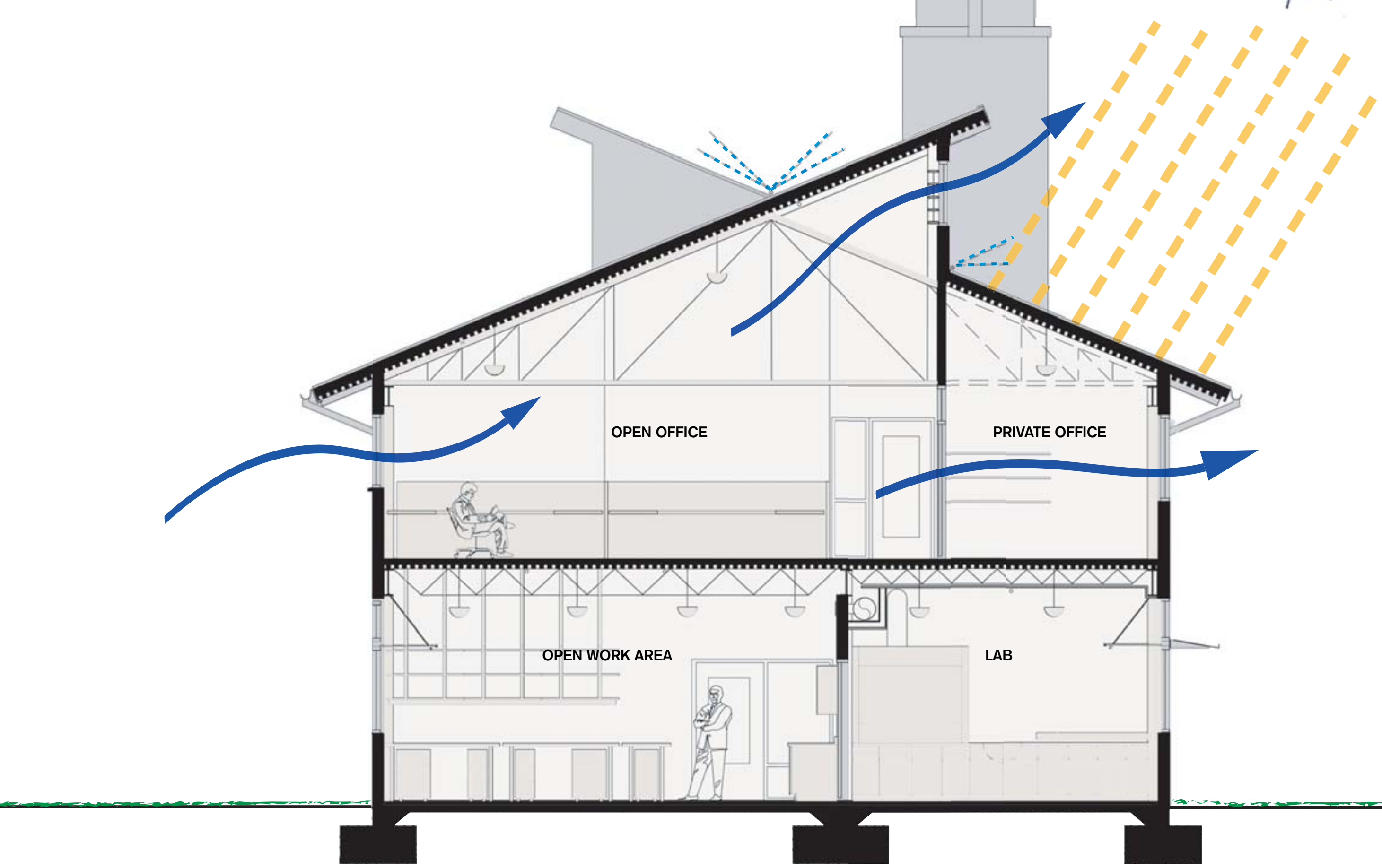
Sustainable Strategies

Center for Global Ecology
Carnegie Institution of Washington

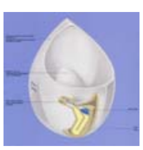


Salvaged Materials
Salvaged materials and elements were used to reduce the waste stream going to landfills. Salvaged lab casework and faucets were located and installed as-is. Solid wood doors were transformed into desks and worktables for the lobby and offices. Fallen urban trees were milled and shaped into conference tables and lobby furniture. Old-growth redwood from old Sebastiani wine vats were re-milled to form exterior siding.

