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Current developments and examples of sustainable energy technologies

Innovation meets tradition

Pioneering technologies for renovating historic buildings sustainably

Renovating the fabric of old, historically valuable buildings to today's standards of energy efficiency is a controversial issue in European towns and cities. The goal is to find intelligent ways of reconciling the conflicting aims of climate protection and architectural culture. In Austria quite a number of projects have been launched in recent years, in order to encourage using innovative technologies and approaches so as to renovate valuable historic buildings sustainably.

The Franciscan Monastery in Graz, Source: Alexander Gebetsroither

From left: Franciscan Monastery in Graz: solar panels, window arrangement; Wißgrillgasse in Vienna: pellet heating system, storage unit, Source: Ulreich Bauträger GmbH

New technologies and concepts for renovating old buildings

Energy-efficient building technologies and renewable sources of energy are in widespread use today for new builds. However, existing buildings possess considerable potential – as yet unused – for saving energy and reducing CO_2 emissions. Renovating the stock of existing buildings in city centres sustainably plays a crucial part in achieving EU and national energy and environmental targets. In European city centres historic buildings predominate; conserving this fabric, with its cultural import, and developing it further is an opportunity to steer urban development in a more sustainable direction.

Renovating historic buildings is an activity where architectural, legal, social and technical issues intersect. Particularly in city centres, there are often special obstacles to innovative renovation strategies, such as rules applying to listed buildings or requirements for urban protected areas. If renovation is to be worth while in these difficult contexts, there is urgent need of intelligent technical and organizational approaches that can be implemented to users' advantage and cost-effectively.

In Austria various projects have been launched in recent years with the aim of improving the thermal efficiency of historic buildings. Within the framework of the programmes "Building of Tomorrow" (Federal Ministry for Transport, Innovation and Technology) und "New Energies 2020" (Climate & Energy Fund), suitable technologies and strategies are being researched, developed and demonstrated. The research findings and demonstration projects presented here show that energy efficiency and using renewable sources of energy are perfectly feasible even in historically valuable buildings. ◘

Kaiserstraße Vienna, Source: e7

Wißgrillgasse Vienna, Source: Ulreich Bautr. GmbH

Kaiserstraße Vienna, Source: Architects Kronreif_Trimmel & Partner

Flagship Project GdZ
A future for Austrian "Gründerzeit" buildings

In Austria a substantial portion of the building stock dates from the "Gründerzeit" period between 1848 and 1918; typical features are elaborate stucco façades, high ceilings and solid brick outside walls. In Austria buildings of this period house 600,000 flats – close to a fifth of the total number. Up to now little use has been made of these buildings' energy-saving potential. This is where the "Building of Tomorrow" flagship project comes to bear, to tackle integrated system approaches to modernizing "Gründerzeit" buildings. The aim here is to develop scalable renovation strategies with which to raise these buildings' thermal efficiency to an up-to-date standard; annual energy demand for space heating ought to be cut from around 120-160 kWh/m² to less than 30 kWh/m².

In collaboration with an interdisciplinary project team (Havel & Havel /social science, Manschein Managing Energy / monitoring, Österreichischer Verband der Immobilienwirtschaft / legal aspects, pos architekten / architecture, Schöberl & Pöll / structural engineering, Gemeinschaft Dämmstoff Industrie / dissemination) e7 Energie Markt Analyse GmbH are managing the project; it covers research into technical, economic and legal issues, developing new components and implementing pilot projects. In addition, cost-effectiveness is being analysed, sociological investigations carried out and the buildings monitored for energy consumption and comfort once they have been renovated.




Making the building envelope thermally efficient

The critical aspects here are how to insulate the segmented façades and the firewalls, and how the joints between structural elements are implemented. Structured façades that are worth conserving can be thermally insulated only on the inside; here either conventional insulants such as mineral fibre, or alternatively insulation panels, e. g. based on calcium silicate, can be employed. The latters' surface-active properties enable them to adsorb moisture, store it and release it into the air. For the key elements thermal-bridge simulations have been carried out and the impact on element reliability (water vapour condensing out, mould developing) has been investigated.

