energy innovation austria

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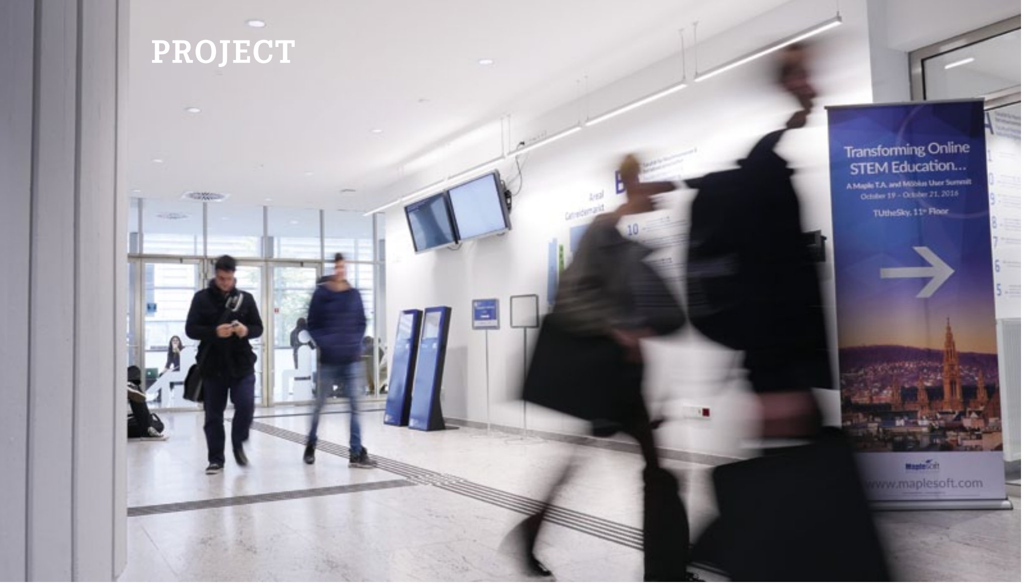
Current developments and examples of sustainable energy technologies

University Plus-Energy Office High-Rise Building

Innovations for buildings in practice

The Plus-Energy Office High-Rise Building of TU Wien (University of Technology Vienna), completed in 2014, is a pioneering example of sustainable construction and renovation in office buildings. The high-rise building, originally built in the 1970s, had formerly been used as laboratory building. Its renovation was accopanied by a research project. In an integrated planning process an interdisciplinary team of experts developed innovative strategies and technologies for extreme energy efficiency in office buildings. Today the pioneering solutions that resulted are being demonstrated in real life at TU Wien.

Photo: TU Wien



Interdisciplinary research & planning
for the plus-energy building strategy

In Austria sustainable, energy-efficient building designs have got in place the recent years, mainly for residential buildings. The low-energy and zero-energy standards are already in widespread use for constructing and renovating detached houses and blocks of flats. In the case of office buildings energy-efficient planning and construction are not yet standard; here people still suppose that innovative, environmentally friendly building technologies cannot be implemented cost-effectively. From the energy point of view office buildings are very different from residential buildings; offices have a higher occupancy and are equipped with a lot of devices that emit heat as a byproduct of their operation. Lighting, indoor temperature and air quality must comply with special requirements and be matched to the particular work-related needs applying.

World's first Plus-Energy Office High-Rise Building

TU Wien's Plus-Energy Office High-Rise Building, completed in 2014, shows that high energy standards are technically feasible and can be implemented cost-effectively even in large, complex office construction projects. The former old high-rise building was renovated from top to bottom, which took two years' work. The result is a pioneering "building of tomorrow": Austria's largest plus-energy office building, in which numerous future-oriented building technologies are demonstrated.

As part of the Austrian government's programme for renovating universities, the high-rise building (which had previously housed offices and laboratories) was renovated to passive-house standard as a building used mainly for offices. This renovation is part of the UniverCity 2015 project, which involves eight new buildings and renovated objects on TU Wien's various sites.

