implemented and the legionella prevention requirements are taken into account sufficiently. An anodic oxidation system will be used to achieve this.
Radiators supply heat to the rooms. Of course, the apartments are ventilated naturally by windows only; controlled apartment ventilation was omitted intentionally. In order to support energy-efficient user behaviour (avoidance of constant ventilation), window contacts were used to stop the flow of hot water through the radiators when the windows are open or tilted.
The complex interaction of the individual components to an energetically optimised overall system sets very high standards, both hydraulically and also in terms of control technology. This applies all the more as the energy efficiency of the overall system is determined less by the planning case and more by the partial load conditions.
As a result of these high hydraulic requirements, the use of decentralised heating pumps is preferred. These newly developed systems are currently in the test phase in commercial buildings. Decentralised heating pumps - extremely small pumps – are fitted directly to the radiator, thus supplying each radiator in the house with heat individually. This solution does not require thermostatic valves, throttle valves and central heating circuit pumps. Thus, the system changes from “supply heating” with a central heating pump to “demand heating”.
The opportunities of the decentralised pump system lie in a demand-oriented heat distribution and heat transfer, improvement of the control quality and a reduction in the pipe network resistance. This results in significant potential savings for electricity and useful heat. A fundamental advantage of this is that the heating system is hydraulically equalised in every operating condition by design. Thus, the use of decentralised heating pumps is an excellent supplement to the innovative refurbishment concept of the residential complex.

Balancing and optimisation of operation

As part of a scientific measurement programme planned for two years, a comprehensive range of measurements will be collected, analysed and used for a continuous operation optimisation process. The operational diagnostics method is to be used for this.
In the "Lilienstraße North Munich" project, the use of high-quality exergy is to be minimised (LowEx approach) throughout the entire energy chain, from generation and transport to application. Overall, this is made possible on energy generation by using a custom-made gas motor heat pump which utilises ground water. The base heat generator is supported by a gas-fired condensing boiler system and a solar thermal collector system. A buffer storage tank charging system provides storage and hydraulic system separation. When distributing the heat, compact thermal insulation is emphasised, whereby the warm pipelines are combined in one thermal envelope. An anodic oxidisation system incorporates the LowEx approach for hot water heating. Thermal heat is transferred to the rooms via the heating surfaces by decentralised pump technology. The individual room control facilitates high control quality and will likely result in intensive user participation. Window contacts will restrict ventilation heat losses via inefficient ventilation.

Energy characteristics

	before	potential	after	unit
Usable floor area (according to EnEV)	7.884,00		12.080,00	m²
Final energy requirements electricity (EnEV)	24,80	26,30		kWh/m²
Final energy requirements heat (EnEV)	268,00	28,10		kWh/m²
Primary energy requirement electricity (EnEV)	361,90	73,00		kWh/m²
Primary energy requirement heat (EnEV)	66,90	42,10		kWh/m²
Primary energy ratio electricity (total)	295,00	30,90		kWh/m²
Primary energy ratio electricity (fossil)		3,00		
Primary energy ratio heat (total)		2,70		
Primary energy ratio heat				

Primary energy ratio heat (fossil)		1,10		
PV yield (return primary energy, according to EnEV)		1,10		