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ENERGYBASE – THE OFFICE BUILDING OF TOMORROW

PLANNING AND IMPLEMENTING A DEMONSTRATION BUILDING AS PART OF "BUILDING OF TOMORROW"

bmvit
Austrian Federal Ministry of Transport,
Innovation and Technology

P R O J E C T

ENERGYBASE – INTEGRATED PLANNING OF A SUSTAINABLE OFFICE BUILDING

"Building of Tomorrow" is one of the Federal Ministry of Transport, Innovation and Technology's research and technology programs. Starting from the low-energy solar building approach and the concept of the passive building, and incorporating ways of using environmentally friendly and renewable materials in construction, new designs with great promise for the future have been developed and implemented both for new construction and for renovating existing buildings. As part of "Building of Tomorrow", numerous innovative residential and office buildings have been planned and implemented, setting new standards for eco-efficient construction and for sustainable ways of doing business in Austria.

"Building of Tomorrow Plus" builds on experience gained in the program "Building of Tomorrow" and takes account of the findings of the strategic process ENERGY 2050. The long-term vision for the "Building of Tomorrow" is to increase energetic efficiency in production and use to a point where, over buildings' entire life cycle, their emissions of greenhouse gases are reduced to zero in total.

In the field of providing accommodation the issues of saving energy, sustainability and using renewable sources of energy have moved to centre stage in Austria. Among promoters and occupants of low-energy and passive houses, energy-efficient construction is associated with a cosier indoor climate, the use of renewable resources and environmental aspects. However, ways of using energy efficiently and sustainably have as yet not been adopted to any great extent for constructing new office and industrial buildings. In office construction only the most expensive projects, e.g. the headquarters of large companies, or ambitious private-sector developments, are likely to feature innovative architecture and equipment; the bulk of low to medium-standard office and industrial buildings for rental (net construction cost € 1200 to 1800 per m^2 floor space) do not yet aspire to the quality of innovative equipment systems.

The ENERGYbase office building of Wirtschaftsagentur Wien at Giefinggasse 6, A-1210 Vienna, erected in 2008 as part of "Building of Tomorrow", is a demonstration building intended to provide vital stimuli for cutting-edge office and industrial construction.
In conventional office buildings heat is generated in central-heating facilities burning fossil fuels (fuel oil, natural gas), unless the building is connected to a district heating grid. Vapour-compression refrigerating machines are normally used for cooling. Heat is distributed via radiators; usually air in circulation is the cooling medium. Providing fresh air in summer and winter is a tricky issue, given that opening windows pushes energy consumption up at these times of year.

The ENERGYbase project features an innovative overall conception offering a high-grade, up-to-date solution to make good the deficits of ordinary office and industrial buildings with

respect to energy engineering, indoor climate and quality in use . The essentials for this pioneering office building were developed in the concomitant research project "Sunny Research" (pos architekten, AIT and Wirtschaftsagentur Wien). Passive-house standard, a stepped façade as solar generator and sunshield, solar cooling and plants filtering the air indoors for top quality are only a few of the elements that go to make up the integrated building design.

More than ten different planners and consultants (specialists in architecture, building equipment, simulation, lighting, combining plants with buildings, using ground water, etc.) formed a team to work out the prerequisites for implementing the project in an interdisciplinary planning process involving close cooperation between the various specialists.

ENERGYbase was completed in June 2008 and has been in use since July 2008. As work progressed, important insights were gained into the individual technologies and the extent to which they can be combined. Although high standards applied as regards indoor climate and quality in use, both end-use energy consumption and primary energy consumption are lower than in ordinary buildings – by a factor of 5.

Thanks to the special steps taken, ENERGYbase consumes around 80% less energy for heating, cooling, ventilation, lighting and various ancillary services, and emits around 200 t/a CO_2 less than a conventional building would.

ENERGY EFFICIENCY – UTILIZING RENEWABLE SOURCES OF ENERGY – WELLNESS AT WORK

The starting-point for the planning process was the intention of making the fullest possible use of the sun and of utilizing plants to condition air indoors. The architects based their consistent design on the technicians' specifications for orientation of the building, most suitable inclination, angle/orientation/surface area of the solar components, and ideal locations for the indoor plants, combining these parameters with functional and urban-development criteria. The integral planning approach is essential if maximum energy efficiency is to be achieved.

