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The Environment and Oberlin: An Update

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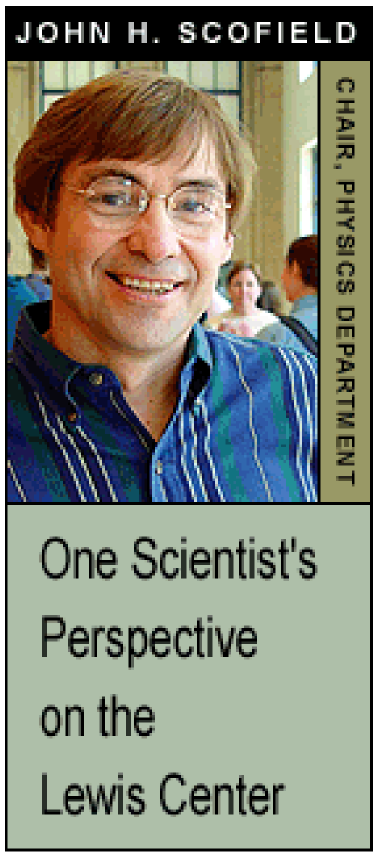
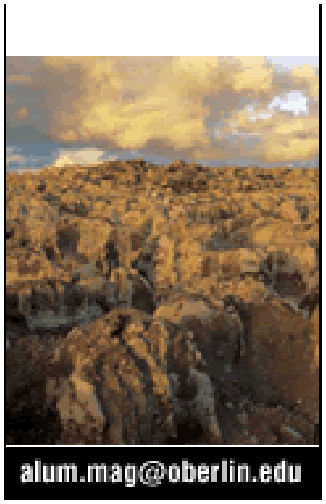


In 1995, President Nancy Dye authorized planning to construct a 10,000-square-foot, $2.5 million environmental studies center that would be a model of ecological design for Oberlin College. The architectural firm of William McDonough and Partners (WM+P) was hired to oversee the programming stage, then subsequently to design the building and supervise construction.The 13,600-square- foot facility was completed in January 2000. Today, the design and construction budget sits at $6.5 million, and the College has had two full years to use the Lewis Center and evaluate its energy performance.

In the seven years since its initial approval, much has been written about the goals and intent of the Lewis Center, but little has been written about the building as it was actually constructed or its energy performance. As more details emerge about the facility's design, I have grown concerned that the media and other publications have failed to capture important aspects of the building and its design history.

On the outside, the Lewis Center resembles the building that has been described all along. But a building's energy consumption is not simply a function of architecture—it is equally dependent on engineering. The building's engineering, or mechanical design, is hidden within. And it is here that the Lewis Center's design deviated significantly from its original intent and public description.

Throughout 1997 the architect considered and simulated a range of mechanical design concepts. But these energy simulations, although useful for guiding the design process, were not constrained by building codes and other engineering realities that frustrate "real" building



projects. In April of that year, WM+P settled on a concept described as a building that would be heated and cooled by geothermal heat pumps, with a backup connection to the College's central steam plant—added, reluctantly, to satisfy concerns of the maintenance department.

But the first set of mechanical drawings does not support this description. They instead depict a building not with steam backup, but heated by steam and cooled by water circulated through ground wells. The design showed tempered-water heat pumps (similar to those used in motels for distributing heating from a central plant), not ground-source heat pumps appropriate for a geothermal building. In short, the heat pumps reduced the efficiency of an otherwise steam-heated system.

The discrepancy is but a historical footnote because this design proved too costly, and the heat pumps and ground wells were eliminated just days before College trustees met in September 1997 to approve the final building design and its $6.11 million budget. A mechanical redesign was authorized. What emerged that fall was a building, without heat pumps, heated with steam from the College's coal-fired steam plant. Construction documents were developed for this design, and the project went out to bid in June 1998. Meanwhile, the College spent about $450,000 to extend the campus' southern steam loop to the construction site. (These lines have never been used, nor has their expense been included in the Lewis Center budget.) Architect William McDonough, in a July 9, 1998, *New York Times* article, said the building was "...like a tree, that gives more than it takes, that makes oxygen and provides a habitat for hundreds of species..." The article appeared as bids were coming in for a building heated from coal-fired steam supplied by the College's central heating plant.