Employing efficient heating, ventilation etc.

Ventilation systems with heat recovery to replace used air with fresh air under full control have already proved their worth in renovated buildings. Modern ventilation strategies achieve excellent energy efficiency and ensure air exchange at controlled rates, resulting in an agreeable indoor climate. With their high ceilings, buildings from the period between 1848 and 1918 are ideal for installing ventilation systems.

Apart from technical issues, a comprehensive strategy must also take economic, social and legal aspects into account. Experience gathered and tentative solutions have been documented in the course of the project. A guide to implementing the renovation of a "Gründerzeit" building in practice covers all relevant facets for interested parties, such as owners, property managers and planners. ◘ www.gruenderzeitplus.at (in German only)

DI Walter Hüttler, e7, on the opportunities and risks involved in renovating historic buildings

What part does renovating the fabric of historic buildings play in shaping our urban environment sustainably?

Historic buildings form a significant part of our cultural heritage. In many cases the challenge is to conserve this heritage while adapting the buildings to changed patterns of use and current standards of comfort; at the same time energy demand and running costs should come down. With the aid of sustainable energy-efficiency standards a valuable contribution to climate protection can be made in the case of historic buildings, too.

Are the new technologies already mature – where do you see a need for further research?

The main elements, such as inside insulation systems or mechanical ventilation equipment, are on hand. We still see a need for research into high-grade solutions for historic windows. In future special types of insulating plaster might also play an important part, but here again further development is needed as regards use in historic buildings.

Is it possible to implement comprehensive strategies for renovating "Gründerzeit" buildings cost-effectively?

Our demonstration projects show that the costs of ambitious strategies can be kept under control in a variety of business cases. In all our projects we evaluate not only investment cost, but also the subsequent running costs.

What legal and procedural obstacles can crop up when it comes to implementing this kind of renovation project in real life?

The spectrum is pretty wide: from open issues involving neighbours' rights – e. g. if a firewall is to be insulated and the consent of the owners next door is required – to the question of how greater use can be made of renewable sources of energy, given the existing legal situation as regards tenancy and grants. We have also given considerable thought to the implementation processes, and drawn up a guide to informing and mentoring residents. As an example, where in-depth renovation work involves inside insulation the issue of providing temporary accommodation for the tenants plays a part.

Does the subject attract attention in other countries, too?

As we can see, renovating historic buildings sustainably and to a high standard of energy efficiency has become a very important issue in other European countries, such as Belgium, Germany, Italy and Switzerland. This means that we have launched our project in time to give international collaboration activities now the benefit of experience already acquired in Austria.

A future for "Gründerzeit" buildings
Demonstration projects

Kaiserstraße Vienna, Source: Architects Kronreif_Trimmel & Partner

The demonstration buildings renovated in the course of this flagship project reflect the wide variety of building functions in the period between 1848 and 1918. As well as purely residential buildings, mixed-use buildings (residential use plus offices) were included.

Kaiserstraße / 1070 Vienna
Ambitious renovation in compliance with rules for listed buildings

This listed building is part of a complex belonging to the Order of the Lazarites; a conservation order applies to the façade, which features exposed brickwork. It was essential that renovation leaves the façade and the building's roof cladding largely intact. To improve the thermal properties of the building envelope, interior insulation panels were fitted to the listed façades. The roof timbering had to be reinforced structurally; the roof cladding was not affected by renovation.

