energy
innovation
austria

3/2014

Current developments and examples of sustainable energy technologies

Building innovations from Austria in the Arab world

Projects and perspectives

In the field of sustainable building construction Austrian technological advances lead the way internationally. Pioneering products and Austrian know-how in this sector of the economy are well on the way to carving out a chunk of international markets. There is great potential in the Arab world, where interest in modern energy technologies and energy-saving measures is growing. The project "Sheikh Zayed Desert Learning Center" is an impressive example of a cutting-edge, comprehensive strategy from Austria being implemented in the United Arab Emirates.

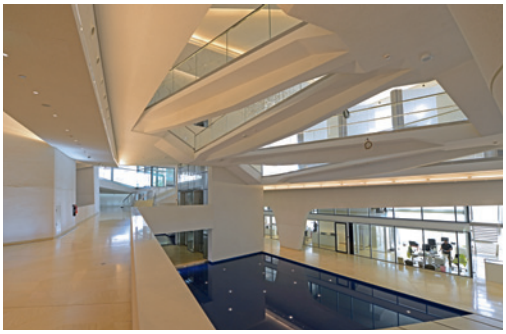
Sheikh Zayed Desert Learning Center
Photo: Chalabi Architekten & Partner

Photo: Chalabi Architekten & Partner

Transferring Austrian energy technologies
Business opportunities in the Arab world

Around the world, buildings account for 40 % of end-use energy consumption. Starting from the construction materials employed, producing and transporting them, through the provision of space heating, cooling and hot water, and finishing with lighting and operating a wide variety of electrical equipment, the building sector offers vast potential for saving energy and utilizing energy-efficient technologies that can help to cut back Greenhouse gas emissions.

In the field of sustainable building construction Austria has been investing in research and technological development for years. Pioneering Austrian firms have a wealth of know-how and experience with cutting-edge building technologies, and have been able (frequently in close collaboration with research institutes) to implement pilot projects that attract international attention, and to launch new products.



Photos: Chalabi Architekten & Partner

As part of their funding programs, the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) and the Climate and Energy Fund initiate pioneering R&D activities and projects in this field. In the Arab world interest in sustainable building technologies is currently growing apace. Even though the Arab countries still have large reserves of fossil sources of energy, there is an increasing need of technologies to save energy, improve energy efficiency and make use of renewable sources of energy. Because electricity is heavily subsidized in these countries, energy-saving measures have not yet been attractive for consumers up to now. However, as the high cost of such subsidies is increasingly impacting government budgets, interest in strategies and technologies for conserving the resources is growing.

Austrian energy technologies and building innovations have excellent opportunities in these markets. The topics of insulating buildings, multifunctional façade systems, solar heating and cooling, supplying electricity locally by means of photovoltaics, storage technologies, ultra-efficient lighting systems, demand-side management, Smart Home solutions and technologies for conserving refuse and water are particularly relevant.

One cutting-edge **flagship project** is the **Sheikh Zayed Desert Learning Center**, implemented in the United Arab Emirates and completed in 2014; the Vienna partnership of architects Chalabi Architekten & Partner managed the project, which demonstrates impressively how a pioneering overall strategy for a sustainable building can be successfully implemented under extreme climatic conditions.

Many of the technologies and innovations employed there have been developed by Austrian companies, and some of these achieved commercial viability beforehand by means of research work and pilot projects funded within the programs “Building of Tomorrow” (Austrian Ministry for Transport, Innovation and Technology) and “Neue Energien 2020” (Climate and Energy Fund). ◘

Photo: Chalabi Architekten & Partner

Photo: James Jimenez

Column free and without a single right angle – the complex geometry was worked out in advance by the architects, and then co-ordinated with the structural engineers, Bollinger, Grohmann & Schneider.

The Sheikh Zayed Desert Learning Center
Al Ain (United Arab Emirates)

A gigantic sustainable tourism project is taking shape in the city of Al Ain by order of the government in Abu Dhabi – a 400-hectar wildlife park and resort with hotels, themed safaris, residential areas and the associated infrastructure.

