CASE STUDIES IN DESIGN AND ECOLOGY

Moderator: Charles Waldheim, University of Illinois at Chicago

Ecology and Residential Design: A German Case Study.

George Jell, AIA
The University of Texas at San Antonio

This paper explores contemporary residential design in rural Southern Germany. My focus is on ecology (1) with special consideration to solutions addressing energy conservation. In Germany ecological architecture or "Bauökologie" tries to combine recent advances in technology with traditional materials and methods of construction. The area under consideration is currently experiencing an influx of urban professionals from the cities, and the region is rapidly moving away from its agrarian base (Jell & Jell-Bahlsen 2002). Recent advances in communication technology enabled young families to build a home in the countryside and fulfill their dreams of escaping the congestion of city life. Despite their differing approaches and design concepts these homeowners are united in the strong concern for ecology and energy conservation to a degree that can be described as "Angst". They strive for the fulfillment of a perfectly healthy micro-environment within their homes in a world otherwise full of hazards.

The movement towards "Green Architecture" has a unique history in Germany. The post W.W.II building boom showed little concern for energy conservation and ecology at first. Modern solar architecture begins in the seventies. The advent of the green party as a political force has turned energy savings and a concern for ecology into a political agenda. State subsidies are now favoring investment in active use of solar energy. These incentives encourage the use of solar energy for domestic water and photo-voltaic technology. In addition, modern building codes increasingly enforce higher insulation requirements and air pollution standards for furnaces.

I am comparing and contrasting four buildings that give special consideration to the way in which they address the specifics of the local climate and natural environment. The respective owners all share a heightened concern for the use of materials and methods of construction, as well as for the high cost of energy. None of these homes is part of a large-scale commercial development. Instead, they are highly individualistic and enjoy freedom of personal design, but also seem prey to a vast pallet of "ecologically safe" products, aggressively promoted by the building industry. This increasingly calls for the guidance by critical architects (Gonzalo 2000).

My first example deals with the conversion of a historic farmhouse into modern use. The other three represent versions of contemporary low energy homes or "Niedrigenergie Häuser". The concept of "low energy" mostly relates to energy savings for heating during a building's lifetime. Also under consideration is the equation of embedded energy, or the amount of energy incorporated in the building's construction, and in the manufacturing of the various materials involved. Most organic materials from timber to cellulose insulation provide an advantage in the overall energy equation, and are therefore most popular. But high-fired porous terracotta block with air chambers pushed to its limit of load bearing capacity provides a competitive edge with lowest thermal transmission but lower thermal storage capacity. Several major contrasts emerge between the traditional farmhouse and modern residential buildings with reference to environmental aspects, including among others, thermal mass, site orientation, and day lighting.

The common macroclimate in Central Europe is volatile and rather unpredictable particularly on the northern fringes of the Alps. The summers are moderately warm and rainy with only a few hot days above 80 degrees Fahrenheit. The winter can be mild with wet snow, and temperatures between 20 and 45 degrees Fahrenheit, but some winter days can be ferociously cold and windy with a wind chill factor of –10 degrees Fahrenheit. Spring and fall have few relatively large temperature swings between 30 and 60 degree Fahrenheit. The availability of year round heating is therefore essential. Passive and active solar energy solutions are often hampered by weeklong cloud cover, and therefore used for auxiliary heating or domestic hot water only. Cooling is achieved mostly by natural ventilation, and shading, and mechanical cooling is not used for homes. Underground basement spaces are a common feature of the area's built environment. While the older farmhouses exhibit merely a root cellar, modern residences usually include a full basement, an entire underground floor level, commonly used for utilities and storage facilities.

I shall now turn to my examples consisting of four different residences, one a re-modeled medieval building, the remaining three representing different contemporary design solutions.

