CASE STUDY: BIOHAUS

BEMIDJI, MN | CONCORDIA LANGUAGE VILLAGES | MAY 2006

PASSIVE HOUSE ALLIANCE UNITED STATES

Photographer: Cal Rice

PROJECT OVERVIEW

The mission of Concordia College of Moorhead, Minnesota, focuses on "influencing the affairs of the world" and is reinforced by the mission of its Concordia Language Villages, which emphasizes "responsible global citizenship." Waldsee BioHaus brings this mission to life, dazzling a new generation with a rich immersion experience in German language and culture. It offers a natural extension to the content-rich programs of Waldsee, the German Language Village. Students of all ages learn about energy use, natural resources and how we can all live more holistically in a sustainable global community. Better yet, the entire educational experience happens in German, using the metric system, surrounded by the incredible, hands-on, natural playground of Waldsee. What better way to learn about the future than to live it!

Waldsee BioHaus serves as a powerful catalyst for debate appealing to a new generation of villagers, students and architectural, construction and environmental professionals committed to advancing sustainable design and quality of life.

DESIGN CHALLENGES

The real challenge of the BioHaus project was not its construction or the unprecedented use of certain building components but the integration of design, products, detailing and construction to achieve an astonishing level of building performance—a point, which the Passive House's stringent building envelope airtightness requirement [0.6 ACH50] necessitates. One particular component that has great impact on the airtightness is exterior windows and doors. At the BioHaus the design team sourced windows from Optiwin—a German manufacturer who designed one of the first certified Passive House windows—and invited them to not just manufacture but also install the product on site—integrating design parameters, product, and installation.

The Waldsee BioHaus is located near Bemidji, Minnesota, in US climate zone 7—the coldest part of the country with 10,200 heating-degree days. The Passive House standard was developed in—and for—a much more moderate central European climate with an average of only 6,300 heating-degree days. With the BioHaus project, it would see its first real-world test in an environment with seriously limiting conditions.

Location	Waldsee - German Language Village, Bemidji, MN
Climate Zone	7 (very cold/hot and humid)
Size	5,000 s.f.
Levels	1 Level plus basement
Construction	Educational/Residential
Walls	Total of 6" thick with vacuum insulation panels for the exterior walls with aluminum cladding, R-70
Roof	Flat with an extensive-green roof
Floors	In-floor heating
Mechanical	Lüfta air exchange and heat recovery system
Windows	Triple paned Optiwin "3-wood-window" with shading device
Cost/Benefit	Less than $900 of energy costs per year. Perfo,rs 85% below the current Minnesota energy code

DESIGN SOLUTIONS - BUILDING ENVELOPE

In response to its location and the design parameters the BioHaus' building envelope is extremely well insulated to prevent heat loss. Walls achieve an R-value of 70, while the roof's insulation value sits at 100. Stephan Tanner and his design team at Intep engineered two different wall sections to illustrate different paradigms. A 20-inch 'thick' wall utilizes conventional building materials, while an 8-inch 'thin' wall assembly leverages cutting-edge vacuum insulation panel (VIP) technology from Germany. Both perform at the same level. The building envelope is designed to minimize the need for 'useful energy'. Useful energy is defined as the energy that is directly accessible to the user. Useful energy includes space heat, domestic hot water or lighting.

Once again, windows play a major role in the design and achievement of the performance goals. In this design, windows facing East, South and West are optimally protected from summer heat gains while allowing low winter sun angles to provide heating energy. An active shading system comprised of exterior venetian blinds modulates solar heat gains and daylighting on the south façade. The top and bottom of each shade can be individually controlled to achieve both at the same time.

The airtightness of a Passive House building envelope demands special attention. Uncontrolled air exchanges are to be minimized and a blower door test to be performed to illustrate a maximum of 0.6 air changes at 50 Pascal pressure [0.6 ACH50]. Thanks to the diligent design and construction the BioHaus excelled with a measured 0.18 ACH50 surpassing not only the Passive House limit by an impressive margin but besting conventional new construction [2.0 – 5.0 ACH50] considerably.

DESIGN SOLUTIONS - BUILDING SITE

The extremely cold climate is one reason the Bemidji area serves as a cold weather automotive performance-testing site for automobile manufacturers from around the world, including some German companies. The use of the Passive House performance standard produced a design for the BioHaus, which uses 85% less energy than a comparable structure built to local codes. On campus the BioHaus is located adjacent to the central Marktplatz [market place] to the east of the Stadtpark [city park] on a south-sloping lot with partial winter views of Turtle River Lake.

The site is moderately wooded with a variety of tree species. An opening in the tree cover to the south of the site was cut to allow sufficient solar access. The Waldsee campus is predominantly a pedestrian only environment. Vehicle access is limited to emergency vehicles to the BioHaus' main entrances on the West and South sides. Trails connect to the neighboring language villages surrounding Turtle River Lake, as well as the local beach.