The first building to go up as part of the master plan was the Sheikh Zayed Desert Learning Center, planned as a museum and research centre for desert environments and ecological issues. Pioneering state-of-the-art architecture and technology, this building (total investment cost 56 million EUR) proves that sustainable building concepts can be implemented in desert locations, too. The aim was to reduce environmental impact and life-cycle costs significantly with the aid of innovative designs and technologies.

The project was designed by the Vienna architects Chalabi Architekten & Partner, acting as lead consultant, in a comprehensive process, and implemented largely with Austrian contractors (STRABAG AG, S.O.L.I.D. GmbH, ertex solar GmbH, Bartenbach GmbH, iC consulenten ZT GmbH, Bollinger, Grohmann & Schneider ZT GmbH) and in collaboration with scientific partners (AIT Austrian Institute of Technology).

A walk-in sculpture

The starting-point for the architectural approach was the idea that the building ought to grow out of the landscape and adapt to its harsh, rugged surroundings in terms of design. The architects planned a walk-in sculpture in the shape of a three-dimensional spiral, the highest point of which towers almost 20 metres above the desert landscape. Covering roughly 14,000 m^2, the structure is grouped around an enclosed courtyard, and leads up to an elevated vantage zone that offers a fine view of the Wildlife Park and the rugged ridges of Jebel Hafeet, one of the highest mountains in the United Arab Emirates.

Construction involved mainly local materials; for instance, the entire building shell is clad with natural sandstone from neighbouring Oman. The lozenge structure of the façade results from the stone receiving differing surface treatment, to create smooth and rough surfaces.

Beacon of sustainability

A key issue in hot climates is how to cool buildings; as a rule this consumes a great deal of energy. The Desert Learning Center reveals how the architectural design can help to keep down energy consumption for cooling.

The building lies partially submerged into the ground to some extent – one-third of its cubic content lies below ground level. The entrance area faces north. A low heat transfer coefficient, coupled with the considerable thermal mass of the outer shell (made up of massive concrete walls with an insulated sandstone façade plus air gap behind) greatly reduces the amount of energy needed to cool the building. A roofed enclosed courtyard and a shaded outside court also help to benefit the building‘s climate.

The deep window recesses and roof overhangs above the large glass façades minimize the amount of direct sunlight entering. But enough daylight is still emitted into the building to illuminate the interior efficiently, in conjunction with the building‘s pioneering approach to lighting. ◘

LEED™ and ESTIDAMA Certification

The Sheikh Zayed Desert Learning Center is largely self-sufficient in energy; with the aid of the sun‘s warmth, earth coupling and photovoltaics it can cover 80 % of base load using renewable sources of energy, almost the whole time. Combining active and passive use of solar energy, and employing systems which conserve water and energy, has enabled the building to meet the most stringent criteria of sustainability.

The building has been certified in the US program LEED™ (Leadership in Energy and Environmental Design) with the LEED™ Platinum Standard, and was the first building in the Emirates to be awarded the Arabian Green Building seal of approval: 5 ESTIDAMA pearls.

