RENEWABLE ENERGY

On-Site Renewable Energy in Green Buildings: Case Study Compendium

We have entered an era where human generated pressures on the natural world are unprecedented and threaten our current way of life[1]. Global climate change is considered the most serious among them facing the world today. Carbon dioxide, the primary greenhouse gas emitted by the burning of fossil fuels is the main cause of global warming. Buildings consume approximately 70 percent of the electricity produced in the US.[2] As a result, buildings, both commercial and residential, are responsible for approximately 48 percent of green house gas emissions in the U.S. The majority of those emissions, or 30 percent, come from burning fossil fuels to operate the buildings. The other 18 percent comes from manufacturing the materials to construct them as well as operations and long term maintenance.

The good news is that over 50 percent of our energy and half of our greenhouse gas emissions can be met by energy efficiency and renewable according to a study commissioned by the American Solar Energy Society (ASES) entitled *Tackling Climate Change in the US*[3]. The ASES findings are that "Of the total carbon reductions possible, 57percent are due to energy efficiency and 43 percent are from renewables". The US Green Building Council reports that effective integration of solar technology and design can reduce energy requirements by as much as 80 percent[4]. Mitigation should be viewed as an investment in our economy and in future generations.[5]

Therefore, architects, engineers, developers and owners can help make a significant difference by designing and constructing buildings that are highly energy efficient and that include on-site renewable energy as part of their integrated energy design. Purchasing energy from renewable sources will further reduce the building's carbon footprint. This case study compendium provides an array of examples of LEED [6] and non-LEED buildings in Wisconsin and the Midwest that have successfully integrated on-site renewable energy systems.

Additional Benefits to Increasing Renewable Energy in Buildings

- Diversify electric resource base
- Slow down depletion of natural gas
- Improve environmental performance
- Stabilize energy prices
- Reduce disruptions in power
- Generate energy in-state
- Improve self reliance
- Strengthen WI's rural economy

[1] World Wildlife Fund, *Living Planet Report*, 2006, "If we continue on our current trajectory, …by 2050 humanity will demand resources at double the rate at which the Earth can generate them." http://assets.panda.org/downloads/living_planet_report.pdf
[2] US DOE Buildings Energy Databook, 2003
[3] *Tackling Climate Change in the US*, www.ases.org , January 2007
[4] www.usgbc.org
[5] *Stern Review: The Economics of Climate Change* October 2006. Sir Nicholas Stern, the former chief economist of the World Bank, released a report warning that not fighting global warming now could bring on a worldwide depression, shrinking the global economy by 20 percent.
[6] U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ www.usgbc.org

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for Focus on Energy

March 2007

Focus on Energy works with eligible Wisconsin residents and businesses to install cost effective energy efficiency and renewable energy projects. Focus information, resources and financial incentives help to implement projects that otherwise would not get completed, or to complete projects sooner than scheduled. Its efforts help Wisconsin residents and businesses manage rising energy costs, promote in-state economic development, protect our environment and control the state's growing demand for electricity and natural gas. For more information call 800.762.7077 or visit focusonenergy.com.

Case Study: The Aldo Leopold Legacy Center

Zero net energy design, passive solar design, daylighting, earth tubes, solar photovoltaics (PV) and solar hot water
LEED NC 2.1 Registered

Building Name: Aldo Leopold Legacy Center
Building Location: 13701 Levee Rd, Baraboo, WI 53913 USA
Project Size: 12,000 SF
Building Type(s): Educational, classrooms, laboratory and workroom
Project Type: New Construction
Total Building Costs: $4 million
Owner: The Aldo Leopold Foundation
Building Architect/Project Team:
Architect: Kubala Washakto Architects
General Contractor: Boldt Construction
Project Contact: Aldo Leopold Foundation: 608-355-0279
Web site: http://www.aldoleopold.org/index.htm

Under construction in the Leopold Memorial Reserve, the new Aldo Leopold Legacy Center will serve as a tool of the foundation's mission of fostering land ethic nationally through educational outreach, land stewardship initiatives and research. The Leopold Legacy Center will serve as an extension of Leopold's philosophies in the 21st Century by serving as a model of ecological fitness.

The building has been designed to be energy neutral, with an expected energy load of six kWh/SF/year. Water conservation techniques, including waterless urinals, low-flow fixtures and composting toilets expect to reduce consumption by 65 percent. The project is currently LEED Registered with the US Green Building Council with a goal of a Platinum rating[1].

The building will use a unique earth tube HVAC system, consisting of 66 sections of 24" diameter pipe totaling 600 linear feet and covering just over 5,000 square feet, a third of it under the building itself. Once complete, it will be ten to twelve feet below the soil surface. This system is expected to be up to 80% more efficient than a conventional HVAC system. The peak heating and cooling load is expected to be 50 percent and 75 percent lower, respectively, than buildings insulated to code[2].

PHOTO COURTESY OF BOLDT CONSTRUCTION

Laying the Earth Tubes.

The building is expected to be completed April 22, Earth Day, 2007.

Green Building Approaches and Techniques[3]:

- Zero net energy design
- Photovoltaic system, expected to be the largest in Wisconsin once complete
- Passive solar design
- Solar hot water
- High-efficiency and natural lighting
- Earth tubes geothermal heating and cooling
- In-floor radiant heating
- On-site harvested lumber
- Recycled and rapidly renewable materials
- Rainwater harvesting, composting toilets
- Waterless urinals
- Low-flow fixtures
- Earth-coupled natural ventilation system
- Native landscaping

PHOTO COURTESY OF ALDO LEOPOLD FOUNDATION

Additional Information:

"Aldo Leopold Legacy Center Brochure", Kubala Washakto Architects
http://www.aldoleopold.org/Legacy%20Center%20Brochure.pdf

"Green Feature: Earth Tubes", Boldt Construction, July 2006.
http://www.aldoleopold.org/LandEthicCampaign/earth%20tubes.pdf

"Green Feature: Radiant Floor Heating", Boldt Construction, October 2006.
http://www.aldoleopold.org/LandEthicCampaign/radiant%20floor.pdf