The entire building has a net floor area of 13,500 m² on 11 floors, and provides high-quality workplaces for around 800 of the university's employees and students. It is the first multistorey office block worldwide designed to produce more energy than is needed to operate and use the building. With renovation involving a wide range of measures to improve energy efficiency, energy consumption is now up to 90 % lower than it was in the original building.

Initial situation

The former high-rise building was built in the early 1970s to house the Faculty of Technical Chemistry. The complex consists of two buildings, the tower itself and a second building in front of it housing auditorium and library. Before renovation the tower had a prefabricated concrete curtain façade with ribbon windows. The ventilation units in the original buildings fulfilled the laboratory building's functional requirements by means of very high rates of air change; the rooms were heated with radiators.

Before / after, photos: TU Wien

New functions

Renovation was coupled with a change in use. The renovated complex is now employed by the Faculty of Mechanical and Industrial Engineering as an office building with facilities for students, while the chemical laboratories are now located in a new wing of the university. On the ground floor the entrance leads straight into the main aula with its lounge areas. A new library plus seminar rooms have been set up on the first and second floors. The office

From left to right: foyer, office, library,
Photos: Waldhör KG

areas are on floors 3 to 10. The basement floors provide access to the main auditorium, which has also been renovated, and to plant rooms, storage facilities, workshops and toilets. The control room for heating, ventilation etc. has been converted into a room for events. Two ultra-efficient ventilation units for the office areas are located on floors 6 and 7. Lecture rooms, the library and the room for events are ventilated by standard systems.

Interdisciplinary collaboration

This research and construction project is an example of successful interdisciplinary networking and integrated planning. From the basic idea to practical implementation more than 20 partners from research and industry collaborated. The ARGE Architekten Hiesmayr-Gallister-Kratochwil was responsible for overall planning; the entire process of planning, construction and commissioning was supervised by experts from TU Wien (Research Center of Building Physics and Sound Protection, Univ.-Prof. Thomas Bednar) and by the specialists for building physics from Schöberl & Pöll GmbH.

In the course of the planning process more than 9,000 components were improved and a large number of pioneering solutions integrated in a comprehensive strategy. For the team it was important that the new developments should be scalable. TU Wien regards the research project's findings as the standard for forthcoming construction schemes, and they are already being applied on all the university's sites (e.g. efficient 7 watt computers, switching technical appliances off at night).

The project was carried out by TU Wien in collaboration with the Federal Ministry for Science, Research and the Economy (bmwfw) and BIG Bundesimmobiliengesellschaft m.b.H. Within the framework of the programme "Building of Tomorrow" the Federal Ministry for Transport, Innovation and Technology (bmvit) contributed financial support to the cost of research and technology. Financial support was also provided by the Austrian Research Promotion Agency (FFG), Kommunalkredit Public Consulting (KPC) and the City of Vienna (Energy Planning Department, MA 20).

Photo: ARGE Hiesmayr-Gallister-Kratochwil

„Contents of the project were determined in regular planning conferences and workshops with more than twenty participants and specialized abilities. Over and above conventional planning processes, supervision by the TU Wien included continual checking of the measures envisaged, by way of a variety of computer simulations and virtual mockups. Finally the key energetic components were segmented, fine-tuned and checked for cost-effectiveness. Together with the firms doing the actual building work the planners checked details for feasibility on the spot and corrected them, so that the model's ambitions could be approximately mapped onto the situation in real life."

Architect Gerhard Kratochwil,
ARGE Architekten Hiesmayr-Gallister-Kratochwil

Awards

- State award "Environmental and Energy Technology 2015"
- klima**aktiv** GOLD-Award of the BMLFUW
- 986 out a possible 1,000 points in ÖGNB's TQB test
- "EUROSOLAR AUSTRIA", Austrian Solar Award 2015
- "The innovative building of 2015" (shared with TU Wien's LISI building) awarded by the platform "Innovative Buildings"

Photo: TU Wien

„Here at TU Wien we were for the first time able to follow the entire process from the initial idea to actual operation. Innovations, from the workplace via building services all the way to structural engineering, were combined so as to generate a cost-effective result. Thus high-quality workplaces are ensured, while more energy is produced on an annual basis than is needed for operating the building and using the offices. The keys to cost-effectiveness are consistently avoiding unnecessary energy consumption, and employing technology only where it genuinely helps people."

