Innovative modernization of historic buildings – pilot schemes in Vienna

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Full Paper

1. Introduction

Economic as well as energy and climate-political specifications require new criteria for the holistic modernization of houses of the era of promoterism (Gründerzeit). Innovative reconstruction solutions are on display in Vienna and are being evaluated from the point of view of economic efficiency, energy efficiency, legal framework and users' satisfaction using several demonstration objects within the scope of the research project "Gründerzeit with future prospects". Present results have uncovered that a wide range of innovative and practically useful components are available for the comprehensive and highly innovative modernization of houses of the era of promoterism, with which historical buildings under favorable framework conditions, can also be converted to the nearly zero-energy or energy-plus standard.

Extremely strong external walls of solid brick masonry, road façades designed in a complex manner, often with stucco ornamentation, immense floor heights and wooden beam ceilings or massive arched ceilings above the basement as well as wooden frame windows with single glazing and room-kitchen layouts: these are the typical attributes of houses of the Promoterism era that were built between 1848 and 1918. Seen from the point of view of the available stock of promoterism houses in urban areas, the spectrum ranges from the multistory workers' residence in the suburban area – many with façades that have in the meantime, been cleaned-up – up until the palace of the era of promoterism at the center of the city.
All over Austria, there are more than 600,000 apartments in buildings of the construction era preceding 1919 thus making the ratio of the stock of promoterism houses in Austria a total of approximately one-fifth. In Vienna alone, there are about 200,000 primary residential apartments in this building segment. Of about 35,000 buildings that were constructed in Vienna before 1919, about 20,000 classical apartment houses make up promoterism in a narrower sense.
The sustenance and further development of this stock of buildings is therefore a central task confronting the residential and real estate sector in the face of the huge number of promoterism residential structures available and the strongly growing need for apartments. The reconstruction of buildings of the era of promoterism is realized virtually at the point of intersection of architectural and building-cultural issues as well as construction-related legal requirements for the attainment of binding energy and climate-political targets in conjunction with the search for adapted technical solutions that can be implemented in a user-adequate and cost-efficient manner.

The project "Gründerzeit with future prospects" that was launched in 2009 within the scope of the research and technology program *Building of tomorrow Plus* of the Federal Ministry of Transport, Innovation and Technology and will run till 2015, is committed to this assignment.
In addition to basic research work on technological, economic, legal and social-scientific issues, individual sub-projects stretch from component development up until the implementation of demonstration projects. Innovative reconstruction solutions will be developed on the basis of five demonstration objects that may be used as a model for houses of the promoterism era and

subjected to comprehensive power consumption and comfort monitoring.
The major objectives in the implementation of innovative measures are the improvement of living comfort, reduction of energy consumption, usage of more efficient and possibly CO_2-neutral heating systems, improvement of architectural quality and thereby, overall guaranty for a contemporary living standard. The prerequisite is, in any case, a sound static condition of the respective building since the measures required for the static retrofitting of the object – particularly in the event of a planned expansion of the attic – may by far, transcend all economic considerations.
Attention should be drawn explicitly to the fact that this is not about simply “wrapping up” houses of the promoterism era and thus “sacrificing” a central urban architectural building segment to a banal efficiency and modernization approach. On the contrary, the major challenge lies in developing innovative solutions for buildings of the promoterism era that are structurally adequate and technically as well as economically implementable.
The spread of the results – multipliable innovative reconstruction concepts that are particularly adapted to the conditions of the stock of promoterism buildings – will be realized amongst others, through the project website www.gruenderzeitplus.at.

2. Energy efficiency and technical solutions [1]

There is a widely held view that the energy-technical quality of buildings of the promoterism era is “not so bad anyway” given the “thickness of the solid brick walls”. This is correct only insofar as a building of the promoterism era has better average values than for instance, a non-reconstructed building of the 1960s. the fact however is that buildings of the promoterism era with a typical thermal heat need within the range of 120-160 kWh/m².a is “worse off” by the factor 5 to 10 than residential buildings that are newly constructed in accordance with today’s customary low-energy or passive house standard. By replacing windows alone, the energy performance of a building of the promoterism era can be improved by just 10 percent.
On the contrary, innovative reconstruction measures can translate into a thermal heat requirement of less than 30 kWh/m².a also for the stock of the promoterism era thus attaining a contemporary energy-technical standard.
It can also be justifiably argued that not all technical standards based on today’s criteria should be applied to historical buildings; this fact is also reflected in the Building Ordinances of the Federal States with numerous exceptional provisions for buildings with segmented façades, buildings in protected zones or monument-protected buildings. Practical examples however show that there are still enormous architectural and technical potentials lying dormant also in buildings of the promoterism era, with which excellent results can still be achieved even in relation to comfort and ease and that have so far, hardly been exhausted.