Native Landscaping
Drought-resistant oaks, chapparel, and grasses will mature into a native habitat supporting wildlife with minimal demands on precious water resources. Existing irrigated grass turf was replaced with native plantings to offset building water consumption.

Sunshades and Lightshelves
Sunshades shield the interior from direct sun which reduces heat gain and glare. Lightshelves balance daylight throughout the laboratory, sending direct and reflected light deep into the workspaces.

Daylighting and Lighting Controls
A narrow, properly-oriented building and careful window sizing and placement result in a fully-daylit interior. Automatic lighting controls react to occupancy and light levels so that lights turn on only when needed, reducing energy loads and internal heat gain.

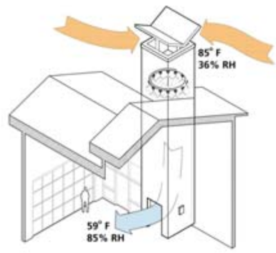



Efficient Water Use
Dual-flush toilets, low-flow faucets, and a waterless urinal – combined with drought-resistant landscaping – promise a 40% water savings over a conventional building.

Night Sky Radiant Cooling
During summer nights, water sprayed over the roof loses heat to the cold night sky. The cooled water is collected and stored in an insulated 12,000 gal. tank and pumped through the building during the day. This system supplies chilled water at 55 – 60° F for an energy cost of 0.04 kW/ton and a water usage one half that of conventional water cooled systems.

Natural ventilation
The second floor is entirely naturally-ventilated which, this combined with radiant slab heating and cooling, allows for the elimination of ducts and fan energy use on the second floor. A conference room has radiant cooling ceiling panels to allow for quick reaction to changing loads.

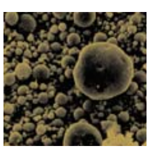
Spectrally-Selective Glazing and Roofing
High performance, low-E windows allow a high degree of daylight transmission while limiting heat gain through windows. Cool roof coatings increase the solar reflectance of the metal roof, reducing heat isld effects and building heat gain.



Cool Tower
The lobby is envisioned as an indoor/outdoor space with large bi-fold door forming two of the walls. A Cool Tower provides a small amount of cooling to the space even when the doors were open. A carefully-designed "windcatcher" captures breezes from above the roof line and directs them down into the lobby area. Atomizing spray nozzles evaporatively cool the air, increasing air humidity and density while dropping temperatures, inducing a thermally-driven downdraft to carry cool air into the lobby.

Radiant Heating + Cooling
Increased comfort and energy efficiency are achieved through radiant heating and cooling tubing installed in floors throughout the building. This strategy limits the conditioning of outside air brought into the laboratory and complements the natural ventilation of the second floor and lobby.

Built to Last
(100-Year Building / Flexible Design)
The structure, layout, and furnishings are designed with the utmost flexibility in mind to accept changes over time. An open lab with suspended shelving and movable workbenches and a highly-efficient, free-span structural system on the second floor allow reconfiguration in the short and long term. Future modifications can proceed with a minimum of demolition and waste.



High-Volume Fly Ash Concrete
Nearly all concrete used in the building and site contains 50% fly ash replacement for cement. This reduced the carbon emissions associated with concrete from 186 tons to 93 tons, cutting embodied energy by one-third overall as compared to a conventional building.

Materials

Center for Global Ecology
Carnegie Institution of Washington

REDWOOD SIDING
The second story exterior walls are clad in redwood siding salvaged from 20 foot high, 20 foot in diameter, 80 to 100 year old wine tanks from Sebastiani vineyards in Sonoma, California. This redwood is rated as the clearest, highest grade old-growth available – and was obtained without felling a single tree.

Countless options were considered for the wood siding. Initially the architects specified Ipe, a tropical hardwood which is harder than Teak and is available from FSC-certified forests. After prolonged discussions with expert suppliers of certified lumber and the Global Ecology faculties' own research into the issue, the design team and client decided that, while supporting sustainable tropical forestry may be a worthwhile strategy, the industry has a long way to go before it meets standards that the Global Ecology faculty could endorse.

Our search moved on to salvaged tropical hardwoods, such as Jarra from sheep shearing barns in Australia and railroad ties from Thailand, FSC-certified domestic woods, such as redwood and cedar, and the Sebastiani redwood.