[1] Aldo Leopold Foundation http://www.aldoleopold.org/index.htm
[2] "Green Feature: Earth Tubes", Boldt Construction, July 2006.
http://www.aldoleopold.org/LandEthicCampaign/earth%20tubes.pdf
[3] Kubala Washakto Architects http://www.aldoleopold.org/Legacy%20Center%20Brochure.pdf

Case Study: Mead Wildlife Center

Solar photovoltaics, solar hot water heating, wind, biomass, geothermal and daylighting
LEED NC 2.1 Registered

Building Name: Stanton W. Mead Education and Visitor Center
Building Location: S2148 County Highway S Milladore, WI 54454 USA
Project Size: 6,208 SF
Building Type(s): Commercial office, classroom
Project Type: New Construction
Total Building Costs: $1.5 Million
Owner: State of Wisconsin, Department of Natural Resources
Building Architect/Project Team:
Architect: Thomas Brown
Project Contact: Thomas Brown
Web site:
http://www.meadwildlife.org/sustainability.html

PHOTO COURTESY OF THOMAS BROWN ARCHITECTS

The Mead Wildlife Center, built for the Wisconsin Department of Natural Resources by Thomas Brown Architects, features five different renewable energy technologies: wind, solar photovoltaic, solar thermal, biomass and geothermal. The facility was originally intended as a headquarters office for a small DNR staff. However a local community group, Friends of the Mead McMillan Association Inc., raised private funds to add an education classroom component to the facility. In-kind donations of building materials and services were received in excess of $1.2 Million[1].

Renewable Energy Systems

Wind: The Mead facility has a "grid-tied" 10 kW Bergey XL wind turbine on a 120' free-standing tower, with an estimated annual energy output of 8,400 to 10,800 kWh/yr. It uses the utility grid as its "battery storage," purchasing energy when needed and selling electricity to the utility when the generated amount exceeds the building's needs.

PHOTO COURTESY OF THOMAS BROWN ARCHITECTS

Solar Electric: The Mead facility has a "grid-tied" 2.3 kW free-standing, pole-mounted, dual-axis tracking solar electric array, with 18 Kyocera KC125 125 watt panels. Its estimated annual energy output is 3,700 to 4,100 kWh/yr.

Solar Thermal: The Mead facility has a three-panel ground-mounted solar hot water collector array for domestic hot water, with a solar photovoltaic pump. It is self-regulating since the PV pump operates only when the sun is shining.

Bioenergy: The Mead facility has a Central Masonry Heater for radiant heating, with an hydronic heat exchanger for hot water radiant floor heating. The heated "bench" around the base is actually part of the chimney flue.

PHOTO COURTESY OF THOMAS BROWN ARCHITECTS

Ground-source Heating and Cooling: The Mead facility has eight closed-loop ground-source heat pumps for heating and cooling. There are four water-to-water units for the multi-zone in-slab hydronic-radiant floor heating system, with a 16 ton heating/cooling capacity rating. There are also four water-to-air units for the multi-zone ventilation and conditioned-air system, with a 13 ton heating/cooling capacity rating. Outside the building there are 32 exterior heat-exchange ground loops, each 600 feet long, buried 8 feet deep, in an area about the size of a football field.

PHOTO COURTESY OF THOMAS BROWN ARCHITECTS

Green Building Approaches and Techniques:

- Zero net energy goal, based on intermittent occupancy patterns
- Reduced energy load and renewable energy sources for heating & cooling
- High-performance building envelope
- Cool day-lighting and advanced lighting controls
- Cut-off exterior lighting fixtures to eliminate glare and light pollution
- High-performance mechanical systems
- Fundamental building commissioning for optimal system performance
- Reduced site disturbance at building, site access roads, parking and utilities to reduce erosion
- Panelized construction to reduce construction waste
- On-site construction waste management, with 95% recycled and diverted from landfill
- Operable windows for light, views and ventilation
- Physically-isolated and separately-ventilated janitor and copier rooms for indoor air quality
- Environmentally-responsible building materials and construction methods
- Water-conserving fixtures and landscaping

Renewable energy incentives received: [2]

Options Feasibility Study (Wisconsin Focus on Energy Pilot Program)	$11,000
Equipment Capital Cost-sharing Grant (Wisconsin Focus on Energy)	$50,000
Demonstration Grant (Wisconsin Focus on Energy)	$10,750
Total Renewable Energy Incentives:	**$71,750**

[1] Thomas Brown Architects http://www.tombrownarchitect.com/mead-case-study/mead-case-study.htm
[2] A Renewable Energy Cinderella Story: The Mead DNR Headquarters & Education Center. Thomas Brown Architects. http://www.uwsp.edu/cnr/gem/Conference%20Procceedings/Track4Papers/T-Brown-A-Renewable-Energy-Cinderella-Story-Mead-DNR%20_2_.pdf

Case Study: Schlitz Audubon Nature Center[1]

Solar photovoltaics, geothermal HVAC, natural ventilation and daylighting
LEED-NC 2.0 Gold

Building Name: Dorothy K. Vallier Environmental Learning Center
Building Location: 1111 E. Brown Deer Road, Milwaukee, WI
Project Size: 30,000 SF
Building Type(s): Education
Project Type: New Construction
Total Building Costs: $5.6 million
Owner: Schlitz Audubon Nature Center
Building Architect/Project Team:
Architect: Kubala Washatko Architects, Inc.
Contractor: Jansen Group
Engineering: Harwood Engineering
Project Contact: Kubala Washatko Architects, Inc; 262-377-6039
Website: http://www.schlitzaudubon center.com/

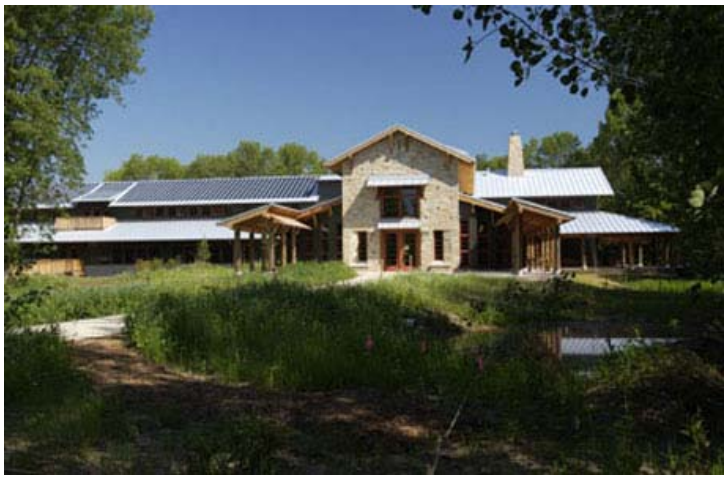

PHOTO COURTESY OF WE ENERGIES

The Dorothy K. Vallier Environmental Learning Center is located at the Schlitz Audubon Nature Center, a privately funded, 183 acre non-profit nature preserve dedicated to environmental education and land stewardship. Awarded LEED Gold certification, the Center provides space for classrooms, an auditorium, exhibits, a nature-focused preschool and a nature store.

