energy innovation austria

1/2017

Current developments and examples of sustainable energy technologies

Building innovations from Austria

Pioneering technological developments – internationally approved

Austria‘s technological developments in the field of sustainable construction are international trailblazers. Innovative products and Austrian know-how in this business sector have excellent prospects in international markets. Demonstration projects implemented in other countries with Austrian participation act as beacons of innovation and help to spread cutting-edge technologies and strategies around the world.

LISI House, Solar Decathlon USA, Photo: Vienna University of Technology

International highlights in sustainable construction with know-how from Austria

Sheikh Zayed Desert Learning Center, Photo: Chalabi Architekten & Partner ZT GmbH

Energy consumption in buildings accounts for around 40 % of global carbon-dioxide emissions. There is huge potential here for saving energy and deploying energy-efficient technologies which can help to diminish greenhouse-gas emissions. From the construction materials used, via providing space heating, cooling and hot water, all the way to illuminating buildings and to technical equipment, there are any number of openings for pioneering technologies and solutions.

Austria started investing in research and technological development in the field of sustainable construction years ago. The Federal Ministry for Transport, Innovation and Technology (bmvit) and the Climate and Energy Fund initiate numerous R&D activities in this area as part of their funding programmes. The topics of insulating buildings, multifunctional façade systems, solar heating and cooling, generating electricity on the spot with photovoltaics, storage technologies, ultra-efficient lighting technologies, demand-side management, smart-home solutions and technologies for cutting down on waste and saving water are particularly relevant here.

One aim of bmvit's technology programmes "Building of Tomorrow" and "City of Tomorrow" is to spread the results gained from research activities widely. Among other things, beacons of innovation are realized in other countries, so as to help improve energy efficiency around the world with the aid of Austrian know-how.

Today there is a demand for Austrian technological developments in the field of sustainable construction; quite a number of pioneering products and system solutions from Austria have been successfully positioned in international markets.

In this issue we present demonstration projects employing trend-setting construction technologies and strategies from Austria in several other countries. Many of these innovations have been developed on the basis of experience gained in the Austrian R&D programmes. ◘

Photo: bmvit

„As a result of dedicated research and technology programmes, Austria became a leader in the area of smart city technologies, as well as in the field of sustainable and energy efficient construction techniques. Therefore, it is especially important to support Austrian companies and innovation leaders when entering global markets."

Ingolf Schädler
Head of Division Innovation,
Federal Ministry for Transport, Innovation and Technology (bmvit)

Sheikh Zayed Desert Learning Center Al Ain/United Arab Emirates

One pioneering flagship project is the Sheikh Zayed Desert Learning Center, realized in 2014 under the management of the Vienna architects Chalabi Architekten & Partner in the United Arab Emirates. This pioneering structure – a museum and research centre for desert regions and environmental issues – shows that sustainable strategies for buildings can be successfully implemented even under extreme climatic conditions. In this project environmental influences and life-cycle costs were reduced considerably with the aid of innovative designs and technologies. The Desert Learning Center is an almost energy-self-sufficient building. With its combination of active and passive use of solar energy, and with systems that save water and energy, the building satisfies the strictest criteria of sustainability. Total energy consumption is 40 % lower and drinking water consumption 80 % lower than in comparable conventional buildings. Many of the pioneering solutions and components incorporated were supplied by Austrian firms. Within the US programme LEED™ (Leadership in Energy and Environmental Design) the building has been certified as meeting the LEED™ Platinum Standard; it is also the first building in the Emirates to be awarded the Arab Green Building seal of approval Estidama 5 Pearls. ◘

www.energy-innovation-austria.at/issue/eia-2014-03 en/?lang=en

Desert Mountain Highschool, Scottsdale/Arizona, Photo: S.O.L.I.D. Gmbh

Know-how for large solar heating facilities places S.O.L.I.D., a trailblazing Styrian firm, among world leaders in the solar field. S.O.L.I.D. plans, constructs and installs large-scale facilities for supplying hot water, space heating, supplying heat to district grids, solar process heat and cold, and thermal-driven chillers. The firm initiates and participates in numerous research and development projects. Many of the pioneering technologies it deploys around the world have been developed to the point of commercial viability within the framework of bmvit's technology programmes.