Univ.-Prof. Thomas Bednar
TU Wien, Institute of Building Construction and Technology

Technical challenge
Plus-Energy in office buildings

A plus-energy building supplies more energy than it consumes on an annual basis. “Energy consumed” comprises the energy the building needs for basic functions, such as heating, cooling, ventilation and lighting. However, TU Wien’s Plus-Energy Office High-Rise Building supplies enough energy to meet the energy needs arising from the use of the building (e.g. for computers, printers, telephones etc.); so you could well call it a plus-plus-energy building.

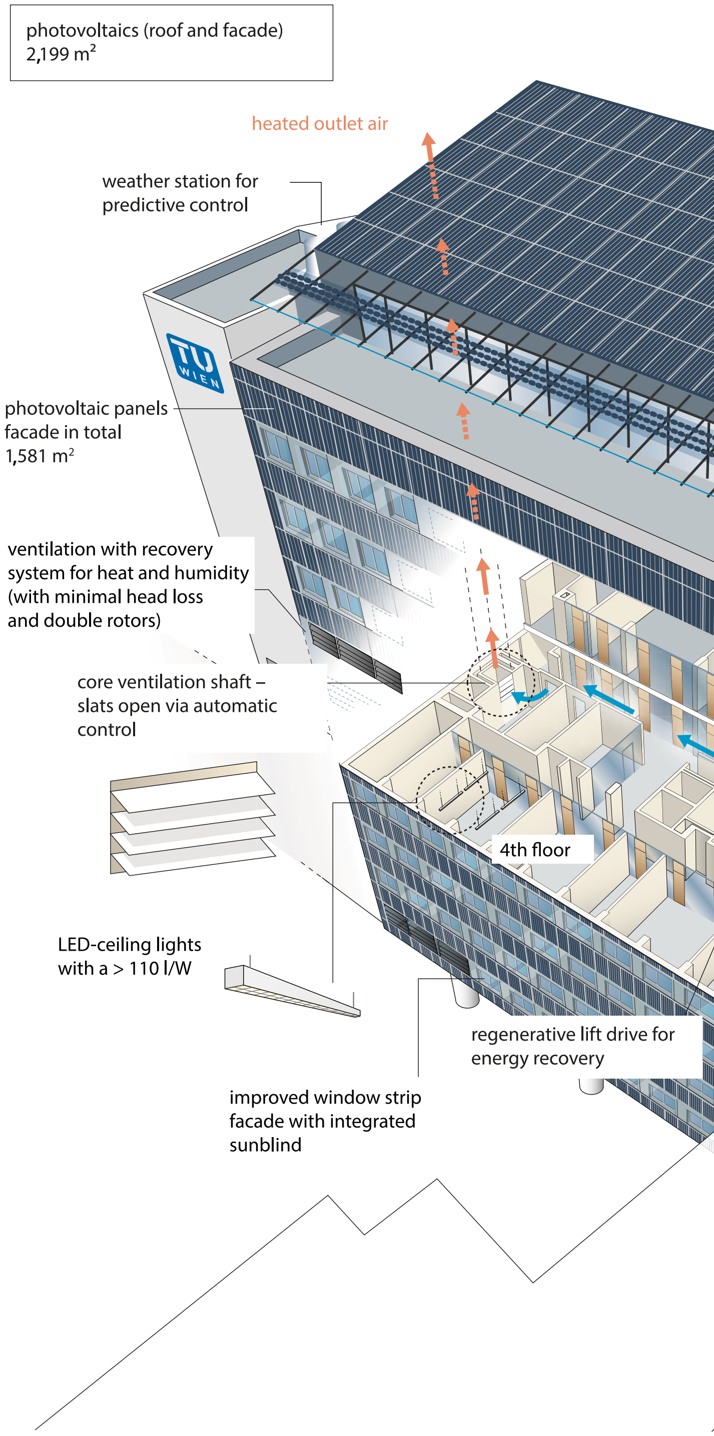
The taller the building, the harder it is to produce enough energy on the building itself, as proportionately less surface area in relation to a given level of energy consumption is available for producing energy. In the case of an 11-storey office block this is a real technical challenge. The answer is not one single measure, but an intelligent overall strategy combining numerous individual elements.