The annexe and the courtyard façade were renovated very successfully (U-value approx. 0.15 W/m²K), using outside insulation. The outside casements of the Viennese box-type windows were renovated in line with conservation rules, and wood-frame windows were fitted inside to yield a result complying with zero-energy building standards. A central ventilation system with heat recovery ensures a satisfactory rate of air change in all rooms which people spend time in. As the building was already connected to the district heating grid, no changes were made here. When renovation was completed in the summer of 2013, unit heating energy demand had been reduced by around 80 %. ◘

Year built: 1904
Floor area before renovation: 1.935 m²
Heating energy demand before renovation: 121 kWh/m²a
Floor area after renovation: 2.750 m²
Heating energy demand after renovation: 25-55 kWh/m²a
Project partners: Architects Kronreif_Trimmel & Partner, Congregation of the Priests of the Mission (Lazarites)

Eberlgasse / 1020 Vienna
First-ever renovation of a "Gründerzeit" building to Passive House standard

When this building (erected in 1898, damaged in the Second World War and later rebuilt) was renovated, the focus was on achieving Passive House standard. The building's compact structure, and its location wedged in between other buildings, were definite advantages here. Renovation was carried out in close co-operation with the tenants living in the building, and was successfully completed in the autumn of 2013.

In order to achieve Passive House standard, a composite thermal insulation system was fitted to the outside of the façades facing street and courtyard. The vaulted ceiling in the cellar was insulated, and top-grade windows and doors to Passive House standard were installed. The innovative features of the building include a central ventilation system with ultra-efficient heat recovery, the groundwater heat pump and photovoltaic equipment. The entire electrics, heating, ventilation etc. were replaced, and energy-efficient lighting fitted, which saves even more primary energy. The energy balance sheets computed for the building show that after renovation it qualifies as a zero-energy building, and that savings of more than 80 % can be anticipated with respect to heating energy demand, end-use energy demand, primary energy demand and CO_2 emissions. ◘

Year built: 1898
Floor area before renovation: 585 m²
Heating energy demand before renovation: 178 kWh/m²a
Floor area after renovation: 810 m²
Heating energy demand after renovation: 15 kWh/m²a
Project partners: Andreas Kronberger, Schöberl & Pöll GmbH

Wißgrillgasse Vienna, attic conversion, Source: Ulreich Bauträger GmbH

David's Corner / 1100 Vienna

Comprehensive strategy for renovating a group of "Gründerzeit" buildings

This group of three buildings form the corner of a typical perimeter block development in Vienna; one of them has a segmented façade worth conserving.

The goal of the project was to develop scalable, comprehensive strategies for making the entire group of buildings more energy-efficient. Under the current grant regime the actual strategy selected can be realized cost-effectively; it is now being implemented within the framework of a full-scale renovation partly funded by Wohnfonds Wien. The special feature of this project is that heating, ventilation etc. are implemented en bloc for all three buildings: heat is supplied "cross-border", and ventilation is handled by a central system for the whole group of buildings.

The following renovation measures are now in progress:

> installing a central transfer station from the district heating grid
> installing a solar facility to aid in providing hot water
> installing a central plant for comfort ventilation
> adapting room layouts to today's needs
> attic conversion in all three buildings
> providing barrier-free access to all three buildings
> organizing the open space across property boundaries ◘

Year built: 1884/85, Upward Addition: 1890
Floor area before renovation: 2.350 m²
Heating energy demand before renovation: 116 kWh/m²
Floor area after renovation: 3.030 m²
Heating energy demand after renovation: 23 kWh/m²a
Project partners: Condominium Immobilien Gesellschaft m.b.H., Architekturbüro Treberspurg & Partner

ROOFJET Wißgrillgasse / 1140 Vienna

Factor-8 renovation with ultra-efficient attic conversion

This building, in Penzing, was put up around 1900; the main building, with its segmented façade, faces onto the street, with a courtyard wing joined on via the staircase. This arrangement involves a considerable proportion (32 %) of free-standing firewalls bordering on various neighbouring plots. The goal of renovation was to modernize the existing building so as to economize on resources, and to convert the attic to two storeys in an ultra-efficient way. The comprehensive renovation strategy incorporates numerous scalable elements:

> renovating the building envelope to a high standard and cutting down on thermal bridges
> installing different central/decentral convenience ventilation systems
> CO_2-neutral heating arrangements (pellet-fired central heating, with solar collectors integrated in the façade and tied in)
> installing a stand-alone PV facility for the attic
> reducing electricity consumption by means of efficient heating and ventilation, plus LED outdoor lighting
> planting greenery on flat and sloping roofs to improve the microclimate