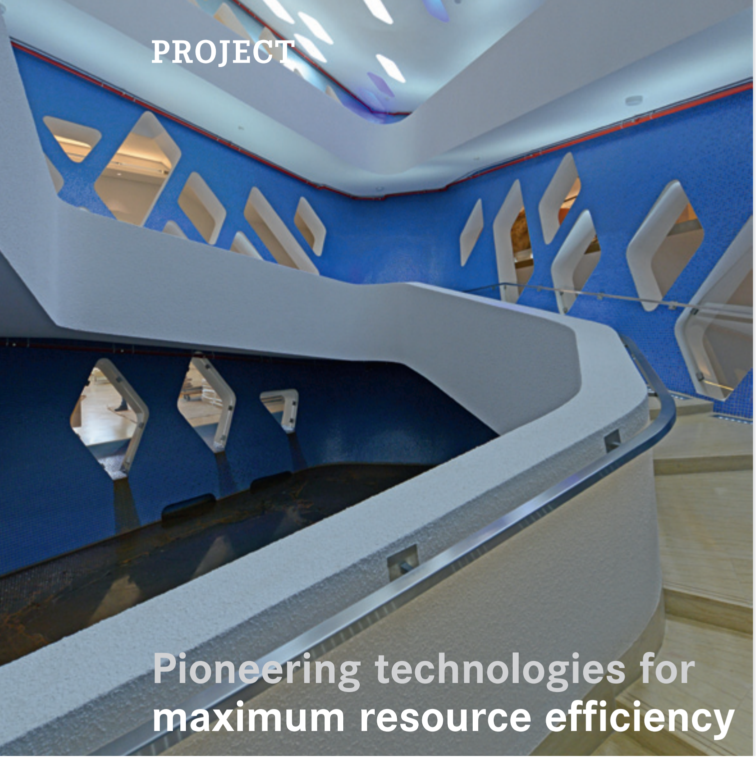


Photo: Chalabi Architekten & Partner

Pioneering technologies for maximum resource efficiency

For a highly efficient building strategy to be implemented successfully, an integrated planning process is essential, taking all aspects of energy and building services engineering into account. iC consulenten ZT GmbH were commissioned to plan the energy systems (based on renewable sources) and state-of-the-art building services, and also advised on building physics, energy-efficient operation and certifying the Desert Learning Center. The bulk of the systems and components employed were supplied by Austrian firms.

The Desert Learning Center's overall energy consumption is 40 % lower than that of comparable conventional buildings; its water consumption is 80 % lower.

Underground air cooling

Warm ambient air is first drawn through an underground system of 9 ducts (overall length 1200 metres) lying 8 metres beneath the desert surface; this lowers the temperature of the incoming air by roughly 8 to 10 K. This method of cooling the air in advance reduces cooling energy consumption by about 20 %.

Photo: Michael Paula

"Thermal solar panels are the most effective method of using solar energy. The project in Al Ain demonstrates how very suitable solar cooling is for reducing power consumption under extreme climatic conditions."

Christian Holter, CEO
S.O.L.I.D.

Photo © S.O.L.I.D.

Active solar cooling system

Solar cooling technology is of interest in hot climates where plenty of solar energy is available, since the buildings' energy demand is more or less proportional to their insulation. Solar collector panels are used to heat large quantities of water to a temperature of 90° C. With this solar heat an absorption chiller is driven. The chiller produces cold water at 14° C, which is pumped into a distribution system.

The Desert Learning Center's cooling system utilizes ultra-modern solar cooling technology from the Styrian firm S.O.L.I.D. The cooling system is coupled to thermally activated elements: cold water flows through pipes integrated in the building's floors, walls and ceilings. The cooling load for the building is around 1 MW. The solar cooling system supplies the active elements in the concrete core, which has a setpoint of 16° C. Six closed-circuit cooling towers with adiabatic pre-cooling are on hand to cool the compression and absorption chillers; this arrangement minimizes water consumption while achieving the necessary limited deviation of only 4 K above wet-bulb temperature.

Key technical data of the solar cooling system:

- Cooling capacity of lithium/bromide absorption chillers: 352 kW
- Collector: 1134 m^2 high temperature collectors
- Slope: 25°
- Capacity of hot-water storage tanks: 2x13 m^3
- Capacity of cold-water storage tank: 5 m^3
- Recooling: 6 closed-circuit cooling towers in conjunction with compression chiller
- Solar yield: 825 kWh/m^2a

Photo: Chalabi Architekten & Partner

Power supply from renewable sources of energy

The bulk of the electrical base load for the Desert Learning Center is covered by the photovoltaic system. PV modules from ertex solar (a manufacturer from Lower Austria), installed on the roof of the building on a large scale, supply solar power to the entire complex via 8 power inverters; total rated capacity is 149 kWp.

To work out the most suitable dimensions and specifications for the PV modules extensive simulation was necessary. For this special-purpose application a custom-made sandwich design with two layers of glass each 2 mm thick was developed, making the modules highly elastic; they can actually be walked on, so maintenance work can be done on the module array without individual panels shattering. Installing the panels on the roof surface, which is curved in three dimensions, was quite a challenge, too.

Key technical data of PV equipment:

- Rated capacity 150 kWp
- 1030 panels measuring approx. 1x1 m
- Individual panel rating 145 W
- Sandwich design with two glass layers 2 mm thick
- Framed modules bolted to customized supports
- Dummy panels employed (95 Dummy panels 0,5x1,0 m and 26 Dummy panels 0,5x0,5 m)

Water conservation

There is no fresh water in the desert – the drinking water for the Desert Learning Center has to be brought to Al Ain from a desalination plant 150 km away.