The Schlitz Audubon Nature Center has a 10 kW photovoltaic solar power system, donated by We Energies. This system provides between 10 percent and 20 percent of the Center's electricity needs annually. A GeoExchange geothermal heat system that uses 90 groundwater wells provides heating and cooling for the Center.

Additional design techniques and green products and materials used include: thermal massing, roof overhangs, passive solar design, natural ventilation, low flow plumbing and waterless urinals, site harvested lumber, reused materials and low VOC finishes. Focus on Energy's New Construction Program awarded the Center with at $10,000 grant to study and incorporate these energy efficient features into its design.

PHOTO COURTESY OF WE ENERGIES

Additional Information:

New Facility Embodies Environmental Mission – Schlitz Audubon Nature Center Constructs Green Learning Center. *Wisconsin Focus on Energy Case Study*
http://www.focusonenergy.com/data/common/pageBuilderFiles/SchlitzAudubon%202619.pdf

Project Profile, Energy Center of Wisconsin
http://www.daylighting.org/pubs/profile_schlitzaudubon.pdf

Schlitz Audubon Nature Center Case Study, Johnson Controls
http://www.johnsoncontrols.com/CG-Cases/CSST-X05-002.pdf

Schlitz Audubon Nature Center Construction Waste Reduction and Recycling, WasteCap Wisconsin, Inc.
http://www.wastecapwi.org/casestudies/SchlitzWebFinalReport.pdf

Sustainability Fact Sheet, Schlitz Audubon Nature Center
http://www.schlitzauduboncenter.com/documents/New%20Building%20Kubala%20Sustainability%20fact%20sheet.pdf

[1] Schlitz Audubon Nature Center http://www.schlitzauduboncenter.com/

Case Study: Wisconsin Energy Conservation Corporation

Solar photovoltaics, solar hot water heating and daylighting
LEED 2.1 Registered

Building Name: Wisconsin Energy Conservation Corporation
Building Location: Madison WI
Project Size: 34,500 SF
Building Type(s): Commercial Office
Project Type: New Construction
Total Building Costs: $5.4 million
Owner: Wisconsin Energy Conservation Corporation; non-profit corporation
Building Architect/Project Team:
Architect: Eppstein Uhen Architects
Contractor: Vogel Brothers Building Co.
Commissioning: Sustainable Engineering
Solar: Seventh Generation Energy Systems
Project Contact: Cindy Moubry, cindym@weccusa.org
Website: www.weccusa.org

Wisconsin Energy Conservation Corporation (WECC) champions innovative energy initiatives that deliver short- and long-term economic and environmental benefits to consumers, businesses and policy makers. WECC is making a commitment to sustainable design and is striving for LEED Gold certification[1]. WECC's building will be a showcase for energy efficiency, affordability, renewable energy and sustainable design.

The 19 kW solar energy system is composed of four pole-mounted solar arrays and a large solar array on the roof of the two-story building. These were engineered and installed by Seventh Generation Energy partnering with Conergy. The Suntech panels are expected to supply 23,000 kWh per year, or 14% of the building's annual energy needs[2]. A solar water heating system, donated by Hot Water Products of Milwaukee and also installed by Seventh Generation Energy Systems, will provide approximately 40% of the building's domestic hot water needs.

Additional Information

Wisconsin Energy Conservation Corporation Building Fact Sheet
http://www.weccusa.org/pdfs/WECC_LRFinal.pdf

[1] WECC http://www.weccusa.org/about_WECC/ground_breaking.html
[2] Conergy http://www.conergy.us/Desktopdefault.aspx/tabid-519/820_read-5381/

Case Study: Center for Green Technology

Solar photovoltaics
LEED-Platinum

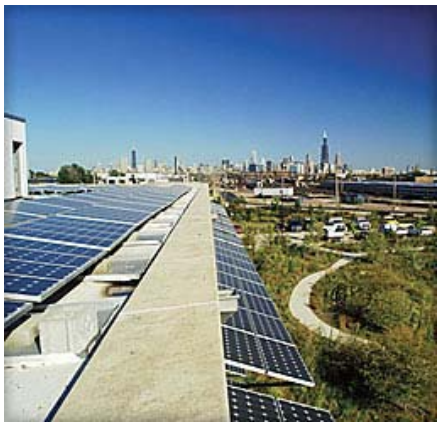

PHOTO COURTESY OF IBC ENGINEERING

Building Name: Center for Green Technology
Building Location: Chicago, IL
Project Size: 34,000 SF
Building Type(s): Office/Education
Project Type: Renovation, Remediation
Total Building Costs: $3 million
Owner: City of Chicago
Building Architect/Project Team:
Architect: Farr Associates
Project Contact: Center for Green Technology - 312-746-9642
Website: www.cityofchicago.org/Environment/GreenTech/

Originally constructed in 1953 and occupied by a number of different companies, the property was repossessed by the Chicago Department of the Environment (DOE) in 1995 due to illegal dumping of debris. It took 18 months and about nine million dollars to clean the site of over 600,000 tons of concrete, which took 45,000 truck loads to remove. After remediation was complete in 1999, the Chicago DOE took this opportunity to develop the property into the Center for Green Technology as an energy efficient building and example of sustainability technologies[1].