Just weeks before the Lewis Center's September 1998 groundbreaking, this second mechanical design was abandoned and another redesign initiated. As I understand it, Professor David Orr agreed to raise additional funds (as high as $250,000) to return to geothermal heat pumps and wells—this time without a connection to the campus steam plant. The building was to use only electric energy so that it might one day be powered by a rooftop photovoltaic array (which generates electricity from sunlight) or a fuel cell.

Groundbreaking went forward with neither a construction contract nor a mechanical design. Though the mechanical design would not be completed for another five weeks, the architect released a performance data sheet that summarized the building's key features. Included was the projected annual energy consumption: 63,609 kilowatt-hours, which is roughly 20 percent of the site energy used by a conventional building and slightly more than the annual energy expected from a 3,700–square-foot photovoltaic array, thought then to be the largest array the roof could support. In the October 1998 issue of *Atlantic Monthly*, architect McDonough wrote that "[the Lewis Center] is designed to make more energy than it needs to operate and to purify its own wastewater." Thus began an immense publicity campaign about this building that would be powered by sunlight and produce more energy than it used.

But the third mechanical design differed significantly from that described by the architect. In a September 1998 memo, WM+P's engineers, Lev Zetlin Associates, wrote of their plans to go forward with a tempered-water heat pump system with the circulating water loop cooled by ground wells and heated with an electric boiler. This "redesign" essentially returned to the very first design of April 1997, replacing heat from steam with electric boilers. The "historical footnote" now becomes important. This redesign would have led to the least efficient heating system possible—a building heated entirely by electric, resistive heat!

The details are uncertain, but drawings dated September 18, 1998, showed pumps now taking heat from the ground to heat two-thirds of the building. A 112-kilowatt electric boiler would provide heat to the remaining third, including the atrium and Living Machine, spaces that account for 50 percent of the building's heat load. Revised drawings issued a month later included a second electric boiler, as well as two electric air heaters, an electric hot water heater and nine fans that exhausted air without energy recovery. The electric resistive heating power was nearly double the combined heating capacity of all the heat pumps! The potential electrical use was so large that in December 1998 engineers upsized the building transformer to 500 kilowatts—10 times larger than the photovoltaic array intended to power the building—and similar to the transformer that serves the local Ames department store, a building nearly six times larger! When the construction contract was finally signed in November 1998, it was for a mechanical design that differed significantly from the one described in documents released at the groundbreaking. Furthermore, it was incapable of achieving the design intent.

Construction of the Lewis Center was completed in January 2000 (the 4,700-square-foot photovoltaic array would be installed 11 months later). One month into occupancy, it was clear that the Lewis Center consumed far more energy than the architect had projected. In another month, it was clear that the assumptions used for the energy projections did not apply to the building that was actually constructed.

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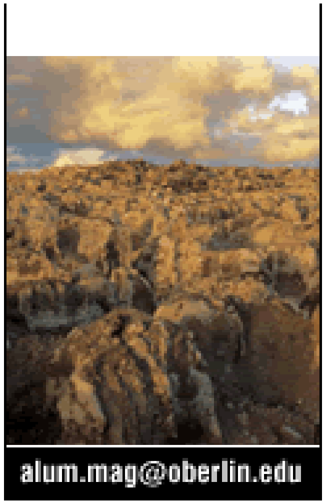
The True Energy Picture

After more than two years of operation we can now evaluate the Lewis Center's energy performance. So far the building has been powered mostly by coal, not sunlight. In its first 27 months of use, the rooftop photovoltaic array produced 70,000 kilowatt-hours of electric energy, only 17 percent of the 420,000 kilowatt-hours of energy consumed by the building (including transformer losses and parking lot lights) during this same period. The bulk of the energy was purchased from the local power company.