Renovating the building in Wißgrillgasse was successfully completed in the spring of 2011. With heating energy demand cut to 27.5 kWh/m²a, the building now meets the standard for ultra-low energy consumption. ◘

Year built: ca.1900
Floor area before renovation: ca. 1.100 m²
Heating energy demand before renovation: 185 kWh/m²a
Floor area after renovation: ca. 1.900 m²
Heating energy demand after renovation: 27,5 kWh/m²a
Project partners: Ulreich Bauträger GmbH, Gassner und Partner GmbH, daneshgar architects





1 Crèche in Schönbrunnergasse (historicism blended with art nouveau, 1885); 2 "Gründerzeit" building in mixed use in Radetzkystraße (1840/the façade dates from 1900); 3 Residential building in Vinzenz-Muchitsch-Straße (1930); 4 St. Peter Primary School (inner-suburb development, 1885/enlarged in 1930); 5 Franciscan monastery (medieval urban structure, 1230)
Source: all Photos Graz University of Technology, Institute of Thermal Engineering

Denkmalaktiv
Research for listed buildings that point the way ahead

The research project "denkmalaktiv" is intended to harmonize the aim of conserving listed buildings with technical requirements for energy-efficient renovation. The scope of the project covers identifying and further developing new technologies for renovating historic buildings sustainably, and working out renovation strategies for five typical listed buildings in the centre of Graz. Simulation and instrumentation processes were used to analyse the effects of various different renovation measures, and the strategies were further refined in consequence.

The project team is made up of representatives of the city administration (City of Graz Environmental Departement), university and private research organizations (Graz University of Technology, Institute of Thermal Engineering and Institute for Building Construction, GET Güssing Energy Technologies) and the Graz Energy Agency. The Federal Conservation Agency is also involved in the discussion. Subsequently these approaches are to be incorporated in specific renovation projects undertaken by the City of Graz; at the implementation stage scientific super-vision will be provided. The initial project phase has already been completed, and is providing scalable results. Dialogue between the relevant stakeholders in Graz has begun by means of workshops and interviews.

In connection with improving the thermal performance of historic buildings, the following **technical issues** have been dealt with:
> utilizing capillary active internal insulation systems
> upgrading box-type windows with respect to thermal and hygric behavior
> renovation and the fluid dynamics of box-type windows
> implementing ventilation systems with control facilities
> thermal wall activation for improving thermal comfort
> the potential of thermal activation for reducing wall moisture
> utilizing solar energy in active systems

The framework for these investigations is focussed on five selected **reference buildings** in Graz (see illustrations above), which have undergone structural, equipmental and architectural analysis. The project team worked out various renovation strategies for each building, and assessed them as regards for saving useful energy, end-use energy, primary energy and CO_2 emissions. In addition, the architectural impact with respect to conservation was analysed in qualitative terms. It turned out that in all the buildings investigated it is possible to implement structural and equipmental measures that result in significant improvements in energy efficiency while complying with conservation requirements. ◘

International ties
The link to an international group of experts active in the field of thermal renovation runs through the International Energy Agency's Implementing Agreement SHC (Solar Heating and Cooling) TASK 47 (Solar Renovation of Non-Residential Buildings) programme. The Institutes of Graz University of Technology participating in "denkmalaktiv I" are project partners in this task, and table the results of their research in this forum.

Upside: Franciscan Monastery in Graz, solar collectors integrated in façade (actual status of renovation)
Below: thermal wall activation and boiler room with heat pumps, Source: AEE INTEC

Vision of zero-emission standard
Renovating the Franciscan Monastery, Graz

The renovation of the Franciscan Monastery in Graz is an impressive example of implementing a sustainable renovation strategy in difficult circumstances. Together with the Franciscan church and the tower, which was originally part of the town wall but is now attached to the church, the Franciscan Monastery forms one of the most prominent groups of buildings in the Old Town. Along with all the technical and economic challenges, a way had to be found of coping with the requirements imposed by the Federal Conservation Agency, the need to conserve the local architectural heritage and restrictions to protect the UNESCO World Heritage site.