Chicago Green Tech features three arrays of photovoltaic panels:

- A Roof-mounted system (28.8 kW) covering 75 percent of the roof.
- Building-integrated photovoltaic system of south facing window awnings (10.8 kW)
- A solar berm and solar panels on top of parking structures at ground level behind the building (32.4 kW)

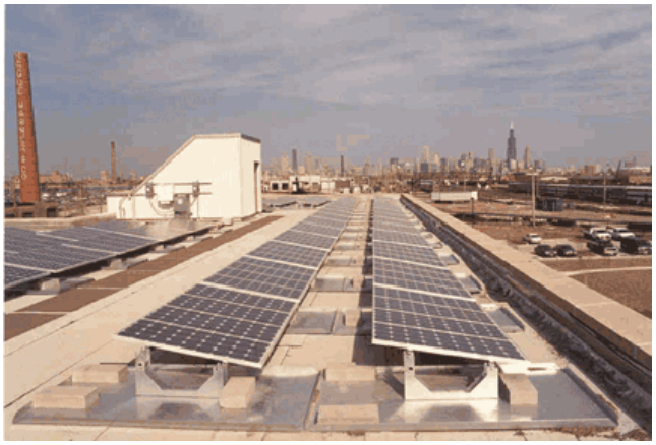

PHOTO COURTESY OF BROWN FIELD NEWS

Peak electric energy output from the panels is 71 kW. Solar energy is expected to satisfy up to 70 percent of the building's peak demand and up to 30 percent of annual energy consumption.[2]

System Details[3]

Roof (Phase 1)

Installation Date	2001
System Type	Ballast pan
Array Angle	Ten Degrees (horizontal)
System Size	28.8 Direct-Current kilowatts; 24.2 Alternating Current kilowatts
Module Type	Spire Solar 75 watts
Number of Modules	384
Average Annual Electrical Output	Approximately 32,000 Kilowatt-Hours

Window Awnings (Phase 1)

Installation Date	2001
System Type	Fixed angle
Array Angle	Second Floor at 30 degrees, First Floor at 20 degrees
System Size	10.8 Direct-Current kilowatts; 9.07 Alternating Current kilowatts
Module Type	BP Solar 75 watts
Number of Modules	144
Average Annual Electrical Output	Approximately 12,000 Kilowatt-Hours

Ground Mount System (Phase 2)

Installation Date	2002
System Type	Ground Mount
Array Angle	10 Degrees - sloped mounds
System Size	32.4 Direct-Current kilowatts; 27.2 Alternating Current kilowatts
Module Type	BP 2150S (150 watts each)
Number of Modules	216
Average Annual Electrical Output	36,628 Kilowatt-Hours

Shade Structure (Phase 3)

Installation Date	2003
System Type	Shade Structure
Array Angle	10 Degrees
System Size	43.2 Direct-Current kilowatts; 36.3 Alternating Current kilowatts
Module Type	Spire Solar SS75 (75 watts each)
Number of Modules	576
Average Annual Electrical Output	50,790 Kilowatt-Hours

Energy Audit[4]

Annual On-site Renewable Energy Production

Energy Source	Quantity	MMBtu	kBtu/ft2
Photovoltaics	136,000 kWh	464	11.6

Total Annual Building Energy Consumption

Energy Source	MMBtu	kBtu/ft2
Total Purchased	868	21.7
Total On-Site Renewable	464	11.6
Grand Total	1,332	33.3

Annual End-Use Breakdown

End Use	Quantity	MMBtu	kBtu/ft2
Heating	173 MMBtu	173	4.33
Cooling	95,900 kWh	327	8.18
Lighting	23,000 kWh	78.5	1.96
Fans/Pumps	106,000 kWh	362	9.04
Plug Loads and Equipment	41,400 kWh	141	3.53
Vertical Transport			
Domestic Hot Water	248 MMBtu	248	6.2
Other			

Additional Information:

Chicago Center for Green Technology – Landscape Design. WRD Environmental http://www.wrdenvironmental.com/projects/ccgt1.html

"The Chicago Center for Green Technology", University of California – Berkeley, Center of the Built Environment case study. http://www.cbe.berkeley.edu/mixedmode/ccgt.html

[1] City of Chicago www.cityofchicago.org/Environment/**Green**Tech/
[2] IBC Engineering Systems http://www.ibcengineering.com/features/ccgt/p2.html
[3] Chicago Solar Partnership http://www.chicagosolarpartnership.org
[4] US Department of Energy Building Technology Program, High Performance Buildings http://www.eere.energy.gov/buildings/database/energy.cfm?ProjectID=97

Case Study: Center for Neighborhood Technology

Solar photovoltaics
LEED 2.0 Platinum

Building Name: Center for Neighborhood Technology
Building Location: Chicago, IL
Project Size: 13,800 SF
Building Type(s): Commercial office, classroom
Project Type: Renovation
Total Building Costs: $993,600
Owner: Center for Neighborhood Technology
Building Architect/Project Team:
Architect: Johathan Boyer, AIA, Farr Associates
Contractor: Phoenix Builders
Commissioning: John Katrakis, J.T. Katrakis & Associates
Project Contact: Marjorie Isaacson, marjie@cnt.org
Website: www.cnt.org

The Center for Neighborhood Technology (CNT) has a unique mission: to invent and implement new tools and methods that create livable urban communities for everyone. CNT planned the green renovation as a model template and educational program to demonstrate to industry specialists, building professionals and the general public that green renovation can be achieved, economically, efficiently and without compromising aesthetics[1].

The building was a 13,800 square-foot abandoned light industrial building that dates back to the 1920s when it originally served as a textile factory. A 4.4 kW solar photovoltaic system was installed by Advanced Distributed Generation LLC.

