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Harvesting the sunlight

Archbold Biological Station
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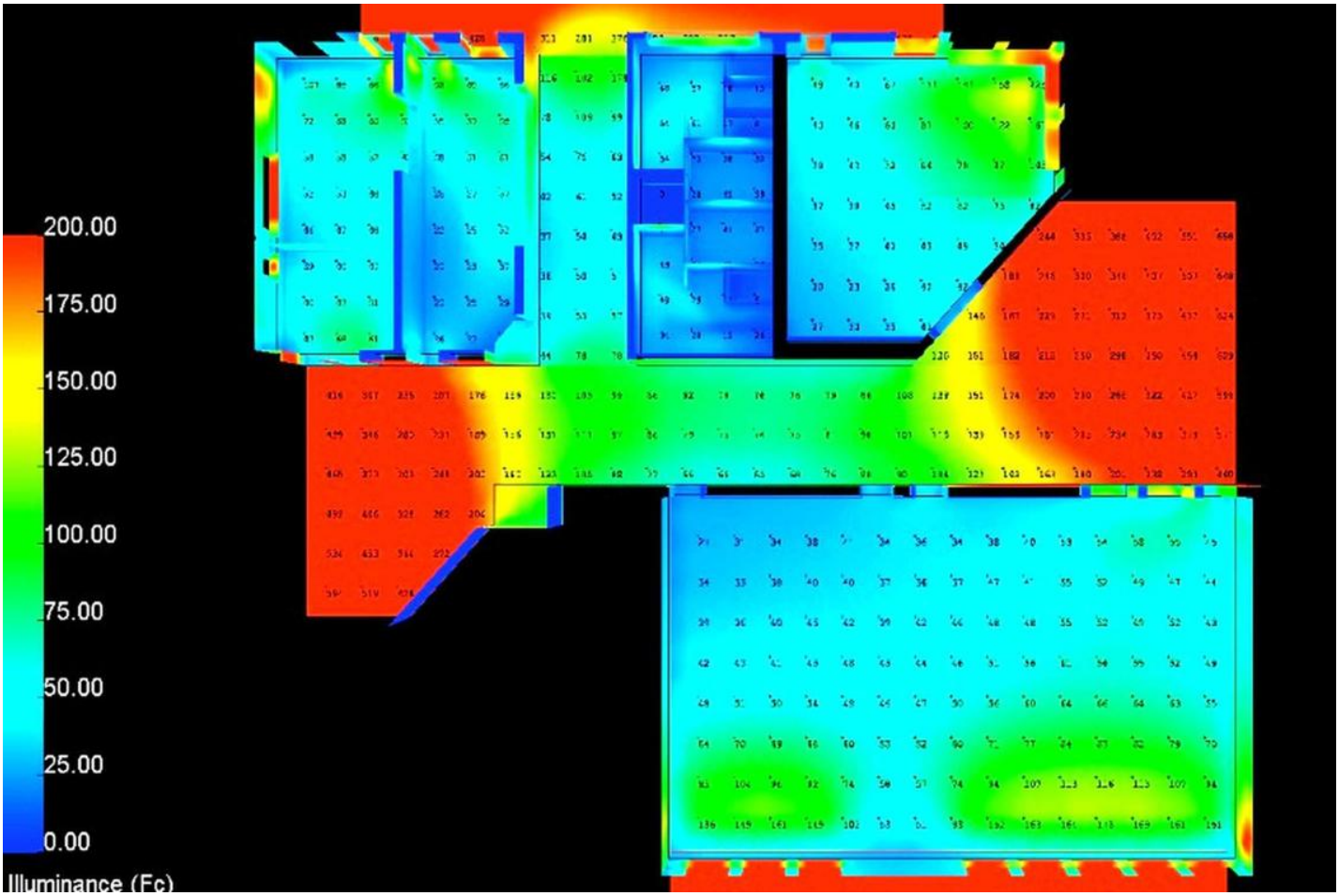

Computer drawing of light intensity in Archbold's Learning Center. Even blue green shading in interior rooms shows desirabl levels. Reds and yellows are brightly-lit exterior decks.

ARCHBOLD BIOLOGICAL STATION/ROCKY MOUNTAIN INSTITUTE

Have you ever wondered why some buildings feel so light and airy throughout whereas others have dark corners, even in rooms with plenty of windows? Or, been frustrated switching on indoor lights on a bright, sunny day in Florida just to see what you are doing? Or, felt gloomy losing your view and the sunlight when pulling down the blinds to keep out the heat?