With 9200 m^2 of floor space, the building was designed to passive-house standard and equipped with a number of innovative special features. The integrated conception is based on three central ideas:

- **Energy efficiency**
  The aim was to use as little energy as possible for running the office building.
- **Renewable sources of energy, not fossil fuels**
  The energy for heating and cooling is 100 % from renewable sources (ground water, solar energy).
- **Wellness at work**
  A uniquely cosy indoor climate makes working in the building exceptionally comfortable.

At the planning stage special attention was also paid to ecological measures such as flushing toilets with ground water, and to selecting materials so as to preserve resources, e.g. by using certified construction materials and avoiding PVC. For the outside façade a lightweight timber structure was developed that makes passive-house standard possible in spite of its modest wall thickness (31 cm) and can be recycled completely by material category.

4 x solar - active and passive use of solar energy by means of stepped south façade

ENERGYbase uses the sun's power four times: twice passively and twice actively. The passive thermal gain goes to the south-facing rooms directly and to the north-facing rooms indirectly, via the ventilation system. With its special form, the stepped façade delivers these gains only in winter; in summer sunlight cannot enter the rooms directly, as each step in the façade in overshadowed by the step above.

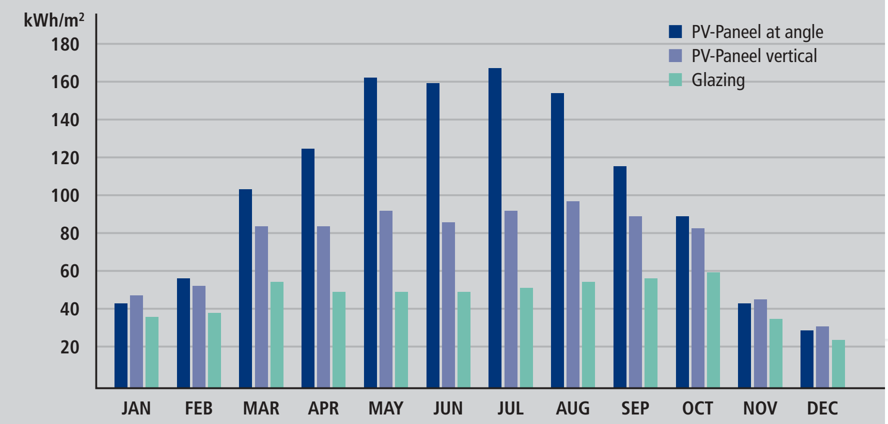
Just behind the stepped façade perforated anti-dazzle slats are located, with the air exhaust for the entire storey above them. This arrangement means that warmed air behind the façade is exhausted directly, not drawn into the centre of the room. On sunny winter days this air passes through a heat exchanger, so its heat content is transferred to fresh air and thus reaches the north-facing rooms, too.

The active photovoltaic and solar heat components are arranged specially to achieve maximum energy yields. The façade carries PV elements mounted with an air space behind (12 cm gap). The 400 m^2 of photovoltaic modules supply around 37,000 kWh of solar power per year. Inclined at an angle of 31.5°, the modules are much more effective – particularly in the summer months – than vertical modules integrated in the façade would be.

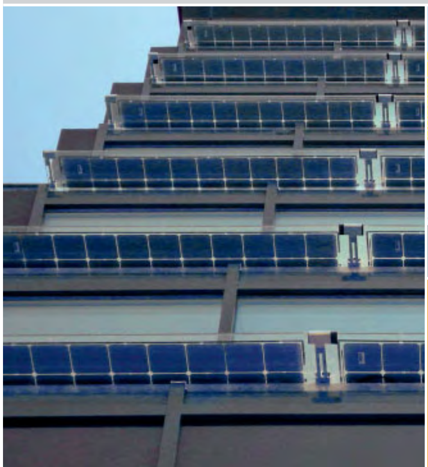
In the top segment of the façade 285 m^2 of thermal collectors are integrated in the shell of the building; these are used for solar cooling (evaporative cooling cycle) in summer and contribute to heating in winter. As the windows are set high, daylight can penetrate right into the rooms in winter, so even the core of the building is very well lit, thanks to ample interior glazing.