3. Legal challenges [2], [3]

Major legal questions in the reconstruction of buildings of the promoterism era arise in connection with the utilization of neighboring plots in the insulation of fireproof walls (minimum standard of energy vs. property), for sustaining side gaps and building lines (intrusion in the subjective rights of neighbors) as well as in respect to restrictions in monument-protected buildings and buildings in protected areas (public service restrictions).
While reconstructing the demonstration building in Wißgrill Alley, the huge number of detached fireproof walls particularly proved to be problematic because the installation of insulation on the firewalls requires the consent of the neighboring property owner. There can be no insulation without such consent – a delicate issue that was successfully resolved through high communication competence and creative offers. Even though detached fireproof walls do not constitute any architectural characteristic of buildings of the promoterism era, they may constitute up to one-third of the façade area. The insulation of the fireproof wall is thus compelling from the point of view of energy efficiency and living comfort.

4. Costs and Economic feasibility [1]

The decision on if and how a building of the promoterism era should be reconstructed depends largely on the costs of the measures implemented as well as on economic feasibility. From the point of view of the property owner, the user-investor dilemma – seeking to ascertain if the measures (window replacement, façade insulation, renewal of the heating system) associated with energy savings “pay off” – is of less relevance as a consequence; rather it is more relevant if a (higher) overall dividend can be achieved in the medium to long-term. In the process, not only will investment costs and attainable savings flow into the costs of energy, but also the usage of residential building promotion funds and finally also, tax-related aspects. Moreover, it is also customary practice to expand the attic in the reconstruction of a building of the promoterism era, which in most cases, finally enables the realization of positive overall proceeds. The reason for this is that tenancy-rights-related statutory provisions strictly regulate rents that can be charged. In case of reconstructed old buildings, reference value rent applies to fresh tenancy, and clearly higher rent can be charged for reconstructed attic apartments. Should residential building promotion funds be used however, only a so-called maximum covering sum can be charged for the term of the state loan; the tenant will then be paying back the complete costs of reconstruction; proceeds will be realized only thereafter.

5. Monitoring

To be able to make a clear statement on the actual performance of the building and the individually applied technologies, buildings must be subjected to a technical power consumption and comfort monitoring. In addition to the measurement of power consumption and comfort parameters, user-satisfaction and economic feasibility of the reconstruction measures can also be evaluated within the course of extensive monitoring. From the viewpoint of building developer and property owner, monitoring constitutes a significant instrument of quality assurance with multiple benefits. In addition to the high level of safety during initial operation and acceptance certification of the building, the constant optimization of operational management leads to a reduction of running expenses and thereby, to the improved rentability of the building. In addition to this, learning experiences that have been gained and facts acquired with respect to the behavior of the building will be used directly in future projects.
In the course of the leading project “Gründerzeit with future prospects”, documentation and the related monitoring will be done in line with Best Practice examples through a period of two years. For the first time ever, highly innovative reconstruction measures will be applied on promoterism buildings in the individual demonstration projects and subjected to attendant research works covering the following dimensions:

- Documentation of applied technical reconstruction measures particularly innovative measures on the building shell and the building equipment and appliances
- Documentation of the costs of the innovative reconstruction measures for investment and running operational management
- Monitoring of energy consumptions and central comfort parameter through two years including evaluation and the optimization of operational management
- Social-scientific attendance through survey conducted on residents (satisfaction with reconstruction particularly with the innovative measures implemented)
- Certification in accordance with the Building Evaluation system TQB
- Recapitulative evaluation and presentation of results, conclusions regarding further development of the funding of residential constructions

6. Demonstration buildings

6.1 Demonstration project Wißgrill Alley [4], [5], [6]

The first demonstration project was successfully completed already at the start of 2011. It is a comprehensive reconstruction including the expansion of the attic that was implemented by Ulreich Bauträger as property owner and building developer along with Gassner & Partner as General Contractor for planning and design.