Solar materials used:

- 40 – Shell SM110-24P - 110 watt modules
- Two – Sunny Boy 2500U - 2500 watt inverters
- One – Sunny Boy SBC485 - Communications/Control Module

Additional Information

"Case Study: Center for Neighborhood Technology", Whole Building Design Guide.
http://www.wbdg.org/references/cs_cnt.php

Center for Neighborhood Technology Virtual Tour
http://building.cnt.org/tour/site.php

Center for Neighborhood Technology – An Urban Green Renovation
http://building.cnt.org/about/tech-info

[1] Whole Building Design Guide http://www.wbdg.org/references/cs_cnt.php

Case Study: Bethel Commercial Center

Solar photovoltaics
LEED 2.0 Registered

Building Name: Bethel Commercial Center
Building Location: 4000 W. Lake, Chicago, IL
Project Size: 23,000 SF
Building Type(s): commercial, retail, restaurant, daycare
Project Type: New Construction
Total Building Costs: $4.5 million
Owner: Bethel New Life, non-profit corporation
Building Architect/Project Team:
Architect: Farr Associates
Contractor: Phoenix Builders
Project Contact: 773-473-7870
Website: http://www.bethelnewlife.org/default.asp

The Bethel Commercial Center is located on the corner of a rail stop and includes retail, community services and day care space. The center incorporates energy efficient systems and sustainable strategies, including a green roof and photovoltaic cells, and is designed to Gold LEED standards. The energy cost reduction is estimated to be 50 percent compared to average commercial buildings[1].

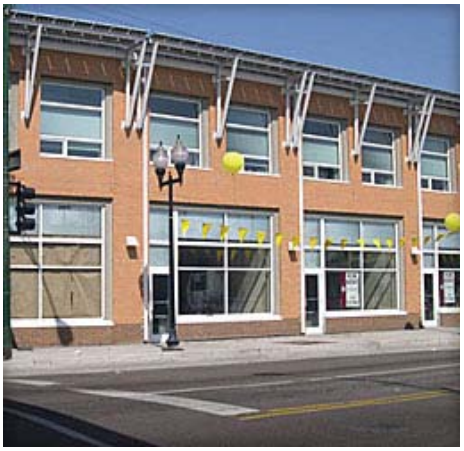

PHOTO COURTESY OF IBC ENGINEERING

The Bethel Commercial Center has two different solar photovoltaic arrays, each using a different technology. The first is a 25 kW roof tile system. The second is a 6.6 kW awning system manufactured by Spire. These two systems combine to provide approximately 11 percent of the building's power[2].

PHOTO COURTESY OF SPIRE CORPORATION

PHOTO COURTESY OF IBC ENGINEERING

System Details[3]

Roof

Installation Date	October 2004
System Type	Powerguard, Tiles
Array Angle	Nominal Zero Degrees
System Size	25 Direct-Current kilowatts; 21 Alternating Current kilowatts
Module Type	BP380 (80 watts each)
Number of Modules	308
Average Annual Electrical Output	see combined output below

Awnings

Installation Date	October 2004
System Type	BIPV (Building Integrated Photovoltaics)
Array Angle	Zero Degrees from horizontal
System Size	6.6 Direct-Current kilowatts; 5.8 Alternating Current kilowatts
Module Type	Spire Solar Custom SSC75 (75 watts each)
Number of Modules	88
Average Annual Electrical Output	32,484 Kilowatt-Hours (total system)

Additional Information:

"Bethel Center Case Study". Local Initiative Support Organization
http://www.lisc-chicago.org/documents/Bethel_Center.pdf

[1] IBC Engineering Services, Inc. http://www.ibcengineering.com/work/p3.html
[2] Spire Corporation http://www.spirecorp.com/spire-solar/downloads/case_studies/spire_case_study_bethel.pdf
[3] Chicago Solar Partnership http://www.chicagosolarpartnership.org

Case Study: Oberlin College Lewis Center for Environmental Studies

Passive solar design, solar photovoltaic,; geothermal heating & cooling and solar parking pavilion
LEED 2.1 Registered

Building Name: Adam Joseph Lewis Center for Environmental Studies
Building Location: 122 Elm St., Oberlin, OH
Project Size: 13,600 SF
Building Type(s): Higher Education, Laboratory
Project Type: New Construction
Total Building Costs: $6,405,000
Owner: Oberlin College
Building Architect/Project Team:
Architect: William McDonough + Partners
Lighting: Loisos + Ubbelohde
Project Contact: David Orr, 440-775-8312, David.Orr@oberlin.edu
Website: http://www.oberlin.edu/ajlc/ajlcHome.html

Completed in January 2000, the Lewis Joseph Center for Environmental Studies was one of the first in a new generation of green buildings in the United States. More than 4,600 SF of monocrystalline PV panels cover the south-facing roof of the Lewis Center and are connected to the Ohio power grid. When the PV panels produce more energy than is needed by the Lewis Center, excess power is sold to the local utility, supplanting some coal-fired power production[1]. When the Lewis Center demands more energy than the PV panels can supply the center purchases power from the utility.

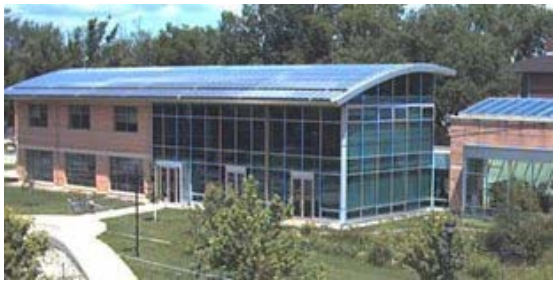

PHOTO COURTESY OF ROB WILLIAMSON, OBERLINE COLLEGE

PHOTO COURTESY OF ROB WILLIAMSON,

Although the rooftop system has a theoretical maximum output of 60 kW, realized peak has been around 45 kW. Between March 2001 and March 2002, the PV system produced 53 percent of the building's energy demands. The cost of the rooftop solar array was $402,500[1].

Additionally, a 100 kW Solar Parking Pavilion was completed in April 2006 covering the adjacent parking lot of the Adams Joseph Center. The pavilion's 8,800 square-foot roof will collect sunlight through 336 Shott 300 PV panels and an 85 kW Solectra Inverter**.** With the addition of this array, the combined two solar systems are estimated to provide 30 percent more energy than the building's needs[2]. The goal remains for the building to be a net energy exporter, creating more energy than it uses over the course of a year[1].

Energy production and consumption figures are updated on the Lewis Center's website in real-time.

