The Aldo Leopold Legacy Center Baraboo, Wisconsin

"This building does things that people are dreaming about. There are people out there saying, 'Somehow, somewhere a building will be able to do that.' This building is doing it today."
~ USGBC President Rick Fedrizzi.

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Aldo Leopold was an ecologist, forester, environmentalist, and professor of at the University of Wisconsin – Madison. He is perhaps most noted for his hand in developing the concept of environmental and land ethics through his essays which were collected into the Sand County Almanac. In 2004, the Aldo Leopold Foundation (ALF) began assembling a team to design and build a legacy center that would not only serve as a headquarters for their advocacy and research efforts but would stand out as a model of living lightly on the land. At the time of its completion, it was the highest scoring USGBC-LEED ® building ever (awarded 61 points). It is the first building to have been awarded a LEED ® innovation credit for carbon neutral operation and it was selected as one of the 2008 American Institute of Architects COTE Top Ten Green Projects.

The phrase “using energy modeling to inform design” is bandied about in the industry a very great deal. It was clear early on in the ALF project when the Foundation director said “we’re going to use LEED Platinum as a jumping-off point” that this project would test the limits of that phrase and that TESS, as the energy modeling experts on the design team were in for a supremely interesting and challenging project.

- **The Buildings and System**

The ALF campus is a 12,000 sq.ft. complex of three buildings. The 10,000 sq.ft. main building contains office space, meeting rooms, exhibit space and a document archive. The other two buildings contain a seed-sorting facility, workshops, a garage, and a lecture hall. Only the main building is fully conditioned and even there, many of the occasional-use spaces are minimally conditioned by traditional means.

A displacement ventilation system serves the main wing of the main building only with its code outdoor air requirements; there are no recirculation fans. The outdoor air is drawn through a series of five parallel earth ducts; the relatively constant ground temperature preheats outdoor air in winter and precools and dries outdoor air in summer. Most of the time, the earth duct air then passes through an air handler that contains a changeover water coil (hot in winter, cold in summer) to further temper the outdoor air. On high-occupancy days, some of the earth duct air passes through an energy recovery ventilator (ERV) where it exchanges heat with an exhaust air stream.

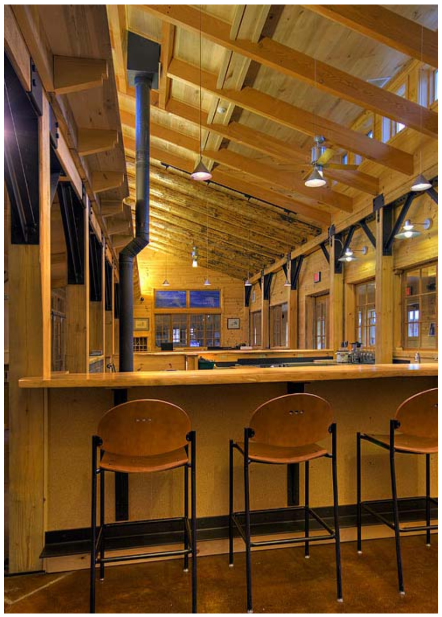
Conditioned air that is supplied from the air handler to the fully-occupied office zone is exhausted through the minimally conditioned transitional corridors that act as a buffer between the offices and ambient conditions.

The thermal loads of the space are met by radiant floors that are heated in winter and cooled in summer. A 16-bore vertical ground heat exchanger and three parallel water-to-water heat pumps keep a 600 gallon thermal storage tank hot in winter and cool in summer. The changeover coil in the air handler is also served by the same tank.

A lecture / meeting room wing on the west side of the building is intentionally thermally isolated from the rest of the building. It is served by a fourth heat pump and a 4-bore vertical geothermal well field. The heat pump is designed only to maintain the space at 55F; a stove fired with wood harvested from the Foundation's forest management efforts boosts the temperature when meetings are in session.

- **Space Programming by Thermal Comfort Requirements**

Many schematic design phase building sketches show attention to the traditional aspects of passive solar design: building form and orientation, well placed overhangs that mitigate solar loads in summer while allowing light and energy to penetrate the space in winter, windows placed to promote daylighting and natural ventilation, mass walls, etc. The ALF project architects (Kubala Washatko Architects) took space programming to a new level, identifying work areas by their usage and by their thermal comfort requirements. Transitional spaces with operable openings were used to buffer conditioned areas from ambient conditions. Seldom used spaces were moved to the east and west ends of the building and were served either by dedicated systems (in the case of the west meeting wing) or by more energy intensive extensions to the main system (in the case of the ERV that assists the exhibit space at the east end of the building). Seed sorting and workshop spaces were designated as having even wider ranges of allowable comfort based on the time of year that they are used and based on the frequency with which they will be used. As a consequence, they were moved out of the main facility and across a courtyard in separate buildings.