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DESIGN SOLUTIONS - MEP SYSTEMS

The mechanical system in a Passive House is typically dominated by a high-performance ventilation system. The one in the BioHaus continuously supplies outside air—there is no recirculation. Wetrooms and auxiliary spaces are continuously exhausted to the outside. In an effort to reduce operations energy for pre-heating or pre-cooling and dehumidification, the ventilation system connects to an earthtube system. Fresh air is taken into the building is via this underground network of pipes. A bypass was installed to allow for the direct intake of outside air during times when tempering of the intake air is not needed.

The BioHaus' Passive House design did not require a stand-alone heating system as the heating demand can be met with a post-heater for the ventilation system. Due to a request of a project sponsor however the decision was made to install an in-floor heating system to provide the heating load and to forego ventilation air heating. The system is fueled by a combination of a ground-source heatpump and solar thermal energy from collectors on the roof, which also serve as the sources for the domestic hot water system. Between the coefficient of productivity of the heatpump and the solar thermal input both system dramatically reduce source-energy needs.

DESIGN BENEFITS

Concordia Language Villages believes that architects, engineers, contractors and staff are responsible for creating the most educationally inspiring, efficient and cost-effective building possible. Through the BioHaus project, Concordia Language Villages is able to commit to:

- **Reduced life cycle costs**
- **Enhanced occupancy comfort**
- **Improved learning environments**
- **Extended life expectancy of each building**
- **Reduced maintenance**
- **Reduced environmental impacts**

Waldsee BioHaus occupants enjoy an improved quality of life inside the building that uses 85% less energy than a conventional structure.

"In Europe, architects don't view green technologies as individual building components. Their approach is a more holistic one, for all the sustainable design components to work in harmony ... for the building itself to be integrated with nature not stand separate from it ... for the living and learning spaces of BioHaus to reinforce the rich, hands-on learning experience that is core to Concordia Language Villages. It's this wholeness of the building that I believe makes Waldsee BioHaus so special."

- Stephan Tanner,
  INTEP, LLC
  BioHaus architect

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ACHIEVEMENTS

Built in 2005/06 the BioHaus is the first certified Passive House in North America. Located in a severe heating climate, it is also the first commercial Passive House building in the U.S. It is now in its sixth year of operation producing amazing results for the owner:

- It works! The first five years of operation have shown that it is possible to build a Passive House in an extreme climate and with a local contractor
- The initial investment cost (approx. $260/sf) for this prototype and first of its kind were only about 20% above comparable educational facilities. This includes added cost for imported products like windows/doors, ventilations system, exterior shading needed for the design, redundant systems, as well as the cutting-edge vacuum insulated panel (VIP) insulation system, that is typically only used in projects where useable square footage is extremely expensive
- The space heating demand is reduced by 90% compared to conventional designs. At the same time occupants experience a new higher level of comfort

LESSONS LEARNED - PROCESS

The design of a high-performance structure like the Waldsee BioHaus requires detailed planning by a highly skilled design team. The achievement is comparable to extreme mountaineering—necessitating strong and experienced leadership and a highly motivated team to make it safely all the way to the peak. The long-term success relies on carefully crafted details and a proper understanding of building science, the design of appropriate building envelope systems, the evaluation and design of thermal-bridge free connection details, and a clear strategy for a durable air infiltration barrier. These skills need to be combined with a "keep it simple" approach to allow for effective execution on the job site. In summary, the BioHaus success is founded in concise planning for a high-performance design, a carefully selected team of designers and builders, effective collaboration and communication, quality control, and proper commissioning.

LESSONS LEARNED – MEP DESIGN

The design of a small-load heating system requires a great amount of professional know-how and experience. In this case, the design of the hydronic heating system proved too difficult for the team and as such does not work as designed—even though individual components are fully functioning. As a result, space heat is only being provided by the ground-source heatpump system, and not augmented by the solar thermal panels on the roof. The building's performance however, has exceeded the predicted performance 4 out of 5 years.

A GREAT IDEA THAT WORKED REALLY WELL :
Trying to have fun while working on the project.

OWNER FEEDBACK

Concordia Language Villages and its deans 'Karl' Hamilton and Edwin Dehler-Setter have been able to develop and expand their vision of an 'environmental living center' and students 'fight' to stay and live at the BioHaus year-in and out.

COST ANALYSIS

The German Foundation for the Environment funded most of the cost of the Waldsee BioHaus with the intention to demonstrate the German understanding of world-leading environmentally appropriate living, and to support Concordia Language Villages' goal to develop an environmental immersion curriculum that leverages a building as its main tool. With the building being built on budget, and annual energy cost of only $900 [5-year average] the BioHaus is considered a huge success by its owners.

Architect:

Intep, LLC
212 2nd St. SE, Suite 222E
Minneapolis, MN 55404 USA

Contact:
Stephan Tanner, Principal
++1-612-339-5515
tanner@intep.us

Client

Concordia Language Villages 8659
Thorsonveien NE Bemidji, MN 56601
USA

Contact:
Warren Schulze, Director of Facilities
++1-218-586-8502
wschulze@cord.edu

Building Technical Systems

Intep, Integrale Plannung GmbH
Innere Wiener Strasse 11
D-81667 München
Germany

Contact:
Thomas Rühle, Principal ++49-(0)89-45-99-490 ruehle@intep.de