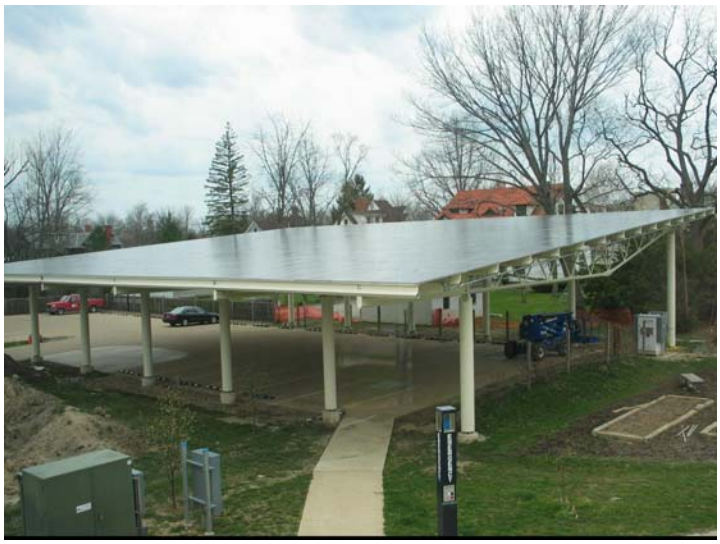

PHOTO COURTESY OF GREEN ENERGY OHIO

Closed-loop geothermal wells fulfill most heating and cooling demands in the Lewis Center. Supplementary radiant coils heat the atrium as needed.

Solar Parking Pavilion

Additional Information

"Adams Lewis Joseph Center for Environmental Studies Case Study". 2002. US DOE Energy Efficiency and Renewable Energy
http://www.eere.energy.gov/buildings/info/documents/pdfs/31516.pdf

"Adams Lewis Joseph Center for Environmental Studies: Learning about geothermal, biological waste treatment, PV, and more". Green Building BC
http://www.greenbuildingsbc.com/portals/0/docs/case_studies/Adam_Joseph.pdf

Pless, S., Torcellini, P., and Petersen, J. "Oberlin College Lewis Center for Environmental Studies: A Low-Energy Academic Building". 2004. US National Renewable Energy Laboratory http://www.nrel.gov/docs/fy04osti/36273.pdf

US DOE Energy Efficiency and Renewable Energy Buildings Database
http://www.eere.energy.gov/buildings/database/overview.cfm?ProjectID=18

[1] US Department of Energy Building Technology Program, High Performance Buildings http://www.eere.energy.gov/buildings/database/energy.cfm?ProjectID=18

[2] Green Energy Ohio http://www.greenenergyohio.org/page.cfm?pageID=968

Case Study: Michigan Alternative and Renewable Energy Technology Center

Solar photovoltaics, microturbine and fuel cell
LEED Gold

PHOTO COURTESY OF MAREC

Building Name: Michigan Alternative and Renewable Energy Technology Center
Building Location: 200 Viridian Drive, Muskegon, MI
Project Size: 26,000 SF
Building Type(s): Commercial office, Higher education, Laboratory
Project Type: New Construction
Total Building Costs: $4 million
Owner: Grand Valley State University
Building Architect/Project Team:
Architect: Integrated Architecture, Grand Rapids, Michigan
Project Contact: Imad Mahawili, mahawili@gvsu.edu
Website: http://www.gvsu.edu/marec/

The Michigan Alternative and Renewable Energy Center (MAREC) is the first fully integrated demonstration facility for distributed generation of electricity using alternative and renewable energy technologies in the United States. A part of Grand Valley State University, MAREC employs a 30 kW Capstone micro turbine that was installed in April 2005 by Unison Solutions of Dubuque, Iowa and purchased from Alliant Energy of Madison, Wisconsin. It has been integrated with MAREC's advanced electric generating technologies that include: a 250 kW molten carbonate fuel cell (Fuel Cell Energy), 30 kW of photovoltaic solar roof tiles (Unisolar) and a nickel metal hydride battery (COBASYS). A Kane heat exchanger was integrated for exhaust gas heat recovery. [1,2] Also housed in the MAREC building are three start-up companies focused on the development of advanced energy efficiency technologies.

PHOTO COURTESY OF MAREC

The four million dollar construction cost does not include the renewable energy technologies that have been integrated and operational for the past three years.

Additional Information

Dubbs, Dana. 2004. “Off the Grid: Michigan Alternative and Renewable Energy Center”. Steelcase
http://www.steelcase.com/na/files/2f4e3464f966433a9da3672889000d26/OffTheGridMichig.pdf

[1] Michigan Alternative and Renewable Energy Center http://www.gvsu.edu/marec/
[2] US Green Building Council http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=269

Case Study: S.T. Dana Building

Passive solar design and solar photovoltaics
LEED 2.0 Gold

Building Name: Samuel T. Dana Building
Building Location: 440 Church Street, Ann Arbor, MI 48109-1041
Project Size: 105,000 SF[1]
Building Type(s): Renovation, Historical Preservation
Project Type: Education, Office
Total Building Costs: $17.7 million[2]
Owner: University of Michigan
Building Architect/Project Team:
Architect: Quinn Evans Architects
Architect: William McDonough + Partners
Contractor: JM Olson Corporation
Engineer: Ove Arup & Partners
Project Contact: 734.764.6453, greendana@umich.edu
Website: http://www.snre.umich.edu/greendana/

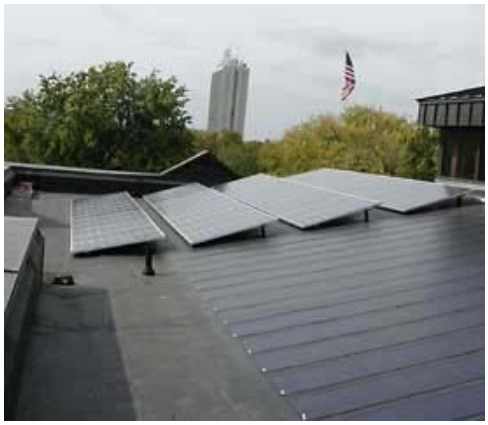

PHOTO COURTESY OF the University of Michigan

The S.T. Dana Building houses the School of Natural Resources and Environment (SNRE) of the University of Michigan in Ann Arbor. The renovation and addition created 20 percent more usable space internally without changing the external footprint of the 100-year old building. Originally built in 1903, the renovation was complete in October 2003.