Solar-cooled school building

In 2014 the world's largest solar cooling facility was realized at Desert Mountain High School in Scottsdale, Arizona (USA). The High School is located in one of the hottest places in the USA; in summer temperatures here are often above 40 °C. The school building (accommodating 2,600 pupils) is equipped with a 4,865 m^2 solar cooling facility with a chilling capacity of 1,750 kW.

In summer, when not all the rooms are in use, the solar system covers 100 % of demand, meeting the base load to prevent the building overheating. From autumn to early summer teaching periods coincide perfectly with the times when the solar system is operative. The existing conventional chillers are available as backups.

Ultra-efficient flat-plate 12.5 m^2 collectors are used throughout. They are arranged over a total area of 1,500 m^2 so as to provide shade for the parking lot; a further 1,300 m^2 are mounted parallel to sloped roofs, while the remaining collectors are installed on flat roofs. The heat is delivered to the plant room via insulated pipelines. The collector loop is directly connected to the storage vessel and the chiller, without a heat exchanger. As energy is extracted throughout, the existing 30,000 l storage vessel acts only as a hydraulic balancer. At full load circulation is completed in less than 30 minutes.

The lithium-bromide chiller, with a capacity of 1,750 kW, operates at full power for several hours around midday, cooling the reflux from the building cooling facility. In the morning and evening the chiller is supplied at lower temperatures, from 65 to 75 °C, helping to cool the building at partial load.

Release of the power grids

The solar cooling system not only lowers electricity consumption but also helps to release the power grids, specifically at peak demand times. During heat-waves in this climatic zone more than 75 % of power consumption goes exclusively on cooling. The regional electricity utility, Arizona Public Service (APS), has grasped the advantages of solar cooling and supports the project. A special amount per kWh of solar heat is payed to the plant operator, invoiced quarterly over a ten-year period. ◘

Solar cooling/Desert Mountain High School:
Collector area: 4,865 m^2 HT collectors
Hot-water storage vessel: 34.5 m^3
Chiller: 1,750 kW LiBr
Cooling Tower: about 4,250 kW
Investment costs: about 10 Mio. USD

top: chiller, insulated pipes
bottom: flat-plate collectors, hot-water storage vessel
Photos: S.O.L.I.D. GmbH

Zero Carbon Resorts
Conserving resources and energy self-sufficiency

In 2009 the GrAT - Center for Appropriate Technology at Vienna University of Technology (headed by Robert Wimmer) started on the development cooperation project "Zero Carbon Resorts" in the Philippines. The project received funding from the EU within the framework of the "Switch Asia" programme. The research team's aim was to develop sustainable building strategies and appropriate technological solutions for tourist resorts and to demonstrate their value in practice. Up till now locally available resources have hardly been used at all for constructing the resorts on the islands of the Philippines and supplying them with energy. Electricity for building operation, air-conditioning and providing hot water is generated from diesel fuel brought to the islands by boat. As part of the project a demonstration building was for the first time constructed with locally available materials to a resource-conserving design in Puerto Princesa, on Palawan. A key factor here was that local architects, engineers and SMEs were involved.

Reduce, Replace und Redesign

Today roughly 800 hotels are members of the "Zero Carbon Resorts" project. The Austrian specialists have already analysed 202 resorts in detail and made improvements. These resorts are now saving nearly 6.2 million USD per year in energy costs, while helping to reduce environmental impact. The researchers proceed in three phases. In phase one "Good Housekeeping" measures (which cost nothing) are implemented, saving up to 30 % of energy costs. In phase two the money saved is invested to replace inefficient equipment and technologies in the resort with ultra-efficient ones. In some cases up to 70 % of the monthly running costs could be saved. In phase three, or in the case of a new build, the building itself is improved along zero-carbon lines.

Building concept and construction materials

For the demonstration building in Puerto Princesa, which makes extremely efficient use of resources and energy, all three phases have been implemented. The building consumes a minimum of energy throughout its entire life cycle, using locally available renewable resources and solar technology. The model for this was the GrAT`s S-House in Lower Austria, a "Building of Tomorrow" demonstrating sustainable, energy-efficient construction with locally available raw materials. >> www.s-house.at

The building envelope of the cottage in Puerto Princesa is made of locally available materials such as bamboo, rattan, palm leaves and timber, and is fully recyclable. The soil excavated from the foundations was also used in construction as thermal mass, in the shape of a rammed earth wall and a massive structure in the bathroom area. As the soil has excellent thermal properties, these thick walls act as a temperature stabilizer. In this climatic zone cooling the building by passive means plays a key part. Wide eaves provide plenty of shade; the building stands on stilts, so it is ventilated naturally.