What finally tipped the balance was concern over the long-term stability of wood left exposed on the exterior. One of the design goals is to create a 100-year building that requires little maintenance over time. While new growth redwood would require reapplication of sealer every five years, buildings clad in old-growth redwood such as Julia Morgan's Asilomar (1912) hold up beautifully over time with no application of sealer.

It is estimated that every million board feet of lumber reclaimed preserves one thousand acres of old-growth forest. Through supporting the building salvage and deconstruction industry we hope to reduce deforestation and habitat loss due to building activity.

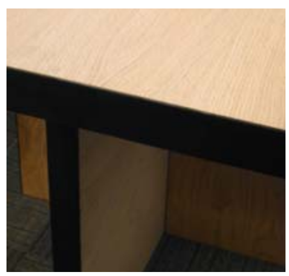
Minimal finishes
Integrated design allows structural, electrical, mechanical, and architectural systems to work together holistically. As a resultm layers of finishes such as acoustic tile ceilings and floor coverings, which would be necessary in a conventional building, can be eliminated. This not only reduces the amount of virgin material used in the construction of the building but allows easier recycling of the building in the future.

For example, the 50% fly ash, integrally-colored concrete lobby floor serves as a medium for radiant tubing, a thermal heat sink, and a architecturally-finished floor surface. Perforated acoustic metal decking acts as structural floor/roof support as well as the primary acoustic control system and finished ceiling.

Salvaged Furniture and Fittings
All lab faucets and a portion of the lab casework was salvaged in perfect condition and installed. Fixed worktables and open office desks are built from solid core wood doors which were hinged incorrectly on another project and destined for landfill.

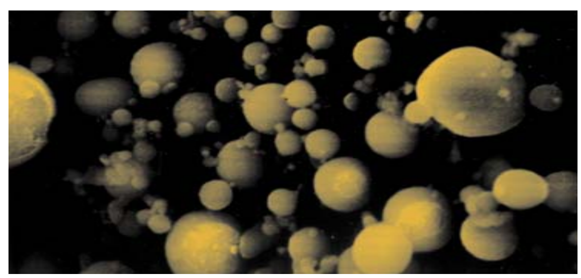
Salvaged Urban Logs
Fallen trees from urban areas and parks represent a rich, untapped resource for architectural use. A fallen Redwood tree was milled and finished to form four 2' x 8' conference room tables while a round cut from a Cypress tree serves as a coffee table in the lobby. More information on tree recycling is available at *www.recycletrees.org*, the website for the Tree Recycling Yard of the East Bay Conservation Corps, who supplied and milled the wood for the Global Ecology Research Center.

FSC Certified Ash
100% of wood used on the interior of the building is Forest Stewardship Council (FSC)-certified Ash or FSC-certified plywood with Ash veneer. Support of FSC-certified forestry is an important initiative that architects and building owners can take to protect habitat and encourage sustainable forestry practices. FSC-certifed wood is now widely available and cost-competitive with conventional wood products.



Embodied Carbon Emissions

Material	Quantity	Unit	Tons of CO^2 per Unit	Tons of CO^2 Emissions	Total	Total
Concrete (no flyash)	620	CY	0.282	186		62%
EcoSmart Concrete	620	CY	0.135	93	45%	
Structural Steel	81	tons	1.05	85	41%	28%
Reinforcing Steel	11	tons	1.05	12	6%	4%
Carpet	3	tons	3.10	9	4%	3%
Steel Studs	4	tons	1.05	4	2%	1%
Glass	2	tons	1.30	2	1%	1%
Gypsum Board	6	tons	0.20	1	1%	0.4%
Polystyrene	0.4	tons	2.10	1	0%	0.3%
Ceramic Tile	0.3	tons	1.40	0	0%	0.1%
Batt Insulation	0.4	tons	1.50	1	0%	0.2%
Acoustic Ceiling Tile	1	tons	0.20	0	0%	0.1%
Totals (no flyash)				**302**	100%	100%
Totals (Ecosmart)				**209**		



Recycled Aggregate
Recycled aggregate was to used to replace 25% of the aggregate used in site concrete. This is a little practiced but potentially important strategy to reduce mining of virgin aggregate and to divert construction waste form landfills. The resultant concrete performed identical to conventional concrete by all standards.

Natural Pavement
TerraPave natural pavement was used in place of concrete or asphalt for paths leading to and from the new courtyard. TerraPave is a natural tree resin system containing no petroleum-based additives.