The architect and I have independently presented energy simulations for the as-built structure. R. Perry, managing partner of WM+P, presented the results at a public lecture in October 2000 in which he acknowledged that the original projections did not apply to the final building. My results were presented in March 2001 and will be published this year in ASHRAE Transactions. Both confirm that, as designed and constructed, the building, under normal use, is expected to consume two to three times more energy annually than the photovoltaic array can supply.

It is now quite clear that the excessive energy use is not the result of poor operating procedures or changes that came about during construction—it is largely the consequence of WM+P's mechanical design completed in October 1998. The original energy claims were nothing more than speculation. There is not now and never has been any factual basis for the energy claims for this building. Oberlin has completed an extensive commissioning process verifying that the Lewis Center was built per construction documents and that systems are operating per specifications. This process uncovered many problems that have been subsequently corrected, resulting in lower energy use. But the major causes of excessive energy consumption remain because they are associated with the building's very design.

Actual energy consumption depends on weather, occupancy (how much is the building used),



and the inside temperatures maintained during use. In the last 12 months, the energy use by the Lewis Center has decreased to 130,000 kilowatt-hours, of which the photovoltaic array furnished 46 percent. There are many reasons for this reduced energy use, including the fact that northeast Ohio experienced its warmest winter in 50 years. (Indeed, heating energy for all College buildings was reduced by 10 to 20 percent.) This performance, while interesting, does not change any of the facts already presented.

In evaluating the Lewis Center's performance, it is important to separate energy consumption from the energy generated by the photovoltaic array. A $420,000, 45-kilowatt array can be installed on the roof of any building and instantly lower the amount of energy the building imports. The benefit is clear, but it says nothing about the energy-efficiency of the building itself. As a leading advocate of photovoltaic power has frequently said, you don't make a conventional building green by simply adding a photovoltaic array to it.

As constructed (absent the photovoltaic array) the building is expected to consume 150,000 to 190,000 kilowatt-hours of electric energy annually, assuming average weather and occupancy. This corresponds to an on-site or site energy use of 35,000 to 45,000 British Thermal Units (or BTUs) per square foot per year. But site energy fails to account for the associated energy consumption and pollution that occur at off-site electrical power plants that run at 30 to 35 percent efficiency. The EPA and Department of Energy use a concept called source energy, which considers the total energy use—on-site and off-site — associated with a building's operation. For the all-electric Lewis Center, the source energy is three times its site energy. Hence the projected source energy use is 110,000 to 140,000 BTUs per square foot per year. One of the ironies of this debate is that Oberlin's Environmental Studies faculty members focus on site energy rather than source energy, ignoring the off-site pollution and energy consumption associated with operating the building.

The source energy consumption for the average non-residential building at Oberlin is about 130,000 BTUs per square foot per year. Hence, without the photovoltaic array, the Lewis Center is projected to consume about the same amount of energy and cause the same amount of pollution as a conventional College building. Because of its photovoltaic array, it does much better—but the credit goes to the photovoltaic array, not the building design. Oberlin could have achieved far more energy savings by constructing a conventional building at half the cost and erecting photovoltaic arrays on seven other buildings.

Can this design be fixed? Of course—and the College has begun this process, authorizing $100,000 to replace the 112-kilowatt electric boiler with a ground-source heat pump. But this change is not without consequences, as it increases significantly the amount of heat that will be taken from the ground, probably lowering the winter water temperature below the acceptable range of the 23 existing heat pumps and requiring that they be changed as well. And there are many other heating, ventilation, and air-conditioning (HVAC) system design flaws that must be addressed for the building to reach its original target. No one knows how long this will take or how much it will cost.

Is the building, on the whole, a good thing for Oberlin? Yes! It provides many educational opportunities to learn about our built environment. I have focused on the failures in the mechanical design. But even with these, the Lewis Center, with the boiler removed, is more efficient than a conventional building. Its lighting design, extensive use of natural lighting, and HVAC control system are exceptional at saving energy in ways not found in other campus buildings. The facility is a bright and delightful space in which to work and learn. And its rooftop photovoltaic array provides a large fraction of its energy. If the College continues to correct the mechanical design flaws, I expect that over time it will move closer to its original energy targets.

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