Object Wißgrill Alley before and after comprehensive reconstruction and attic expansion (Photos: Ulreich, Gassner & Partner)

The building in Wißgrill Alley in Vienna Penzing was constructed at the turn of the millennium and thus belongs to the category of houses of the promoterism era. The object is in the direct proximity of a rail route and has a huge number of detached fireproof walls and a segmented street façade.
The holistic modernization of the building was at the forefront of the demonstration project to guaranty a contemporary living standard with high living comfort. The aim was to present a sustained system solution with the energy refurbishment of the old building and the highly efficient expansion of the attic, which shows reproducibility for a good number of houses of the promoterism era. A qualitatively highly valued reconstruction of the building could be realized through the implementation of the following measures:

- Joining of apartments for the realization of the contemporary concept of space
- Expansion of attic floor for the creation of additional utility area
- High insulation standard of all external structural components
- Renewal of all windows and doors
- Airtight design of structural component connections
- Integration of thermal solar panels in façade area
- CO_2-neutral thermal supply through pellets-central heating system
- Renewal of all supply lines through central access
- Application of efficient building equipment and appliances and external illumination with LED
- Draining of basement floor for the sustenance of the structural substance of building
- Roof integration of photovoltaic modules as isolated application for an attic apartment
- Automatically-controlled sunshade system on the attic floor
- Integrated greening on slanted roofs and flat roofs
- Creation of balconies and terraces in yard
- Area greening also spanning neighboring yard and designing of exterior space
- Erection of elevator within the building

Altogether, the thermal heat requirement could be reduced by more than 80%, it is approximately 30 kWh/m²a in the essential part, 17 kWh/m²a on the attic floor. The attainment of the target values could be confirmed through energy consumption monitoring.

The applied controlled inflow and outflow ventilation systems contributed significantly to the

efficient reconstruction through heat recovery. A reason for the decision to install the controlled ventilation devices was the location-related high level of dust and noise exposure due to proximity to the rail route. To generate facts for other construction projects, the building developer decided to also partially apply ventilation solutions without heat recovery in addition to devices with heat recovery to investigate impacts from a measurement-technical point of view. This facilitates the direct comparison of the performance of the individual ventilation variations.
Four different ventilation concepts that were captured from a measurement-technical point of view and are to be evaluated, were applied in Wißgrill Alley:

- Central comfort ventilation system for apartments in newly expanded attic floor and partly in the main part of the building
- Single room ventilation devices with heat recovery system
- Apartment-wise waste air facilities with window frame ventilation
- Window ventilation

As is well-known, the behavior of the user has the strongest impact on the comfort parameters CO_2 content and relative humidity, which provides information on the quality of ambient air. Yet the comparison of the CO_2 content of the 4 ventilation concepts applied shows clear differences. The CO_2 content in comfort ventilation ran quite constantly through the period of 3 months. Only a few measurement values exceeded the reference value in accordance with Pettenkofer of 1000 ppm. The measurement values of the remaining ventilation concepts are subject to a much higher band width and are constantly at a higher level. A tendency can be observed, towards a drop in the CO_2 content of the single room ventilation device and window frame ventilation during the months of summer. This is attributable to the additional length of time in which the windows are kept open when external temperature increases.

6.2 Demonstration project Kaiser Street

The reconstructed demonstration object in Kaiser Street of the 7th municipal district of Vienna is the monastery building of the Congregation of the Mission of the Holy Vincent de Paul (short: Lazarists). The planning and local building supervision was done by Architect Kronreif_Trimmel & Partner (Arch. Günther Trimmel). The building was erected in 1904 and is part of a square ensemble comprising a church and a residential building opposite the monastery. The complete ensemble is monument-protected. The reconstruction that was completed in May 2013 shows that a modern living standard is possible even upon compliance with the requirements of monument protection.