High-Volume Fly Ash Concrete
Nearly all concrete used in the building and site contains 55% fly ash replacement for cement. Since cement production is generally estimated to contribute 8% of global carbon dioxide emissions annually, a 50% reduction in cement use can significantly improve the sustainability of a building project.

We calculated carbon emissions associated with electrical and gas use, and with the major materials used for construction. As expected, we found that energy use was the dominant factor affecting carbon emissions. However, as an extremely energy efficient building, the embodied emissions associated with materials became a more significant component. These are dominated by concrete, with structural steel and reinforcing steel also making significant contributions. Other materials, including finishes, were responsible for only a small percentage of carbon emissions. This suggests that designers should pay attention to structural materials and efficiency in addition to the current focus on interior finishes for green buildings.

We estimate that substituting 50% fly ash for cement reduced the carbon emissions associated with concrete from 186 tons to 93 tons, cutting embodied energy by one-third overall as compared to a conventional building.

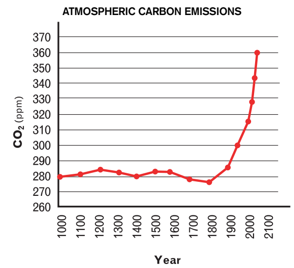
Energy

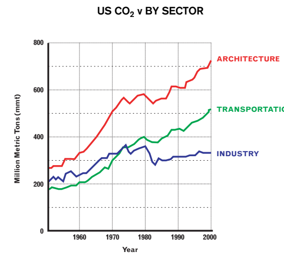
Center for Global Ecology
Carnegie Institution of Washington

Why

LOW ENERGY BUILDING?

The Mission of the Global Ecology Research Center is to conduct basic research on the interactions among the earth's ecosystems, land, atmosphere, and oceans. This research, including climate change issues, established the sustainable design goals, the foremost goal being to reduce carbon emissions.





How

LOW ENERGY BUILDING?

01 optimal design for daylighting and sunshading

Two major energy uses for buildings are electric lighting and cooling. Solar gain through windows is a major cooling load. In this long thin building with north and south windows, direct solar gain can be avoided through shading, while still admitting indirect daylighting.

A Heliodon simulates solar exposure and shading

Natural light reaches into a building double the window head height, so at 40' wide the entire building can be daylit. Super-efficient lighting includes occupancy sensors as well as photo-sensors that dim lights when there is adequate daylighting.

02 planning and programming

The Center's functions were zoned into separate categories requiring different levels of ventilation and cooling. Offices can be naturally ventilated, while lab functions require high levels of ventilation and cooling. Temperature sensitive lab equipment is located is separately controlled rooms. Some equipment and –80 freezers are located in the warehouse so the heat they generate doesn't require additional cooling in the labs.

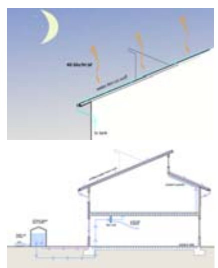
The lobby can be an unconditioned outdoor space much of the year, with a passive cool tower providing increased comfort on hot days.

03 cool tower

To improve comfort on hot days when the lobby is in "outdoor" mode, the cool tower captures breezes from above the roofline. The wind-catcher at the top of the tower catches breezes from any direction and directs them down to the lobby. Atomizing spray nozzles in the tower evaporatively cool the air, creating a thermally-driven downdraft in the absence of wind to carry cool air into the lobby area.

04 cooling

Chilled water for cooling is provided without air-conditioning compressors by using a "Night Sky" roof spray system. It creates a thin film of water on the roof at night using small sprinklers. The water is cooled primarily through radiation to the deep space cold night sky. The water is collected via the roof drainage system into a 12,000 gallon storage tank. Chilled water is supplied at 55 – 60° F using only 0.04 kW/ton and using half as much water as a conventional water-cooled chiller. An existing 20 ton air cooled chiller is used to provide additional cooling on the hottest days.

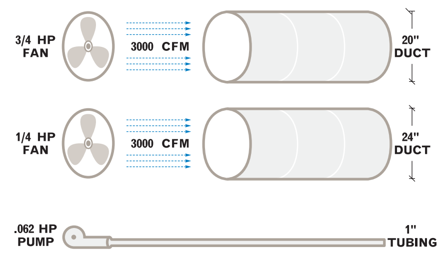


05 heating

Heating is supplied by a high efficiency condensing gas boiler at 110°F (instead of 180°F). The lower temperature allows the boiler to operate at 93% efficiency instead of a typical 80% efficiency.