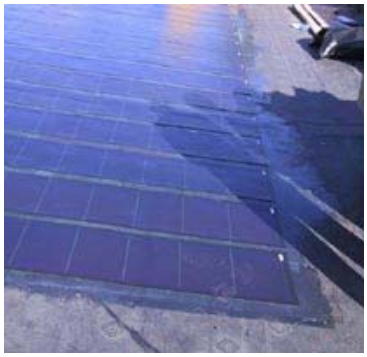

PHOTO COURTESY OF U of M

In addition to using passive solar design techniques including atrium skylights and shading, the S.T. Dana Building also has a 30 kW photovoltaic array consisting of Uni-Solar thin-film panels and Kyocera crystalline solar cells. The system cost $265,000 and is expected to produce three percent of the building's needs[3].

Additional Information

Gundala, Sharada. 2003. LEED Energy Perofrmance Modeling and Evaluation of the S.T. Dana Building Renovations. University of Michigan. Available at: http://css.snre.umich.edu/css_doc/CSS03-07.pdf

JM Olson Corporation Case Study
http://www.jmolson.com/greenbuildingexperience/dana.htm

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[1] Gundala, Sharada. 2003. LEED Energy Perofrmance Modeling and Evaluation of the S.T. Dana Building Renovations. University of Michigan. http://css.snre.umich.edu/css_doc/CSS03-07.pdf
[2] GreenBiz.com Case Study, http://www.greenbiz.com/sites/greenerbuildings/case_studies_detail.cfm?LinkAdvID=63857&print=true
[3] University of Michigan, http://snre.umich.edu/news/details.php?id=778

Case Study: Calvin College Bunker Interpretive Center

Passive solar design and solar photovoltaics
LEED-Gold

Building Name: Helen & Vincent Bunker Interpretive Center
Building Location: 1750 East Beltline Ave SE, Grand Rapids, Michigan
Project Size: 5,270 SF
Building Type(s): Education, classrooms, laboratory and office space
Project Type: New Construction
Total Building Costs: $2 million
Owner: Calvin College
Building Architect/Project Team:
Architect: Frank Gorman, College Architect, Calvin College
Contractor: Wolverine Building Group
Project Contact: Dr. Paulo Ribeiro, pribeiro@calvin.edu
Website: http://solar.calvin.edu/

Intended for students as well as for visitors to the college's 90-acre Ecosystem Preserve, the Bunker Interpretive Center has a classroom, a multipurpose room and a display hall. The Calvin College Bunker Interpretive Center has a 20 kW solar photovoltaic system installed in 2004. The PVL-128 amorphous modules manufactured by Uni-Solar can be directly adhered to the metal pans on the standing seam metal roof. This provides essentially a building integrated photovoltaic (BIPV) array, which would in itself enhance the educational value of the project. This would be accomplished by illustrating that photovoltaic arrays can be integrated into a building structure without detrimentally impacting the aesthetics of the building. This system provides approximately 60 percent of the electricity used by the building annually[1].

The building has composting toilets that are designed to use minimal amounts of water, and also recycles gray water from sinks. This recycled water is used to irrigate indoor plant beds[2].

Constructed above an old college landfill using low-impact building practices, the facility relies on natural light and natural ventilation predominately.

Additional Information

Case Study: Bunker Interpretive Center Calvin College. Clivus Multrum
http://www.clivusmultrum.com/GreenProjects_CalvinCollegeCaseStudy.pdf

[1] Calvin College http://solar.calvin.edu/
[2] Clivus Multrum, http://www.clivusmultrum.com/GreenProjects_CalvinCollegeCaseStudy.pdf

Case Study: Fond du Lac High School

Geothermal pond HVAC
Non- LEED

PHOTO COURTESY OF ALLIANT ENERGY

Building Name: Fond du Lac High School
Building Location: Fond du Lac, WI
Project Size: 402,989 SF
Building Type(s): Education; high school
Project Type: New Construction
Total Building Costs: $41.7 Million
Owner: Fond du Lac School District
Building Architect/Project Team:
Architect: Bray Associates Architects, Inc.
General Contractor: C. D. Smith Construction
Project Contact : Jim Gescheidle, Buildings & Grounds Supervisor, 920-929-2887

Fond Du Lac High School, completed in 2001 with a capacity for approximately 2,400 students, is heated and cooled using a geothermal pond system. This system is a 720-ton WaterFurnace, consisting of two 150-horse power pumps with variable speed drives, two six-acre ponds at 19-22 feet deep and 42 miles of installed loop. The delivery systems are 179 water-to-air heat pumps – one for each classroom – so teachers have direct control over the heating and cooling of their classrooms. There are also 15 water-to-water units for common areas, auditorium and field house. The Wisconsin Focus on Energy Pilot Program awarded the school a grant for engineering and economic analysis as well as assistance with pond loop design and installation.

The school saves an estimated $290,000 per year in avoided operating costs, a 40 percent reduction from standard construction. Cost savings are derived from a 20 percent reduction in energy use of a traditional chiller/boiler VAV system, reduction in peak demand charges and requirement of only four filter changes per year[1]. In addition, by reducing its use of coal-fired electricity for air conditioning and natural gas for heating, the school will reduce CO2 emissions by about 15 percent[2]. The space saved by smaller mechanical systems allowed for the addition of nine classrooms.

Four 1.9 million Btu high efficiency boilers back up the loop and the ventilation system during extreme weather conditions. The systems total cost was $5.2 million, or $12/SF. Of that, $465,000 ($665/ton) was for the pond-loop system.