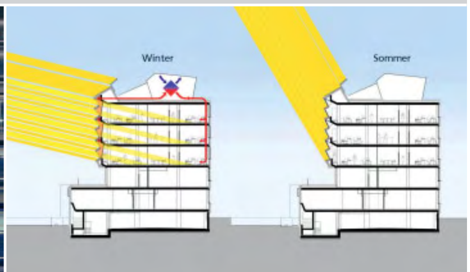
Source: Wirtschaftsagentur Wien

Solar energy: comparison between stepped and vertical façades
Angle of PV modules to horizontal 31.5, angle of glazing to horizontal 63.4°

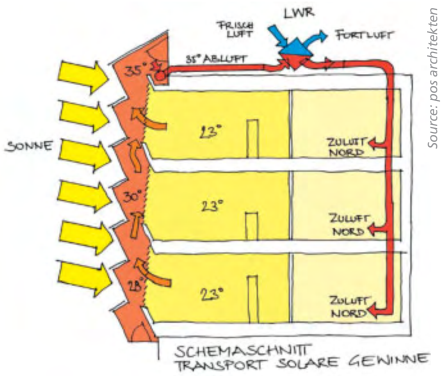


Mounting PV modules at an angle increases their solar energy yield dramatically, particularly in the summer months, in comparison with vertical integration in the façade (e.g. by 75% in May, by 83% in June and by 80% in July).





Source: pos architekten



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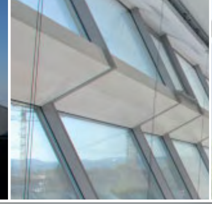
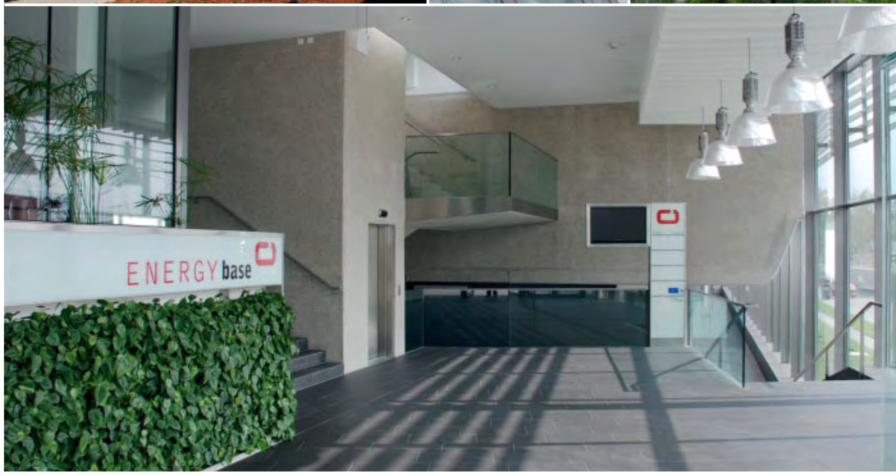




Thermal comfort due to thermally activated building systems

The office units are maintained at the right temperature by means of thermally activated building systems (TABS), which uncouple supplying/removing heat from ventilation. Here suitable parts of the building are used to store thermal energy; water pipes running through the reinforced-concrete floors supply heat in winter and remove it in summer. In ENERGYbase around 6000 m^2 of floor surface are used to maintain the right temperature in this way. Slight overshoot/undershoot in floor temperature (23°C in winter, 18°C in summer) is quite enough to keep the building comfortable.

Ground water used for cooling and additional heat

Thanks to the favourable geology of the site, geothermal energy can be exploited in the form of ground water in ENERGYbase: a heat pump coupled to the water table heats the building in winter. In summer, instead of a vapour-compression refrigerating machine, a solar-powered DEC system (Desiccant Evaporative Cooling) uses the cooling potential of the ground water directly: suitable temperatures for cooling are made available by means of a heat exchanger (16-m drilled well, extraction rate 20 l/s, total wellwater cooling capacity 410 kW, cooling water temperature 16°C to 20°C).