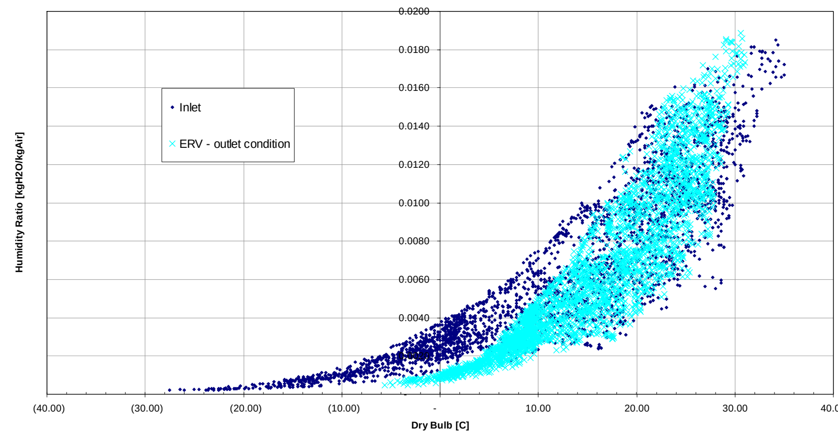


- **Design Questions**

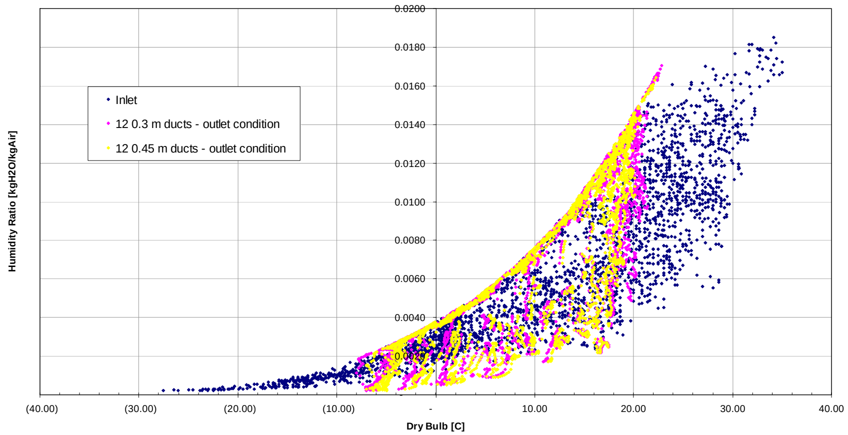
In early meetings, the design team quickly went through the list of no-brainer features that could be added to the project to reduce energy use (overhangs, high performance windows, high levels of insulation) and got into discussions that required study (and more specifically energy modeling) to answer.

- **Earth Ducts versus Energy Recovery Ventilators**

Earth duct systems are not heavily used in the building industry. Proponents claim that they are a simple and elegant air pretreatement device while naysayers doubt their effectiveness. One of their benefits is that they can have comparatively lower fan power requirements than do more traditional devices such as energy recovery ventilators. TESS carried out simulations to compare the performance of earth ducts energy recovery ventilators and found that for the Wisconsin climate, the earth ducts didn't help much in prewarming wintertime air but did an excellent job of cooling and dehumidifying summertime air (the earth ducts were intentionally designed to promote condensation in the ventilation air stream.) The ERV, on the other hand, did quite a lot to warm winter air but did little in the summertime to cool and dehumidify. The chart below shows the temperature and humidity of the ambient air in dark blue for each hour of building operation during the year. Superimposed in light blue are the temperature and humidity of air coming out of a typical energy recovery ventilator.



Next is the same chart but for earth ducts:



In the end, the system made use of earth ducts and used a small energy recovery ventilator as a booster in an exhibit space that is anticipated to see heavy use approximately one afternoon per week.

- ## No Reheat

One of the project requirements was that no gas be used (there is no gas at the site and they did not want to have to install a propane tank) and that no electric resistance heating be used. As a consequence, it was a challenge to the design team to come up with a method for providing reheat to the cooled dried ventilation air stream. It was clear that the trick would be to minimize the need for reheat by maximize the use of natural ventilation while still maintaining comfort and then to meet the remaining reheat needs with water from the solar heated domestic hot water tank. A great deal of simulation effort went into generating a combined model of the thermal energy transfer in the building, of the air flow both into and throughout the building and of the occupant behavior in terms of opening windows under natural ventilation, building loads are non-existent and the building temperature and humidity of just a byproduct of current conditions and which windows the occupants have chosen to open. In the end, the natural ventilation control strategy recommended to the occupants is that they increasingly open windows when the ambient temperature is between 55 and 80F, and that they switch over to mechanical cooling when ambient gets over 80F or when the space humidity gets above their comfort level. Of course it is impossible to mandate such a strategy but it was one of the express goals of the project to integrate the occupant and the building so that occupants would have a high level of understanding about how their choices impact the energy use of their environment.

- ## Will it Work?

The Wisconsin climate has rather lengthy shoulder seasons in the late spring and fall when the weather is conducive to conditioning by natural ventilation. In addition to these periods, however, it was the intent of the design team and of the building occupants to make use of natural ventilation in the morning throughout the cooling season, and only switch to mechanical cooling in the afternoon if the office space got uncomfortable. The building construction is not particularly massive but there was concern that because the primary cooling is provided in the radiant slabs, a switch from natural ventilation (during which higher humidity was anticipated) to mechanical cooling would cause condensation problems on the floors. Simulations, however, showed that no such condensation problems occurred. In investigating why, it was found that the temperature of the comparatively massive cooled slabs came down slowly, while the outdoor-air only ventilation system dried out the office air quickly. The dew point temperature of the zone decreases faster than the slab surface temperature, a result that has been borne out in the building's operation.

- ## Contact

For additional information about this or any other project, please do not hesitate to contact us at:

Thermal Energy System Specialists, LLC
22 North Carroll Street – suite 370
Madison, WI 53719 USA
Phone: +1 608 274 2577
Fax: +1 608 278 1475
Email: tessinc@tess-inc.com
Web: http://www.tess-inc.com
http://www.trnsys.com