1) My first sample, the conversion of the farmhouse "Aischinger Hof" (2), is dealing with historical aspects and its relationship between architecture and ecology. The foundations of the living quarters have been dated back to 1250 AC according to excavated pottery shards, but older items have been found and dated 500 BC. Over the centuries the building has undergone multiple changes and adaptations. The current owner adapted the structure from agricultural use and peasant homestead to the home of a professional family, and did a major restoration in 1981. A laborious process with interior and exterior excavation to create new foundations and drainage has been chosen to free the foundations and walls from moisture content, and molds. The delicate balance between the thermal mass in natural stonewalls and the sizes of windows and door openings was left unchanged. The insulation aspect of a cool attic space and terracotta roofing was also taken into account. The choice for heating was left to a traditional built-in, tiled wood-stove with air ducts to adjoining rooms, and auxiliary electric radiant heat. An in house water well and a raised exterior cistern for gravity water flow were discovered during excavation, as were various other aspects of sustainability from early rural peasant culture. These archaeic features were ultimately abandoned because restoration would have been too costly. The building is constructed of natural rock, and its thermal mass in the heavy load bearing walls of natural stone provide for a perfect heat sink in summer and winter. Moreover, the building's site orientation, featuring an East-West gable, ads to its energy efficiency: The roof angle and overhang designed for shading, and the orientation on the site seems perfect for all annual sun angles. The original construction of these ancient walls hundreds of years ago must have been a major effort, but have they have maintained their value over at least eighthundred years!

   The Bavarian farmhouse shows amazing adaptability to modern social needs, provides a maximum of comfort in the local climate, and is at the same time efficient in its use of energy. But as much as the traditional layout and construction in the farmhouse conversion provided for a healthy interior climate, its limits in adapting to modern needs are also obvious. While a contemporary residence has the advantage of columns and longer spans, more natural light through larger openings with highly adaptable glass technologies and solar control, the farmhouse's rooms are rather small and their use is restricted. Natural stonewalls pose obstacles to running modern utility lines. A contemporary home, on the other hand, could provide for a more flexible layout in its design, and can easily be equipped with all modern technologies including telecommunications.

   The following two examples are modern residences, built by descendants of local farmers. They have placed their homes right next to their parents' old farmhouses, in accordance with a local tradition (3). Haus Fritz, the first contemporary example was built by an entrepreneur farmer who needed office space that can easily be converted to living quarters, once he retires. The second, Haus Thiele, is the home of an art teacher planning to move into his studio when retiring. Both residences were designed for specific uses with maximum flexibility, and the aspect of conversion to retirement residences. Each building represents the specific opinion of the owners and their architects about solutions how "low energy" buildings can be achieved.

2) Haus Fritz (4) is built of timber, following the wood frame construction method, inspired from a visit to the US, and a novelty in the area. Cost reduction was a major concern in the building's inception. Ecology was another important objective. Insulation materials range from sheep's wool to cellulose materials blown into the wall and roof cavities. All organic materials are used without the common moisture barrier to allow the walls to breath. Organic materials allow for moisture absorption and subsequent release back into the air over a period of time. The interior climate clearly differs from the common practice of airtight construction, necessitating a constant control of the flow of air. Instead, the method of construction applied in "Haus Fritz" places strong emphasis on sustainability through "low-tech" use of cellulose materials from timber grown and manufactured on the owner's own farm. The heating system is forced air with a supplemental central hydronic convection system fired with wood pellets produced from trees harvested in local forests. Both, the building's construction materials and its operating energy sources utilize locally available and moreover renewable assets (Fritz 1996).

3) Haus Thiele (5) uses a "high-tech" industrial curtain wall system for maximum light and view. Solar heat collectors with transparent water piping are an integral part of the exterior wall for supplemental domestic hot water and space heating. The passive solar heating aspects of the giant glass wall, as well as its nightly heat loss, have already led the owner to look for shading devices. The building's passive solar performance is rather unpredictable. Due to lot-size restrictions, the glass façade predominantly faces South. There is little roof overhang, and hardly any cross ventilation. In summer, the main living areas overheat, while they are overly exposed to the cold on overcast winter-days, and at night. Neither are the ecological solutions well coordinated nor the passive solar aspects fully utilized. The building's overall design seems to be based mostly on the

architect's predetermined formal solutions, rather than on ecological considerations. The owner is now desperately searching for auxiliary installations to make up for shortcomings in the building's design.