The starting-point for renovation was a master plan (Arch. DI Michael Lingenhöle) with a comprehensive strategy for modernizing the entire monastery premises. Together with experts from AEE INTEC, the (utterly committed) monks succeeded in developing a four-stage "energy vision" for the monastery and implementing it, starting in 2010 (Architecture HoG Architekten).

Renovated function room, Source: AEE INTEC

„To achieve thermal efficiency when renovating old buildings, one must pay close attention to the technical aspects of the building in question. If renovation is to result in major savings in energy consumption, and the building's architectural value is to be conserved, a whole series of circumspect measures will be needed. Apart from the technical challenge, architecturally inspired solutions are essential; after all, motivation in ecological action derives not only from the functional aim, but also from beauty – from aesthetics!"

Brother Matthias
Franciscan Monastery, Graz

Some of the measures carried out were analysed within the research project "denkmalaktiv I".

Structural measures

Insulating the monastery's pitched roofs made a significant contribution to improving energy efficiency; the unheated storage rooms in the attics now function as thermal buffer zones as regards heat flowing upwards / to the outside. The monastery walls did not need insulating, as thermography revealed only minor heat losses through them. The top floors were thermally insulated with foam glass granulate. The single-glazed corridor windows were replaced by box-type windows with insulating glazing inside.

Heating, ventilation and energy strategy

A wall heating facility keeps the masonry dry and improves the indoor climate. A solar facility with 193 m² of panel collectors integrated in the roof and 180 m² of collectors integrated in the façade has been installed; the collectors supply heat for hot water, to warm the walls and to preheat the well water used in two heat pumps. The collectors were fabricated specially for this project; to make the building look good, so-called blind collectors (without an absorber) were fabricated and installed to some extent.

The heated water is stored in three tanks with a capacity of 15,000 litres in the basement. As the monastery walls can store a great deal of heat, the inflow temperature is a mere 32 to 33 °C. Two heat pumps (rated at 200 kW each, with solar preheating) can deliver any additional energy required for heating and supplying hot water. Finally, the monastery is connected to the district heating system as a backup. ◘

Franz Jonas Europaschule Vienna, Source: Wikimedia

SchulRen+
Renovating schools to energy surplus standard

Every year the central government and the Austrian provinces invest several million Euro in maintaining school buildings. Thus there is plenty of potential for reducing greenhouse-gas emissions. To date, though, this potential is lying fallow, as no comprehensive strategies involving criteria for energy efficiency are available to the policymakers. With a typical "Gründerzeit" Viennese school (built in 1898) as a starting-point, researchers at the Energy Department in AIT, the Austrian Institute of Technology, have investigated innovative approaches to turning such buildings into net suppliers of energy.

The goal of the technical feasibility study was to marry pioneering energy strategies to structurally and architecturally valid solutions, and to identify renovation strategies that can be transferred to similar school buildings. Comprehensive analysis has established that renovating schools to energy surplus standard is feasible from the structural, spatial-functional and energy points of view. Thermal renovation, coupled with around 400 m² of PV panels and 30 m² of solar collectors, results in a negative balance of primary energy over a full year for the building investigated. Outlays on energy could thus be reduced by approx. 50,000 Euro per annum.

Photo © krischanz.zeiller/AIT

„For new types of school changes to the room schedule in existing schools are required. Where renovation measures are needed for structural reasons, this is a chance to modernize the buildings comprehensively, including energy and spatial/functional aspects. In this way school buildings can not only contribute actively to climate protection, but also act as key disseminators by setting a good example."

DI Doris Österreicher
AIT Austrian Institute of Technology, Energy Department

To put such model school renovation projects into practice, there is a need for new funding arrangements (such as public-private partnerships, contracting or intracting) and modified grants schemes and/or new financing mechanisms geared to promoting innovation (e. g. in the shape of an energy efficiency fund for public buildings). ◘

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