Archbold Biological Station's Frances Archbold Hufty Learning Center provides answers to these and other questions. This is the first in a series of monthly articles on the principles of 'green building' design, using this building to illustrate how to save water and energy and to improve the quality of life indoors.

"It sounds so simple," said Dr. Hilary Swain Archbold's Director, "How can you build with windows that let in the sunlight while keeping out the heat? When designing the Learning Center, we quickly learned you start with basic common sense, and throw in a little physics and geometry." In Florida, large north-facing windows can let in lots of sunlight while minimizing radiant heating through the glass since they are not directly facing the heat of the sun. North-facing windows don't need to be shaded by an overhang, which would limit cloudy day sunlight and provide no heat gain benefit, although they should be installed with glazing that keeps cool air-conditioned air inside.

"What I hadn't fully appreciated," Dr. Swain went on to say, "Is that windows on the east and west sides of buildings should be avoided in Florida because these cannot be shaded from the heat of the sun as it rises in the east or sinks in the west. And then your problem becomes, if you only have windows on the north side of a room, it can feel very bright on that side and, in sharp contrast, dark on the windowless side of the room. I had never previously considered that balanced light throughout a room is essential to your perception and comfort. The solution, which at first seemed counter-intuitive, is to balance the light by also installing windows on the south side of the room. We learned you can retain light from a south facing window while keeping out the heat by using large overhangs combined with reflective surfaces such as wide concrete paths below the windows to bounce light into the room."

Archbold Learning Center architect Jeff Mudgett from Parker Mudgett Smith in Fort Myers worked on the natural light design for the Learning Center with engineer Erik Bonnett from the Rocky Mountain Institute in Colorado. First Erik built a sun path diagram for Archbold showing the range of sun paths throughout the year, marking the hours of the day for each month of the year and indicating the bearing and the altitude angles of the sun. To protect from the sun's heat, he calculated that overhangs on Archbold's south facing windows would need to be built with a heat gain cutoff angle of 45 to 50 degrees, the angle of a line drawn from the outside edge of the overhang to the bottom edge of the glass. Overhangs improve comfort and save energy thus reducing the emissions of greenhouse gases such as CO2.

Having worked out how to reduce the heat, Erik Bonnett's next question was where and how to let in the light? The great thing about light is that it bounces all over the place for free. Jeff Mudgett's architectural design had already incorporated 'clerestory' windows' to let in daylight high up along a central open-air corridor. The clerestory windows were to be larger on the north side, without overhangs, and smaller, with overhangs, on the south. He also designed the corridor roof to be asymmetric, larger on the north side to match the bigger windows. Based on his architectural design, the engineers at the Rocky Mountain Institute programmed computer models to calculate all reflected light and subsequent light intensity in each room. In multiple iterations, they manipulated the positions and sizes of windows, added interior windows, and included light shelves.

Dustin Angell, Archbold's Director of Education says one of the commonest questions visitors ask about the Learning Center is, "What are all those metal shelves high up along the corridor?" He explains, "These light shelves reflect natural light. Light bounces off the metal roofs and in through the clerestory windows. It is reflected off the asymmetric ceiling onto the angled light shelves on each side. Then is reflected in through interior windows to provide balanced daylight deep into all the rooms." Erik Bonnet's 'light-intensity' drawings showed the success of the design, with all interior rooms indicating desirable light intensity. He told Archbold, "The natural daylighting in this building is the best I have ever been involved in, or even seen."

Dustin Angell reflected, "Our visitors tell us how much they enjoy being in the Learning Center and that 'all-natural' lighting is a big part of feeling comfortable in this space." Bert Crawford, Operations Manager at Archbold noted, "I always argue for building features that are low maintenance and don't rely on mechanical or moving parts to work. Lighting is a big part of energy use and using daylight means long-term savings for our power bills. But it's not all maintenance free—we must get up on our ladders and wash off the tops of those light shelves every year, as the white paint on top is designed to provide the right level of reflectance and that means keeping them clean."

Dr Swain concluded, "As scientists, one of the rewarding aspects about the building design process was that it was rooted in science. I was always excited to open the engineers' emails with the latest run from their computer models; it was like waiting for scientific results. Using science and allowing form to follow function, gave us a building that is practical, beautiful, protects resources, and saves us money."