As part of building services engineering, extensive water conservation measures have been implemented: vacuum toilets are installed throughout the complex – the first time they have been used in the United Arab Emirates. The water from the sewage plant is purified in three stages and used for the cooling towers. The rainwater is collected, and the condensation from the ventilation system is also reused. ◘

Photos: ertex solar

Thermal building simulation

If exact modelling is carried out while sustainable buildings are being planned, comfort and energy efficiency are improved in actual operation. For the Desert Learning Center extensive simulation of the entire complex was performed at AIT Austrian Institute of Technology, in order to work out the most suitable configurations for the active solar cooling system and the pioneering ventilation approach. In the case of the air pre-cooling arrangements, for instance, the drops in temperature to be expected with differing configurations of the underground air ducts were calculated.

Scientific supervision was a great help during the planning process, putting the project on firm foundations; the calculations also formed the basis needed for certification. As the building is so complex in engineering terms, the standard TRNSYS software normally used in energy simulation had to be extended and modified on a large scale.

"Modelling the energy flows in the Desert Learning Centers is AIT's masterpiece as in regard to linking up equipment and building simulation."

Tim Selke,
AIT Austrian Institute of Technology GmbH, Energy Department

Photo © AIT

Pioneering lighting design with energy-efficient lighting systems

The lighting design for the Sheikh Zayed Desert Learning Center was developed by the Tyrolean lighting specialists Bartenbach GmbH; it features integrated lighting fittings (largely concealed) that highlight the building‘s architecture and bring out the complex geometry of the rooms. The lighting strategy is intended to guide visitors through the building dynamically and intuitively. Much of the light is provided by means of energy-efficient LED lights on rails let into the floors, walls and ceilings.

On the walls a glancing light is generated, creating the impression of light from the setting sun on sand. A variety of lighting elements are fitted in the ceiling honeycomb grid, with indirect and direct light sources to illuminate the rooms harmoniously. The light follows the succession of rooms, and the turns in the spiral leading on to the next platform are accentuated out more brightly. To provide integrated lighting without the light sources being visible, every single lighting device, such as narrow-beam LED lights on rails let into the floors, LED wallwashers und other LED lights on rails, is fitted with Jordan reflectors to direct light.

Although light levels in the museum are kept fairly low, care has been taken (as part of the overall conception) to provide enough openings for daylight to comply with the standard required for LEED certification. The relation to outdoors is established via the courtyards within, skylights facing north and openings for light in deep recesses in the façade. Generous windows open onto the office space. ◘

Chalabi Architekten & Partner Talik und Jaafar Chalabi (left to right)

Talik CHALABI on the overall conception of the Sheikh Zayed Desert Learning Center

You were involved in the project as lead consultant. How does one steer the planning process for such a complex construction task?

As principal planners we were also responsible for coordinating the specialist planners. Intensive planning workshops were held at regular intervals. We saw the requirement to achieve a sustainable building as a challenge in terms of architectural, structural and service engineering design. We managed to simplify the planning by employing state-of-the-art 3D planning software with parametric modelling. This software enabled us to design a number of complex elements, such as the lozenge-based façade and the creased lozenge cladding inside the building.

Are our pioneering building strategies and energy technologies suitable for countries with (to some extent) extreme climatic conditions?

Of course pioneering building strategies developed for the European climate need to be adapted to climatic conditions elsewhere, in our case to the extremely hot, dry climate of the Arabian Desert. The biggest difference is that the energy technologies must cope with cooling instead of heating. The solution for the Desert Learning Center involves a combination of solar cooling, electricity from PV modules, earth coupling to pre-cool the incoming air, and conventional technologies. However, this solution works only in conjunction with passive features incorporated in the architectural design.

What were the biggest challenges during project implementation?

The biggest challenge was definitely satisfying the owner‘s ambitions with respect to certification. The Estidama certification process was particularly difficult, as Estidama is a local sustainability standard introduced only in 2010. The Desert Learning Center was one of the pilot projects in the Estidama trials, which meant that all the project partners needed to improvise and act flexibly.