4) The fourth and final residence under consideration is Haus Meyer (6). It was designed with all available technologies incorporated for maximum energy conservation. Ecological and health aspects were used in the choice of organic building materials, so was "feng shui" (Maria Weig). The design executed is rather conventional in a tightly restricted rural town setting. The restrictive zoning law not only prescribes size and location, but also aesthetics, including roof angle and overhang dimensions, and solar orientation. In contrast to the traditional farmhouse, this residence makes full use of the sub-terranean basement for utilities and storage facilities. Moreover, the building features a fairly open floor plan with flexible transitions and options to seasonally include recreational outdoor space, and additional home-office spaces. In contrast to the traditional rock home, this house was built of highly porous brick, a material providing for high insulation but little density, or thermal-mass. The main heating system is a natural gas fired boiler, which supplies hot water to a hydronic pipe system installed under the plaster of the exterior wall. The residence makes use of solar panels on the roof for supplementary hot water supply to a high tech boiler. Additional heating in winter is achieved through a highly efficient wood-burning stove and underground rainwater collectors supplement water for toilets and garden hose. Yet, despite all of the owner's ecological efforts, local zoning laws and building codes prescribe narrowly defined building dimensions, and site orientation, thereby providing a major obstacle to making full use of the passive, low energy solutions.

CONCLUSION

The three contemporary design examples cover the latest trends in German residential architecture, seeking to achieve "low energy" homes, and low energy consumption in view of the constantly increasing, high cost of energy. The farmhouse conversion represents the dialectic between tradition and modern architecture. Together the four examples mirror individual constraints and convictions of the owners facing a volatile local climate, the challenges of available technologies, the high cost of energy, the desire to create a healthy living environment, and tight code restrictions and zoning regulations on building design. In following the trend to more ecologically conscious products, the German building industry is putting a lot of emphasis on the development of new and better building components and systems. New and more refined materials and components are constantly becoming available on the market. In most cases this development leads to an isolated emphasis of individual aspects in the overall design of a building or home. The increasing challenge for the architect will be to direct this process from an isolated emphasis on performance of material and components to a more interrelated and user-friendly application in the design and construction of individual homes. In addition, conflicting interests emerge between contemporary zoning laws and local building codes that emphasize predominantly formal aspects on the one hand, and ecological considerations for passive energy solutions on the other. Unfortunately local planning boards are still dominated by either formal or overly idealistic considerations.

Active and passive solar design principles must be coordinated in early planning stages to integrate all aspects of design including ecology. The local building tradition provides an excellent example for building and site orientation as well as the building's thermal metabolism. Contemporary architects are facing the challenge to integrate all the aspects of solar design and ecology into their building design, otherwise they leave their clients shopping for remedies.

NOTES

[1] "Ecology comes from the Greek roots OIKOS and LOGOS, 'household' and 'logical discourse'. Thus it is appropriate, if not imperative, for architects to discourse about the logic of our earth household. To do so, we must first look at our planet and the very processes by which it manifests life, because therein lie the logical principles with which we must work (William McDonough, 1993)

[2] Architect George Jell, AIA

[3] Bavarian farms traditionally have a smaller replica of the main house built right nextdoor. These were the retirement homes of the old farmers after their oldest son took over the farm operation. Significant changes are taking place in altering the use of added living quarters for the older generation, the "Zu-Haus". Today this tradition is often used to get a building permit within strict zoning laws.

[4] Architect Peter Mair

[5] Architect Wolfgang Ziesel

[6] Architect Maria Weig

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