Generating electricity on the building shell

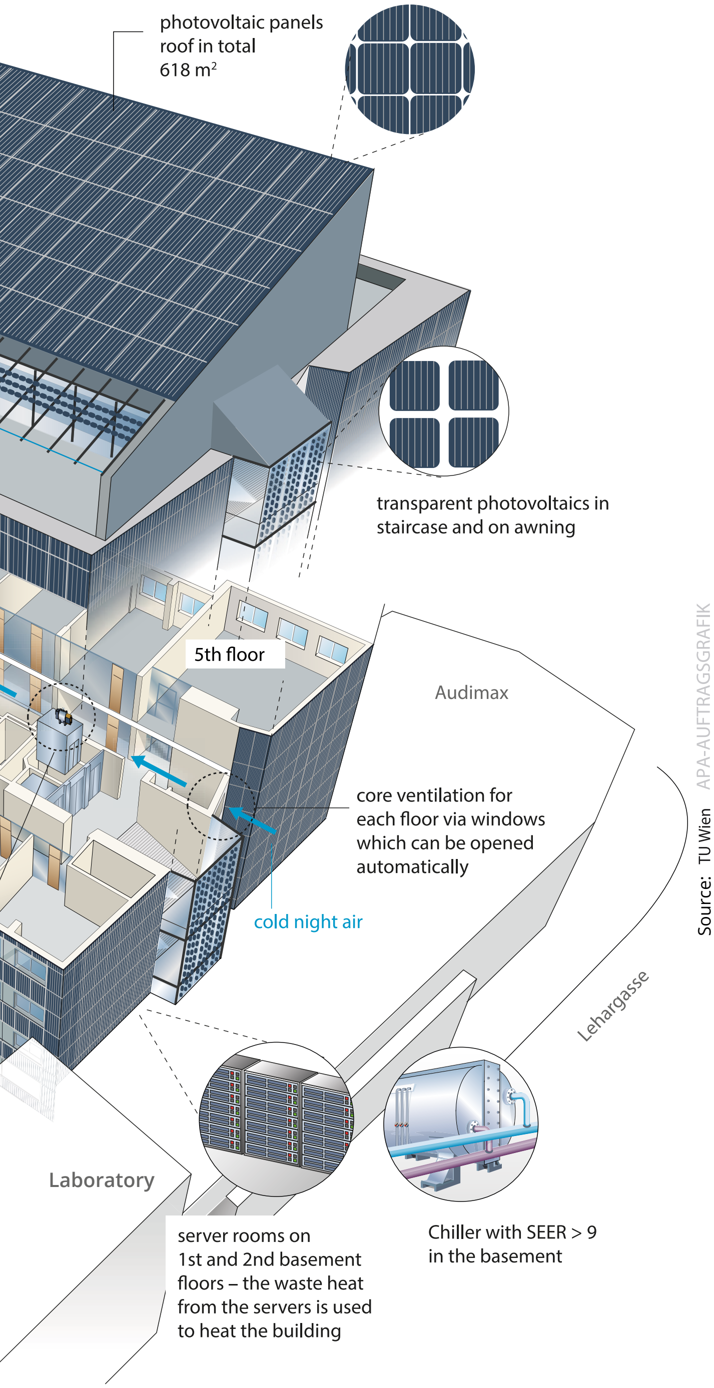
The office tower has been equipped with the largest photovoltaic (PV) plant integrated in a building anywhere in Austria. **PV modules with a total capacity of 328.4 kWp** have been installed on the roof of the building and the south-west and south-east façades; their total area comes to 2,199 m². The simulated annual yield from the entire facility is around 248,804 kWh. On the roof the PV modules were installed at a pitch of 15°; this ensures that snow and rainwater can run off and the modules stay fairly clean. On the south-west façade PV modules were sandwiched in the apron wall between the ribbon windows; modules with monocrystalline solar cells (glass-glass laminate) were employed here. The south-east façade is completely covered with PV modules. Part of the PV plant is integrated in the stairwell glazing, in the form of semitransparent modules which allow light into the building.