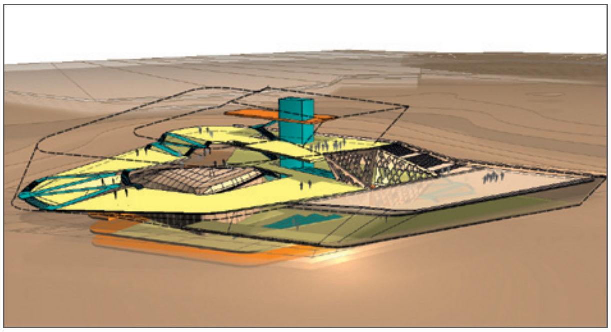
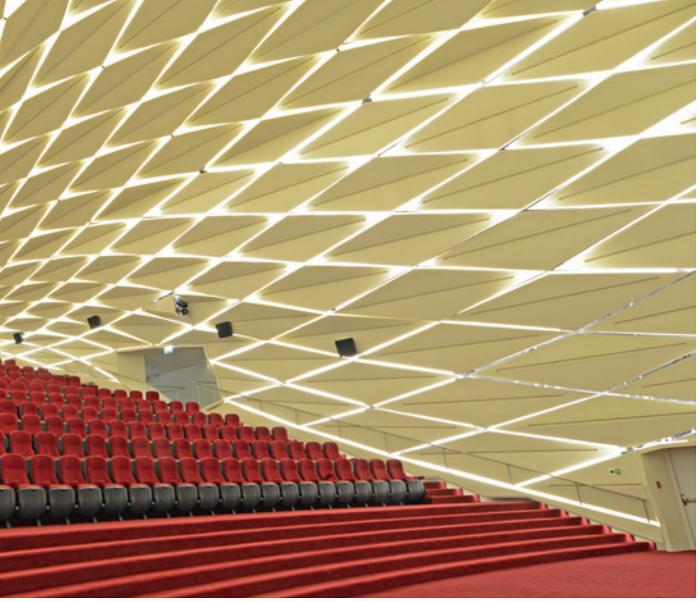


Photo: CAP Chalabi Architekten & Partner



The CAD-generated parametric geometry of the wall and ceiling cladding creates a "vault of heaven" over the seating. The panels are lit by strip LED fittings.

Photo: Chalabi Architekten & Partner

What do you think about the chances of disseminating such strategies further in the Arab world, e.g. in residential construction?
Given the publicity effect of the Desert Learning Center as a new attraction in Al Ain and as a pilot project while the Estidama sustainability standard was being introduced, we detect a very positive trend as regards disseminating sustainable approaches and technologies in the field of public buildings.

The chances of a similar trend in residential construction are likely to show in the next few years. A project to build a residential district with 256 villas right next to the Desert Learning Center, which we have planned for the same owner, was also selected during the planning phase as a pilot project for Estidama, with the aim of evaluating and improving the criteria of sustainability in the field of residential construction and urban development. ◘

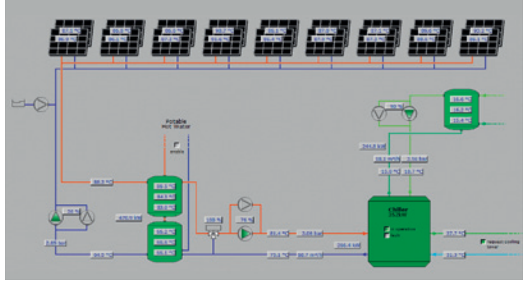
Austrian solar technology
for 36.300 m² facility in Saudi Arabia

In 2012 one of the largest solar facilities to supply hot water anywhere in the world started operation in Riyadh. The facility was implemented by Millennium Energy Industries (MEI), a plant supplier based in Jordan and specializing in renewables. Austrian know-how was employed for the collectors and the hydraulic engineering: the solar collectors for this project come from the Carinthian manufacturer GREENoneTEC, and experts from the research institute AEE INTEC developed the entire system hydraulics. Both organizations have been researching and developing pioneering energy strategies and technologies for years, partly within national and european funding programs.