Using plants for natural air-conditioning

One key aim in planning ENERGYbase was to make the indoor climate specially comfortable. A central ventilation system takes care of replacing exhaust air with fresh air, while recovering 75% of the heat from the exhaust air. The indoor climate depends not only on the effective air temperature and air speeds in the rooms, but also on humidity there. Relative humidity in offices should be in the range 40 to 60%; in our latitudes humidity is usually lower than this from October to April. In low to medium-standard office buildings the air indoors is not normally humidified, so air humidity is extremely low in winter. In high-standard buildings in which air humidity is regulated electricity is used to power the process.

In ENERGYbase plants are used to buffer moisture: galingale, which emits moisture naturally, humidifies the incoming air and recovers moisture as well. The air indoors is humidified by four arrays of plants (500 in all, occupying 110 m^2, i.e. 2% of the total floor space); this arrangement achieves a comfortable 50% humidity in winter, too. For the first time ever, anywhere in the world, the humidifying capacity forecast for each individual plant has been exploited in a building systems conception.

Energy-saving lighting

In conventional office buildings 40% of floor space is lit entirely by artificial light. In ENERGYbase 100% of the floor space receives daylight. This is made possible by the open-plan, transparent spatial layout. As early as the planning phase the various areas were defined precisely in terms of workplace requirements. Lighting intensity is regulated as a function of daylight, measures typical of cold-storage facilities are taken to increase lighting efficiency, and customized solar shading also helps to make the lighting system more efficient: all in all the energy savings can add up to as much as 65 %.

Figures on energy efficiency

- ***Heating energy consumption to PHPP*: 10.83 kWh/m^2 a***
- ***Cooling energy consumption: 13 kWh/m^2 a***
- ***Overall end-user energy consumption: 25 kWh/m^2 a*** *(for heating, cooling, ventilation, lighting and all ancillary services)*

Conventional new office buildings require around 15 kWh/m^2 a just for lighting. Around 20% of the residual consumption of energy (25 kWh/m^2 a) is covered by the photovoltaic equipment integrated in the building. So to run ENERGYbase only 20 kWh/m^2 a electricity (100% hydro-electricity) is taken from the grid.

** Passive-house planning package from the Passive House Institute, Darmstadt*

R E S E A R C H

SCIENTIFIC SUPPORT DURING THE PLANNING PROCESS

■ AIT, the Austrian Institute of Technology (previously arsenal research), provided scientific support during the process of planning ENERGYbase; this made it possible to document key data on the behaviour of the building in the early stages of conception and planning. These data formed the basis for working out how to make the office building as energy-efficient as possible. As a centre of competence in sustainable construction and energy systems, AIT has also made significant contributions to the detailed planning of the innovative building systems.

Extensive analyses carried out with experts' tools such as dynamic simulations of the building and its systems, and simulations of fluid flow, produced results which were presented and discussed in the progress meetings held regularly. Various questions to do with the building shell, activating building systems, utilizing ground water, outdoor and indoor shading, etc., were investigated throughout the full year of site work.

With comprehensive modelling of the building in a dynamic simulation environment, suitable methods were employed and developed further so as to compute the building's thermal behaviour at an early stage of planning. Special attention was given to developing suitable approaches to control special energy systems; for instance, the behaviour of thermally activated building systems in maintaining a constant temperature, and utilizing solar energy to improve the indoor climate, were investigated in detail.

The planning team also wished to have various approaches to heating and ventilating the mid and south-facing sections of the building, behind the stepped south façade, investigated as regards their impact on indoor comfort. To answer these specific questions the simulation tool CFD (Computational Fluid Dynamics) was brought in as an additional aid. Meaningful statements about indoor comfort, involving temperature layering or the rate at which fresh air mixes in the rooms in question, can only be derived from these detailed physical simulations.

Incorporating plant buffer spaces to humidify air ecologically was also investigated scientifically in advance. Here the following issues needed clarification:

- What is the humidifying capacity of the plant buffers planned?
- What are the humidity and the temperature in the plant buffers?
- Is there a risk of condensate accumulating in the plant buffers?
- What ventilation regimes are appropriate during and outside office hours?