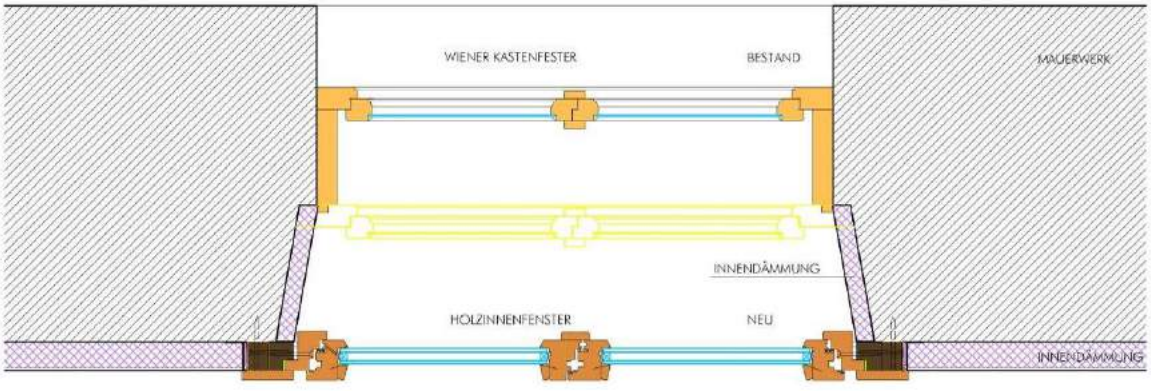
In addition to the thermal reconstruction of the roof truss, yard façade and fireproof walls and the application of a central ventilation system with heat recovery and particularly the installation of interior insulation and complementation of the box-type windows to be sustained by applying inward lying wooden window frames that are suitable for passive houses, can be highlighted as innovative reconstruction measures.

Square and Street view of Kaiser Street before and after reconstruction (Photo: AKP)

External insulation did not come into question in the face of the sustenance-worthy, segmented closer façade comprising small ceramic tiles. The thermal improvement of the building shell was possible only through the application of interior insulation.

The possible consequences of different interior insulation systems were highlighted, evaluated and examined for damage hazards. The major parameters for hazard assessment in the process were external impacts such as climate and exposure to driving rain, internal impacts such as interior air humidity and user's behavior and structural component-related impacts such as water absorption and water retention capacity and the diffusion behavior of construction.
Investigations carried out by the Construction Physics company Schöberl und Pöll using the software Ham4D_VIE of the Technical University of Vienna revealed a maximum insulation strength under conservatively assumed marginal conditions with capillary-active material of 2.5 cm for the long-term safety of the structural component.[7]
The structural-physical computations made by the company Xella Porenbeton were done using the non-steady computation program WUFI-Pro 5.0. According to the simulation, there will be no further rise in the water content of the brickwork in the following years at 8 cm interior insulation. The complete wall structure dries up in the dry seasons of the year and there is subsequently, no increased accumulation of humidity in the wall construction.
In the aftermath of the computations and experience reports, a 5 cm strong insulation system without diffusion barrier and with capillary-active mineral insulation board was applied.
To counter the uncertainties emanating from the structural-physical simulations regarding the maximum strength of interior insulation, the construction was subjected to permanent monitoring. Together with the Technical University of Vienna, the structure is monitored at different cross-sections within the scope of "Gründerzeit with future prospects" using measurement sensors integrated in the brickwork and the risks or eventual accumulation of moisture ascertained and evaluated.

Solution was worked out for the reconstruction of the monument-protected box-type windows in cooperation with the Federal Bureau of Monument Protection, in which the external wings the box-type windows are retained, maintained and refurbished. The interior wings are dismantled, the box extended and a wooden window suitable for passive houses and with 3-fold thermal protection glazing installed. The overall U-value of the window construction is specified by the window constructor as Uw= 0.9W/m²K.



Kaiser Street: Box-type window with interior insulation, old interior wing shown in yellow (Source: AKP)

6.3 Demonstration project Eberl Alley

Another demonstration object in Eberl Alley, 2nd District (Property owner: Kronberger, Planning: Schöberl&Pöll) is to go down in the history of refurbishment in Vienna, as the first house of the promoterism era that is reconstructed in compliance with passive house standard. The house that

was erected in 1888 was badly damaged in 1945 after being struck by a bomb and was reconstructed in the year 1952. The windows overlooking the street were replaced by plastic windows in the seventies. The peculiarity is that reconstruction is performed in cooperation with all tenants and can be implemented without renting-out.


Pilot Project Eberl Alley: First reconstruction in Vienna in passive house standard (Photo: Kronberger)

Since no building of the promoterism era has ever been reconstructed as passive house all over Austria, the project commands a high demonstration value. The reconstruction of the façade to passive house quality and the installation of passive house windows and doors as well as the high quality insulation of the ceiling of the lower floor stand out as major actions undertaken. Moreover, an additional living room was created in the course of expanding an attic floor. The reconstruction contains the renewal of the complete building equipment and appliances and electro-technical equipment including conversion to energy-efficient lighting system. A groundwater thermal pump and a photovoltaic facility were installed for the supply of heating.