The project partners succeeded in making the collectors significantly more efficient and easier to integrate in large collector arrays hydraulically, while adapting collector design to the climatic extremes in this region. The facility is located on the campus of the Princess Noura Bint Abdulrahman University for women in Riyadh, where it supplies hot water and supports the heating system. The facility is implemented as a central array of collectors on the flat roof of a warehouse with an area of 60,000 m^2. At the planning stage it was essential to ensure uniform flow distribution throughout the array, while minimizing pressure drops and simplifying pipework (to keep both costs and heat losses down).

Photo: Millennium Energy Industries

Another challenge: with sandstorms involving wind speeds up to 150 km/h, wind loads are a real structural issue. The heat from the collectors is fed straight into a district heating grid; to cope with periods of intense insolation and modest consumption, a storage system with a capacity of 900 m^3 has been provided. In conjunction with an oil-fired boiler unit, the facility supplies the entire university campus, with buildings and infrastructure for roughly 40,000 students. ◘



Screenshot und Photo: S.O.L.I.D.

IP Solar
Automated supervision of thermal solar facilities

The core units in the thermal solar facility at the Sheikh Zayed Desert Learning Center are remotely supervised by means of IP Solar, a monitoring system developed in Austria. The system evaluates instrument data, supervises operation and monitors the energy yield of solar facilities automatically; it has been developed by S.O.L.I.D. in collaboration with four research partners: Graz University of Technology/Institute of Thermal Engineering, Kassel University/Department of Solar and Systems Engineering, Cerebra Informationssysteme GmbH and Schneid GmbH.

In practice it turns out that the energy yields from many large thermal facilities do not come up to expectations. High solar yields can be maintained long-term only if operation is monitored continuously. With IP Solar an inexpensive method of automatically supervising solar-based energy supply systems in a standardized way is now available. Quality control and yield assessment are handled by means of an intelligent system of complex algorithms. Not just the solar circuit, but the entire energy supply facility (including storage circuit, downstream heating unit and process water treatment) are monitored automatically. The current data are retrieved from the solar facility's controller and data logger. Any malfunction immediately triggers an SMS or E-Mail message to the facility operator. This makes it possible to plan maintenance steps in advance and to remedy malfunctions in operation without delay; as a result, service and maintenance costs are kept low and energy yields are maximized throughout. IP Solar currently supervises thermal solar facilities with a total area of roughly 17,000 m^2 in Europe, Asia and North America.

Building on experience so far, the project partners AEE INTEC, S.O.L.I.D., LandesEnergieVerein Steiermark and Cerebra are now developing the monitoring system further in the follow-on project METHODIQA. The aim is to provide automated supervision and quality assurance for biomass heat plants, thermal solar facilities and systems combining solar, biomass and fossile sources of energy. ◘

energy innovation austria presents current Austrian developments and results from research work in the field of foward-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.nachhaltigwirtschaften.at** **www.klimafonds.gv.at**

INFORMATION

Sheikh Zayed Desert Learning Center

Chalabi Architekten & Partner
Contact: Talik Chalabi
office@chalabi.at
www.chalabi.at

S.O.L.I.D.
Contact: Harald Blazek
h.blazek@solid.at
www.solid.at

ertex solar
Contact: Dieter Moor
dieter.moor@ertex-solar.at
www.ertex-solar.at

Bartenbach GmbH
Contact: Robert Müller
robert.mueller@bartenbach.com
www.bartenbach.com

iC consulenten ZT GmbH
Contact: Klaus Kogler
k.kogler@ic-ces.at
www.ic-ces.at

Bollinger, Grohmann & Schneider ZT GmbH/Structural Design
Contact: Arne Hofmann
ahofmann@bollinger-grohmann-schneider.at
www.bollinger-grohmann-schneider.at

AIT Austrian Institute of Technology
Contact: Michaela Jungbauer
michaela.jungbauer@ait.ac.at
www.ait.ac.at

IP-Solar
Contact: Bernhard Gerardts
info@ip-solar.com
www.ip-solar.com

Riyadh Solar Facility
AEE Intec
Contact: Christian Fink
c.fink@aee.at
www.aee-intec.at

IMPRINT
Published by Austrian Federal Ministry for Transport, Innovation and Technology, (Radetzkystraße 2, 1030 Vienna, Austria) in cooperation with the Climate and Energy Fund (Gumpendorferstr. 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