The relevant data were obtained by the Institute of Thermal Engineering at the Graz University of Technology, using a dynamic environment for simulating buildings.

The AIT (Austrian Institute of Technology) Energy Department

Steadily increasing energy consumption, impending shortages of fossil resources, global climate change: these are key challenges confronting us this century. We can cope with them only by switching to renewable sources of energy, using energy more efficiently and managing energy intelligently. AIT's Energy Department has adopted an integrated approach in order to ensure that tomorrow's buildings and cities will have heating, air-conditioning and a supply of power without environmental drawbacks.

Interdisciplinary teams of researchers are using state-of-the-art instrumentation and innovative simulation tools to link together local suppliers, efficient distribution grids and intelligent buildings with efficient heating and cooling systems, to form a sustainable energy network. The experts' know-how, derived from decades of experience, ranges from developing and optimizing individual components, via integrating innovative technologies and control strategies at the system level, all the way to working out comprehensive energy conceptions for buildings and regions.
The Department's overriding aim is to push on the process of innovation by means of targeted R&D and thus to play an active part in shaping the energy system of the future.

EVALUATION

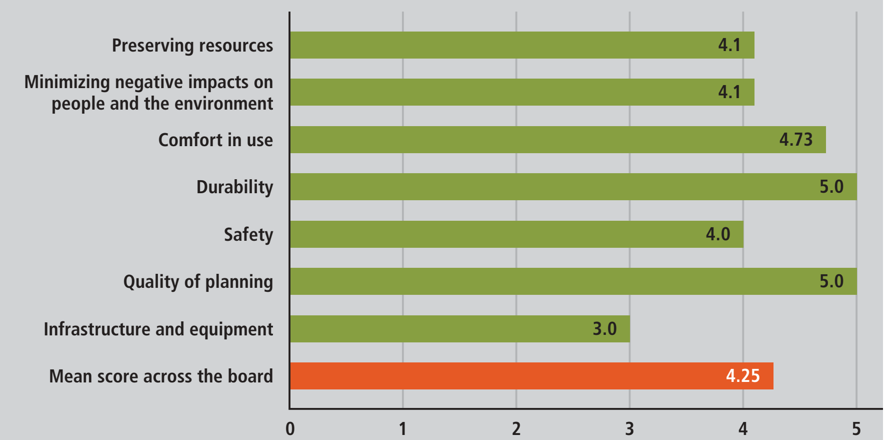
MONITORING AND CERTIFICATION

Scientific monitoring continues with ENERGYbase in operation. AIT has developed a monitoring system in which 300 sensors in the building provide data for investigating how much potential for further improvements is left. The data collected cover energy consumption, temperature control and efficient operation; errors and/or defects in operation can thus be identified and cured.

Within the framework of a TQ (Total Quality) inspection ENERGYbase has undergone extensive certification, confirming the positive results from planning. In line with the TQ catalogue of criteria the planning data for the building were gathered, and then checked and assessed by an independent organization: the TQ consortium (comprising IBO, Österreichisches Institut für Baubiologie und Ökologie, and Österreichisches Ökologieinstitut). The aim of such assessment is to document measures that improve a building comprehensively as regards comfort in use, cost and environmental performance. The diagram below summarizes the overall result of the TQ assessment of how the building was actually planned. A separate certificate covers the inspection of the building as built.

ENERGYbase counts as an exemplary project abroad, too, which is why the EU Commission has certified it as a Green Building.

TQ Total Quality assessment of the ENERGYbase office building



The scale for assessment ranges from -2 to +5 points. A score of 0 is roughly equivalent to the average quality of conventional buildings.

Source: Wirtschaftsagentur Wien

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KWI Consultants GmbH
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Location of building
ENERGYbase
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INFORMATION PUBLICATIONS

The final report "Sunny Energy Building, ENERGYbase – Bürohaus der Zukunft" (in German) has been published by bmvit in the series "Berichte aus Energie und Umweltforschung" (no.13/2009).

A complete list of the reports in this series, plus a download facility, is available on the website www.NachhaltigWirtschaften.at

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