06 heat recovery and nighttime setback

The chilled or heated water is pumped through polyethylene tubing in the radiant floor slabs and ceiling panels, and to the forced air system in the lab. Water holds 100 times as much heat as the same volume of air, so the ¾" diameter tubes require only 1/10 HP pumps to deliver as much heat as a 20" diameter duct using ¾ HP fans. Instead of using standard 20" diameter ducts for ventilation, the labs use larger 24" low-pressure drop duct design to lowers fan power from ¾ HP to ¼ HP for 3000 CFM.

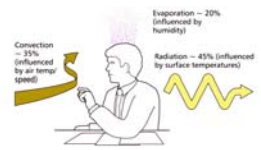


07 efficient delivery of cooling and heating

All air supplied to the labs is 100% outside air at the rate of six room air changes per hour. Most of the exhaust from this space is room exhaust (not fume hood exhaust), and is run through a heatpipe heat exchanger to preheat or precool the incoming outside air. Late at night, when the lab is unoccupied, the rate of outside air is reduced. This is also the peak heating time. Using this night setback and heat recovery allowed the boilers to be much smaller so small inexpensive condensing boilers could be used.

08 thermal comfort

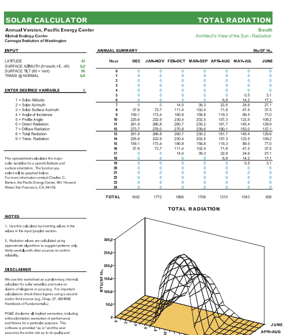
Radiant cooling works very well with the natural ventilation in the lobby and second floor spaces. Unlike conventional sealed air-conditioned offices that are comfortable only between 70° and 72°, radiant cooling affects building surface temperatures allowing a much broader range of air temperatures to be comfortable.

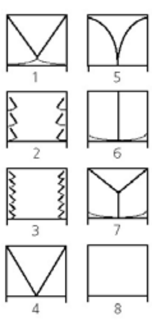


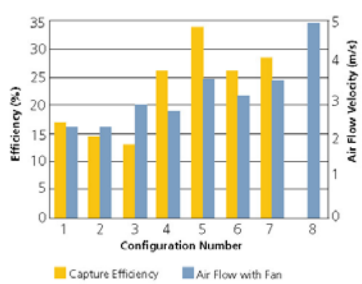
09 conference room

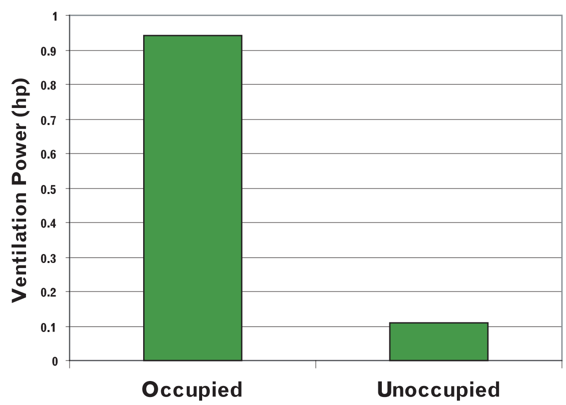
With quickly changing and potentially high occupancy loads, this is the most challenging space to keep comfortable without air-conditioning. Radiant cooling panels on the ceiling provide quick response and additional cooling when occupancies change. All glazing faces north and includes vertical sunshades to keep out 100% of late afternoon summer sun. High ceilings allow heat to stratify high above the occupants. Computational Fluid Dynamic modeling was used to verify airflow in the room.

Solar calculators determine sunshade sizes









Results

An integrated design process between all members of the design team and the client achieved a building with a predicted annual energy consumption of 57% of a standard design building (according to DOE2.1E simulation).

Energy Emissions

Base Case	Global Ecology
x 0.63 lbs CO_2/kW	x 0.63 lbs CO_2/kW
= 112,994 lbs CO_2/yr	= 49,022 lbs CO_2/yr
	= 57% reduction

Concrete Embodied Emissions

Base Case	Global Ecology
349,680 lbs CO_2	167,400 lbs CO_2
	= 52% reduction