Sustainable provision of energy and water

The building is self-sufficient in terms of energy, operating exclusively with renewables. The electricity for the entire cottage is generated with photovoltaics. A solar system supplies hot water for heating and cooking. Sunlight is used for lighting, too; a daylight lighting system directs light from outdoors through ducts to the rooms inside. Roof design is such that rainwater can be collected centrally. Only about 10 % of annual precipitation on the roof is enough to cover the entire water consumption in the building. As water-saving toilets, shower fittings and taps have been installed, process water consumption and the volume of sewage have been limited. Sewage is purified by means of a biological treatment facility. Drinking water can be obtained from rainwater via a straightforward do-it-yourself filter.

Zero Carbon Resorts, Demonstration building, Photo: GrAT

Zero Carbon Resorts,
Demonstration building in Puerto Princesa,
Palawan/Philippines, Photos: GrAT

Perspectives

In future the plan is to put the "Zero Carbon Resorts" strategy to work around the world, for instance in development cooperation in Africa or in other parts of Asia. The GrAT is currently working on projects for further demonstration buildings in Thailand and Nepal.

In 2015 the project "Zero Carbon Resorts" won the **Global Human Settlement Award**, which is granted by the Global Forum on Human Settlements in collaboration with the United Nations Environment Program in New York. The award is made to municipalities, firms or individuals that set an example with their commitment to sustainable development. ◘

Photo: Hanna Philitzer

„Sustainable tourism in the Philippines needs 'island solutions' – literally. Very few of the more than 7,100 islands have an electricity grid, let alone sewage processing facilities. With the 'Zero Carbon Resorts' cottage we have developed a self-sufficient building adapted to local conditions, so as to create adding value in the region and conserving resources affordable and attractive."

Robert Wimmer, GrAT – Center of Appropriate Technology at Vienna University of Technology

Passive House office building in Zhuozhou/China

In 2015 the Chinese window and façade manufacturer Hebei Xinhua Curtain Wall erected a new office building with adjoining hostel for employees in Zhuozhou, near Peking. This is the first office building in China to be certified as a Passive House. The Vienna planning partnership Schöberl & Pöll GmbH was responsible for developing the energy concept and supervising construction. Chinese planning agencies and construction firms were commissioned to realize the project. The Austrian experts contributed their calculations regarding building physics and provided advice to ensure that the building would achieve passive-house standard. The building was certified as a PH by the Passive House Institute in Darmstadt.

Passive House office building, Zhuozhou/China, Photo: Schöberl & Pöll GmbH

Construction and energy concept

The office building (floor area 3,000 m²) and the hostel (2,300 m²) were erected on a precast concrete skeleton and equipped with a composite thermal insulation system made of expanded polystyrene (EPS). In the central ventilation unit two thermal wheels are arranged in tandem, one adapted to recover heat, the other to recover moisture. The heat exchanger is a condensation thermal wheel with ultra-efficient heat recovery; the moisture exchanger is a hygroscopic thermal wheel. The climate of this location makes desiccating air from outdoors a real challenge. In this particular case more than one stage is involved – both passively in the moisture exchanger and also in an active desiccation process. A chiller driven by a heat pump cools air down till it reaches the dewpoint, when the moisture in the air condenses. Humidity is controlled room by room by means of metal heating/cooling ceilings connected to heat pumps via a separate heating/cooling water circulation system. All these heat pumps are connected to a geothermal grid with 30 downhole heat exchangers.

Prospects

The Chinese government has selected this project as a passive-house pilot; the data from monitoring are to be used for planning future passive-house projects in China. Preparations are currently in progress for a project in Zhenjiang, where the CIFAL Training Centre (floor area approx. 12,000 m²) is due to be built with Austrian experts again playing a part.