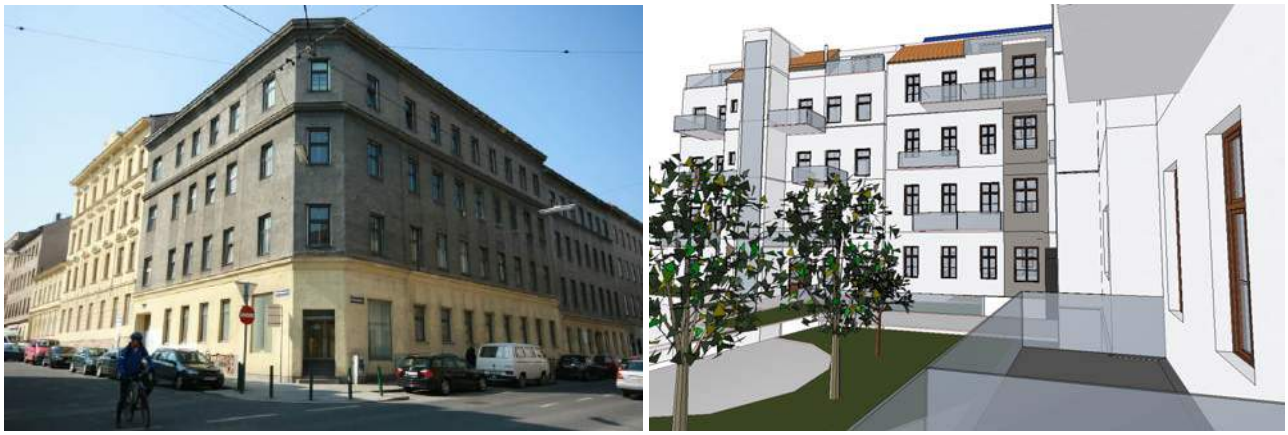

Eberl Alley: Groundwater thermal pump and extraction well

A reduction of thermal heat needs by more than 90% was attained through the measures adopted. The energy balance sheets of the building show that the designated reconstruction measures

achieve passive house standard on one hand while immense energy savings are generated on the other hand. With innovative refurbishment measures implemented and adequate power supply put in place, the overall assessment of energy indicates that savings in excess of 80% can be realized specifically in relation to thermal heat needs, energy needs, primary energy needs and CO_2e emissions!
In addition to the positive ecological impacts, modern living standard can be created by increasing thermal comfort and reducing energy consumption following the implementation of the innovative package of measures.

6.4 Demonstration project David‘s Corner [8]

The ensemble of three buildings of the promoterism era in Vienna Favoriten forms the corner of a typical perimeter block development. But for a few exceptions, the 34 residential units were still in their original room-kitchen configuration. Altogether, the three buildings including the 5 business premises on the ground floor have a utility area of 2,350 m². Two objects have a cleared façade, one object, a fully preserved segmented façade. The objects were in a state that strongly requires reconstruction (moisture, leaking roof, leaking windows etc.). With warehouse halls covering most of its area, the yard was in a desolate situation. The thermal heat requirement of the 3 objects before reconstruction was about 121 kWh/m²a, heat supply was realized through gas converters, while hot water preparation was realized through electrical storage heater in individual apartments.
The buildings are owned by Condominium Immobilien. After a long planning phase, the project is being implemented by Bluewaters, the real estate trustee chancery Dirnbacher, Treberspurg & Partner Architekten and Imoplan ZT for building equipment and appliances. Completion is scheduled for 2014.



Ensemble David‘s Corner, Yard view in accordance with planned reconstruction (Photo, Graphics: Bluewaters)

At the center of the project is the joint development of all three objects. In addition to the restructuring of the yard that will also span neighboring plots and the joining as well as redesigning of the residential layout plans, thermal optimizations make up all external structural components, the efficient expansion of the attic floor and the joint house service facilities-related development of the ensemble make up the peculiarities of this demonstration project. A controlled living room ventilation system is applied with heat recovery in combination with central heating supply with low temperature heating system supported by a solar-thermal facility. The thermal heat requirement can be reduced by factor 5 through the refurbishment measures adopted.
The implementation of the overall concept shows that a highly grade energy-related refurbishment is not only technically feasible with the availability of the respective large utility area but also economically feasible in non-profit yielding locations.

7. References

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