The **energy recovered from braking the lifts** is also used to improve the energy balance. A regenerative drive is used for this; when the cabin is braked, the drive functions as a generator to convert the cabin’s kinetic energy into electricity.

If the energy obtained from these two sources is insufficient to meet the building’s demand for electricity, power can be drawn from the grid. Surplus electricity is not fed into the grid, but transmitted to the university buildings nearby and consumed there.



From left: PV roof panels, transparent PV panels at stairwell, automatic window for night ventilation, lift facility with braking energy recovery. Photos: Waldhör KG, window photo: BMFLUW/Alexander Haiden



Ventilation system with heat and moisture recovery. Photos: Waldhör KG

Heating and cooling

Almost all the heat needed for the offices can be provided by **waste heat from the server room.** In winter, and as appropriate in spring and autumn, the heat from the servers is passed to the building via an underfloor heating system. The reflux (which has cooled down) then serves as inflow to cool the servers. If there is not enough waste heat to meet the building's current demand for heat, more heat can be drawn from Vienna's district heating grid.

In the warmer months the waste heat from the servers is given off to the ambient air via two hybrid cooling towers; depending on ambient air temperature, the cooling towers operate either in **free-cooling mode** or in conjunction with an **ultra-efficient chiller**. In summer this system is used to cool the building, too.

In addition the building is equipped with an **automatic night ventilation system** which helps to cool the building. If required, the associated windows and shutters open, allowing cool night air to flow through stairwells and corridors. Once the air has warmed up, it escapes through the shafts that once ventilated the old laboratory rooms. No additional energy is needed for this – thermal lift is enough to initiate the flow of the night air.

An important element for the users' comfort is the **ultra-efficient ventilation system with heat and moisture recovery**. At the planning stage various ventilation approaches were investigated, down to the level of individual components. In the end a system with two thermal wheels was installed; depending on requirements, one wheel is used to recover heat, the other to recover heat and moisture. ◘

From left: server room as heat source, heat exchanger between server racks, pressure equalizer, chiller. Photos: Waldhör KG

Automatic shading system, photo: Waldhör KG
Motion detector with built-in illuminance sensor, photo: BMFLUW/Alexander Haiden

Maximum energy efficiency throughout the whole building

Offices with LED-lights, smart control of temperature, lights and blinds, corridor, photos: Waldhör KG

In the course of the renovation project numerous engineering solutions and new utilization concepts were developed and implemented. For office buildings to meet plus-energy standard, their energy consumption must be drastically reduced and all components must be extremely energy-efficient. A variety of steps were taken to achieve this; the central theme is reducing heat loss and heat uptake. The façade of the office tower was renovated to **passive-house standard**, i.e. the building envelope was made practically leak-free and insulated to avoid thermal bridges, while all pipes, fittings and assemblies were specially insulated to prevent heat loss. The south-west and the south-east façades consist of a glass-steel curtain structure with integrated PV modules. **Automatically adjustable outside blinds** (protected by an outer layer of glass) are provided in front of the windows.

So as to **reduce the internal loads**, the research team listed, improved and approved all energy-consuming components in the course of the project. Throughout the building **ultra-energy-efficient appliances** are on hand, but operate only when they are needed. This applies for all energy consumers, from the computers via the lighting, the ventilation system and the lifts all the way to the coffee machine. A grand total of around 9,300 components in 280 categories were improved. Today a storey in which all these measures have been implemented consumes only about 24 kWh (!) of electricity per working day – for roughly 35 workplaces.