In 2015 the project was awarded the "**Austrian Green Building Star**" for sustainable, energy-efficient construction. This is an internationally significant certificate of Austrian quality in construction, jointly developed by bmvit and BMLFUW and marketed by the Austrian Economic Chambers' Foreign Department. ◘

The Pallet House
Internationally awarded construction concept

Pallet House, Blaue Lagune Vienna, Photo: palettenhaus.com

The architects Gregor Pils and Andreas Claus Schnetzer developed the idea of a pallet house as students at Vienna University of Technology (supervisor: Karin Stieldorf). The approach involves 800 used Euro-pallets, which are made up into modules and can then be fitted together easily and fast to form a house. Used pallets thus get a second lease of life. The multilayer structure is ideal for installing plumbing, insulation and lighting. The approach is ecological, energy-efficient and affordable; it is particularly suitable for temporary structures in varying locations. The house is prefabricated, and can be adapted to differing requirements in actual use.

„In future construction must take not only energy efficiency but also resource conservation seriously. The Pallet House is meant to help us give more thought to using and reusing materials sustainably."

Andreas Claus Schnetzer
SchnetzerPils ZT GmbH

Photo: palettenhaus.com

„The house of the future must be affordable and respond to the users' individual needs and to their surroundings."

Gregor Pils
SchnetzerPils ZT GmbH

Pallet House, Biennale di Architettura, Venice 2008, Photo: palettenhaus.com

In 2009 the pallet house was developed further in bmvit's programme "Building of Tomorrow" as a passive house and to the production stage. This included establishing structural and physical conformity, simulating thermal bridges in three dimensions and calculating the energy consumption to be expected long-term. As examples two scenarios were investigated: temporary interim use of pallet houses in aspern Vienna's Urban Lakeside, and erecting a low-cost building in South Africa.

Demonstration project in South Africa

For a South African school, the Ithuba Skills College, a simplified design was worked out and implemented in a township south of Johannesburg. The Slumtube, a barrel-shaped longhouse that saves on wood, is insulated with straw, the framing filled in with clay and covered over with sheet metal. One key aim was to keep construction cost down. To spread the know-how needed for construction, the local population was involved in the building-process. Before the end of the project's lifespan the demonstration building was already up and running.

Awards & Presentations

In 2008 the pallet house was awarded the French architecture prize Gaudi, and was then presented at the Biennale di Architettura in Venice. Exhibitions followed in Vienna, Linz (European Cultural Capital in 2009) and Brussels (European Economic and Social Committee/Overshoot Day in 2009). In 2016, coinciding with the 15th Biennale di Architettura in Venice, a permanent exhibition of the house started in the Architecture and Innovation Zone in the Blaue Lagune in Wiener Neudorf. ◘

Ithuba Skills College, Johannesburg, Photo: palettenhaus.com

LISI House, Blaue Lagune Vienna, Photo: blauelagune.at

LISI
Living Inspired by Sustainable Innovation

In 2013 the Austrian LISI House was voted the world's best solar house in the international Solar Decathlon competition in California. The building was developed and implemented in an interdisciplinary project headed by Vienna University of Technology (Karin Stieldorf, Institute of Architecture and Design). The project involved students at Vienna University of Technology, scientific partners (University of Applied Sciences Salzburg, St.Pölten University of Applied Sciences, AIT Austrian Institute of Technology) and a large number of skilled craftsmen and Austrian firms. The "Solar Decathlon" counts as the most ambitious inter-university competition in the field of sustainable construction anywhere in the world; it is organized by the US Department of Energy every two years to promote applying solar technologies to buildings. With the LISI energy surplus atrium house an Austrian university took part in and won this competition for the first time.

LISI House, Interior, Blaue Lagune Vienna, Photo: blauelagune.at

Flexible design

LISI stands for "Living Inspired by Sustainable Innovation" and is a pioneering building design. The combination of lightweight modular construction, ecological materials and renewable sources of energy results in a high-quality, sustainable living space that can be adapted to various locations and various user requirements. The building is divided into three zones: the service core, the living area and the adjacent patios, which can be closed off by means of a flexible façade. The main living space (64 m^2 in area) can be extended to the north and south to double its size. Flexible shading elements (horizontal and vertical) protect against overheating in summer, while yielding satisfactory solar gains in winter. Depending on how much privacy the residents want, they can make the building more or less opaque by means of architectural devices. Bathroom, bedroom and all technical equipment are accommodated in the compact service core.