Relocating workstations

Apart from office computers, research work at TU Wien involves large workstations, on which complex calculations and simulations are performed. Usually these facilities are located right next to workplaces, in which case they release masses of heat into the offices.

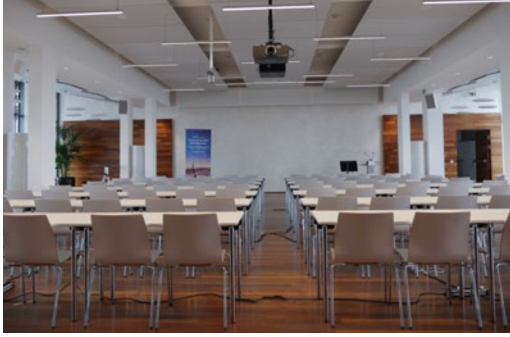
As part of the renovation strategy the processes and applications requiring high-powered computing are being relocated in the server room, where their waste heat can be disposed of efficiently or recovered in order to heat the building. In future only ultra-efficient office computers and monitors for routine office work will be located in the office rooms; users can access the computers in the server room by a remote connection at any time. To date 60 % of the workstations have been transferred to the server room. This requires intelligent IT arrangements; the users are involved in planning these. Relocation is intended to cover all workplaces by mid 2017.

Pioneering lighting system

To light the office space LED ceiling light fittings (Zumtobel LED RAY with 110 lm/W) were selected. In the actual offices the lights must be switched on by hand. The motion detectors installed have a built-in illuminance sensor, and serve to control the lighting efficiently. The sensor measures current illuminance; the LED ceiling lights are then adjusted automatically in line with the users' preferences. Only the amount of light actually needed is supplied. If no motion is detected in the room, the lighting is automatically switched off after a timed delay. Energy-saving recessed LED fittings with motion detectors were also installed in all corridors and stairwells.

Efficient control

Smart control technology is used to steer all components and systems in the office block efficiently. The building automatically adjusts toward a state in which it consumes the least possible amount of energy. However, the users are in a position to overrule this with respect to certain functions (e.g. shading with sun-blinds, or lighting) and set them by hand if the need arises.



Energy-efficient office computer, photo: TU Wien
Room for events, photo: Waldhör KG

South-west façade, inside windows and outside glass layer, south-east façade, photos: TU Wien, Waldhör KG

Monitoring system

Ever since startup in 2014 the operation of the plus-energy office high-rise building has been subjected to extensive monitoring. The system registers production and consumption of electricity, heat and cold, classified by the various groups of consumers. The energy consumed by building services (heating, cooling, ventilation and building automation) is also recorded.

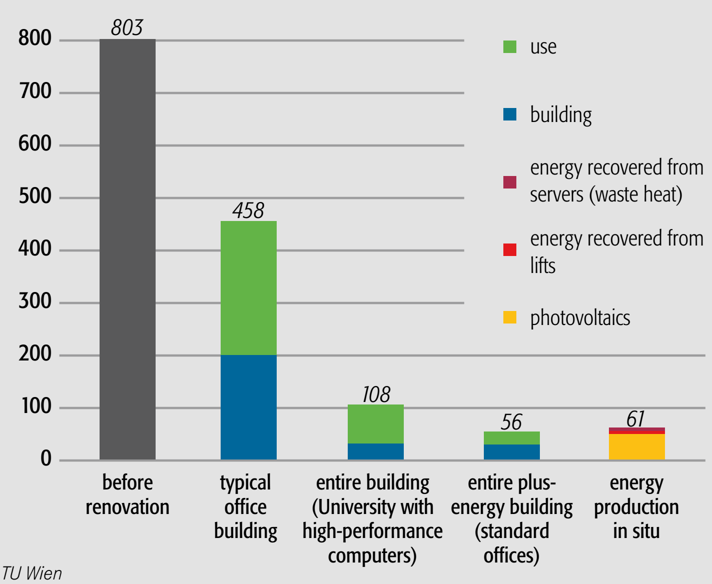
With a separate monitoring system for the PV facility details of the amount of electricity generated from PV are available via a web portal; with this system information about defects in individual modules or power inverters can be provided, too. ◻

Photo: Schöberl & Pöll GmbH

„Converting the old university tower into the first plus-energy office block worldwide reveals just what is possible with the right mix of energy-saving measures. We did not apply any unusually complex techniques, but painstaking analysis and improvements to more than 9,300 individual components resulted in dramatic savings in energy consumption. The project is scalable, which establishes its value for the future. “

Helmut Schöberl,
Schöberl & Pöll GmbH, Building physics and research

Primary energy consumption before and after renovation [kWh/m² GFA per annum]



Graphic: TU Wien

Before renovation the building contained laboratories and consumed 803 kWh/m² GFA (gross floor area) per annum. If it had been renovated to the usual standard for office buildings today, energy consumption would have gone down by around 43 %. But with the pioneering overall strategy actually implemented in the office block consumption is now down to 56 kWh/m² GFA per annum (for building and office use) – a further reduction of 88 %.

Over the year the entire energy needed in the eleven storeys can be produced on the spot; the building produces around 5 kWh/m² GFA more energy per annum than the office area (excluding the high-performance computers in the server room) consumes in total, and it thus fits the definition of a plus-plus-energy building. If we add on the high-performance computers needed for university research etc. (unnecessary in an ordinary office building), energy consumption goes up to 108 kWh/m² GFA per annum.

CEO Hans-Peter Weiss
BIG Bundesimmobilien-gesellschaft m.b.H.

Photo: Suzy Stöckl

In constructing and renovating public buildings BIG sets value on high quality standards and sustainability. Are the solutions developed for TU Wien's Plus-Energy Office High-Rise Building scalable?

Together with our long-term partner, the TU Wien as principal and key promoter of innovation, we have implemented a lot of individual solutions here that are fully scalable and can be incorporated in future projects. One tantalizing aspect is the insight that, even with intelligent energy arrangements, the target values may be unattainable if inefficient equipment is employed. Appliances with high stand-by consumption are a case in point. So a comprehensive strategy must not only be well planned, but also be put into practice the right way. A complex building like this office block therefore needs a good facility management – something we offer as part of our range of services. That is vital if such a large number of pioneering solutions are to be orchestrated so as to achieve the desired result.

In recent years BIG has implemented the research project BIGMODERN, which focussed on criteria for energy-efficient and cost-effective renovation of buildings. What are its main findings?

In the current state of the art it is easy to plan an energy-efficient building, but still difficult to achieve the ambitious targets planned in actual operation. BIGMODERN's flagship projects within the programme "Building of Tomorrow plus" are showcases for energy-efficient renovations and innovative measures. The Engineering Faculty in Innsbruck features a combination of mechanical ventilation for the core of the building and automatic hopper windows. In the office building in Bruck an der Mur a solar honeycomb façade has been tested. It is worth pointing out that for both buildings construction costs were lower than planned (contrary to expectation), and no higher than for comparable conventional thermal renovation projects. The research results are of immediate use in our Holistic Building Programme.

What are the aims of this programme?

The aim of the Holistic Building Programme (HBP) is to plan holistically and to encourage sustainable construction and operation. As part of this, criteria of sustainability have been selected with an eye to maximizing the cost-benefit ratio. The HBP makes it possible to target criteria of sustainability accurately, while at the same time ensuring full documentation. In this way the right measures for the project in question can be lined up without difficulty, neatly arranged and fully accessible, and mistakes can be avoided early in the planning process.

energy innovation austria presents current Austrian developments and results from research work in the field of forward-looking energy technologies. The content is based on research projects funded by the Austrian Federal Ministry for Transport, Innovation and Technology and the Climate and Energy Fund. **www.energy-innovation-austria.at** **www.nachhaltigwirtschaften.at** **www.klimafonds.gv.at**

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