Materials and design

LISI is largely made of renewable and ecological materials, and offers residents healthy, comfortable surroundings. Wood accounts for 96 % of the construction materials – nine different local varieties of wood were employed, and all the tree's constituent parts were used: solid timber for the structure and surfaces, bark as surface material indoors, and sawdust for living-room furniture. Wood is an ideal material for prefabricating houses, as it is easy to handle and transport. With its modular design the house can be erected and dismantled again repeatedly without difficulty. Two horizontally bracing cores containing all the technical equipment are positioned on four floor modules. The roof consists of four ceiling modules which carry the photovoltaic facility. The supporting structure (timber boxing) makes up all the walls and ceilings. The space between the structural timbers is filled with cellulose insulation, which ensures a pleasant climate indoors.

Pioneering services engineering

LISI is an energy-surplus house and received the following certificates: klimaaktiv Gold (AT), TQB/ÖGNB Gold (AT), DGNB Gold (D) und LEED Platin (USA). The photovoltaic facility integrated in the roof delivers more electricity than the house actually needs. Two air/water heat pumps provide hot and cold water for heating and cooling. A ventilation module acts as a heat and moisture exchanger between warm waste air and fresh air, ensuring a healthy atmosphere. Heat, cold and fresh air are distributed throughout the building via piping and thermally active mass elements in the floor. Since 2014 LISI is shown in the Architecture and Innovation Zone in the Blaue Lagune in Wiener Neudorf and can be purchased tailor-made and in different sizes. ◘

Karin Stieldorf,
Institute for Architecture and Design, Vienna University of Technology

Photo: Vienna University of Technology

You developed the award-winning LISI House together with some of your students – it shows that the combination of attractive architecture and high residential quality plus sustainable construction methods can be affordable. What happens next in the LISI project?

The project will be continued with developing new floor plans for larger families. At the same time we want to put more effort into the issue of building control systems, since there is a great deal of energy-saving potential here. The thing is to employ systems that can help us to utilize buildings in the right way; for instance, an intelligent control system helps to regulate temperature and ventilation as well as possible. In addition, we want to develop the building design further toward prefabrication plus a do-it-yourself element. Multi-storey buildings are another area of interest; here we join massive structures to lightweight prefabricated structures, and the massive concrete elements can be used to store energy.

How can the LISI House be adapted to differing climatic zones and user requirements?

First of all it is always necessary to analyse the climate in question and the characteristics of the country with great care. The findings are then incorporated in the design of the building envelope. For instance, the thickness of insulation can vary – this can be calculated accurately in advance. The shading elements and supply systems can be matched to what the sun actually provides. And of course the number of residents and their lifestyle play an important part at the planning stage.

Do innovative Austrian developments in the field of sustainable construction have good prospects in international markets?

Yes, I believe that there is considerable international demand for Austrian know-how in this area. Our experience in the Solar Decathlon has shown that we can compete with other institutions around the world. One area of great international interest is construction in timber, for example; Austria is an industry pacemaker here.

Sustainable construction requires integrated planning processes. Is this taken into account in architects' training today?

The young generation takes great interest in sustainable construction. While there isn't an all-in-one teaching programme for this yet, we do practise integrated planning within the field of design; here colleagues in various specialized areas provide feedback and inputs for the students' projects. Vienna University of Technology also offers a postgraduate course which combines all the components of sustainable construction in a single course.

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.open4innovation.at, www.nachhaltigwirtschaften.at, www.klimafonds.gv.at**

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IMPRINT
Published by Austrian Federal Ministry for Transport, Innovation and Technology, (Radetzkystraße 2, 1030 Vienna, Austria) in cooperation with the Climate and Energy Fund (Gumpendorfer Strasse 5/22, 1060 Vienna, Austria)
Edited and designed by Projektfabrik Waldhör KG, 1010 Vienna, Am Hof 13/7, www.projektfabrik.at
For change of your shipping address contact: versand@projektfabrik.at

Production minimizing impact on climate, FSC certified, Green Seal and Austrian Seal of Ecological Approval