Additional Information

Design 2003: A Lesson In Excellence. Fond du Lac High School Case Study, Bray Associated Architects. http://www.asbj.com/lbd/2003/projects/fond-du-lac.pdf

[1] Alliant Energy
http://www.alliantenergygeothermal.com/stellent2/groups/public/documents/pub/geo_act_sch_001349.hcsp
[2] Wisconsin Focus on Energy, Fond du Lac High School Case Study:
http://www.focusonenergy.com/data/common/dmsFiles/W_RW_MKCS_Fond%20du%20Lac%20High%20School%20installs%20a%20geothermal%20syst.pdf

Case Study: Mary Ann Cofrin Hall

Passive solar design, solar photovoltaics, building integrated photovoltaics and solar air heating (solarwall)
Non- LEED

Building Name: Mary Ann Cofrin Hall
Building Location: 2420 Nicolet Drive, Green Bay, WI 54311
Project Size: 69,150 nSF / 129,850 gSF
Building Type(s): Education, classrooms and offices
Project Type: New Construction
Total Building Costs: $20 million
Owner: State of Wisconsin – Department of Administration Facilities Services
Building Architect/Project Team:
Architect: Somerville Architects
Contractor: JC Basten Construction
Design: HOK Architects, St. Louis Division
Project Contact: Joe Sokal, Wisconsin Department of Administration, 608-266-2608

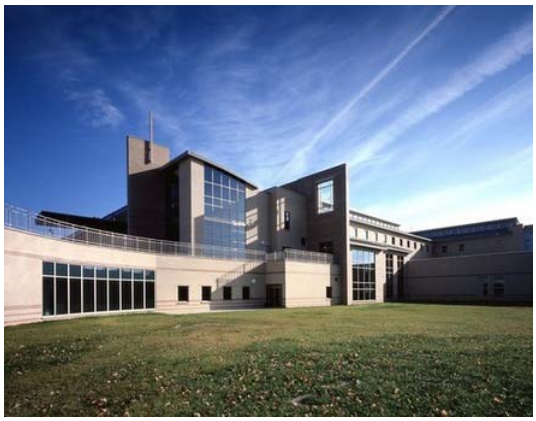


PHOTO COURTESY OF WISCONSIN PUBLIC SERVICE

The two-story academic building at the University of Wisconsin-Green Bay completed in 2001 serves as a campus center housing 20 classrooms, representing about half of all classroom space on campus.

PHOTO COURTESY OF wps

The building design incorporates two types of building-integrated photovoltaic systems designed by Massachusetts-based Solar Design Associates. The total cost of the solar photovoltaic systems totaled $268,029 (see BIPV Project Breakdown).

One system comprises thin-film technology integrated with the standing-seam metal roof that makes up the building's major roofing system. Standing Seam Metal (SSM) roofing is a traditional roofing material that uses long, vertically sloped metal trays with raised edges. The trays are snapped together along the long axis to build the roof. Thin-film, amorphous-silicon, triple-junction photovoltaic (PV) modules can be glued or laminated to the tray surface. The material, manufactured by United Solar Systems Corporation, produces electricity as well as performs its traditional weather-sealing function. The building has 100 of the 128 watt laminated modules (model SSR-120) spanning 2,300 square feet, and generating approximately 15,000 kWh annually.

The second type is a translucent film-on-glass panel called vision glass. The vision glass product is the first installation of its kind in the United States. A total of 252 modules were installed. Each vision glass surface has 13 layers of thin film, altogether thinner than one piece of paper, sandwiched between two protective layers of glass. This four kW system spans 2,000 square feet and generates about 5,000 kWh annually[1].

In addition to active solar, Mary Ann Cofrin Hall also has a 2,256 square-foot passive SolarWall. This unglazed porous collector absorbs the sun's energy and uses it to heat the air that is pulled through the collector surface and into the air distribution path connected to the mechanical system of the building. This project was funded in part by the Wisconsin Focus on Energy Pilot Program and Wisconsin Public Service.

PHOTO COURTESY OF wps

PV Performance Data, 2005[2]

	PV (kWh)	Bldg (kWh)	Bldg Total (kWh)	Month Max	Month Average	Dollar Savings
January	787.1	135,578.7	136,365.8	5.91%	0.58%	$38.42
February	1,116.0	135,481.5	136,597.5	5.97%	0.82%	$54.48
March	1,903.8	137,686.5	139,590.3	6.78%	1.36%	$92.93
April	2,054.7	115,837.2	117,891.9	10.08%	1.74%	$100.30
May	2,049.9	118,950.7	121,000.5	10.58%	1.69%	$100.07
June	2,180.2	114,748.3	116,928.5	7.01%	1.86%	$106.43
July	2,287.7	124,130.8	126,418.5	7.96%	1.81%	$111.68
August	2,183.2	121,494.3	123,677.5	7.26%	1.77%	$106.58
September	1,877.7	120,385.4	122,263.1	8.13%	1.54%	$91.66
October	1,455.4	124,186.9	125,642.3	7.99%	1.16%	$71.04
November	716.6	115,350.7	116,067.3	5.33%	0.62%	$34.98
December	567.0	108,912.3	109,479.3	5.74%	0.52%	$27.68
	19,179.31	1,472,743.3	1,491,922.61	10.58%	1.29%	$936.25

Additional Information

"Learning from the sun: UW – Green Bay goes solar". Wisconsin Focus on Energy Case Study
http://www.focusonenergy.com/data/common/dmsFiles/W_RS_MKCS_UW%20Green%20Bay%20case%20study.pdf

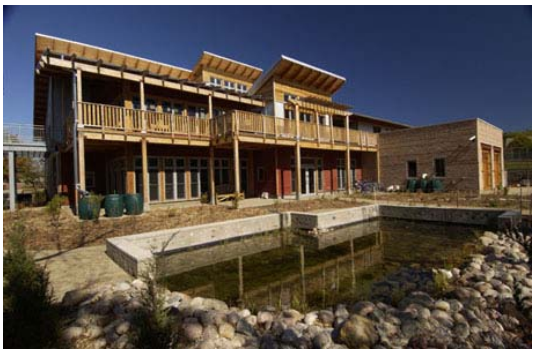
Mary Ann Cofrin Hall Project Case Study, Wisconsin Public Service
http://www.buildingsolar.com/design.asp

BIPV Project Breakdown[3]	Cost Estimate	% of Total
Photovoltaic Modules *(Includes $57,753.70 for Standing Seam Metal roofing and $50,929.30 for vision glass)*	$108,683.00	40%
Inverters *(Includes $16,669.00 for Standing Seam Metal roofing and $14,773.00 for vision glass)*	$31,442.00	12%
Electricians & Installers *(Includes $6,328.34 for Standing Seam Metal roofing and $5,580.56 for vision glass)*	$11,909.00	4%
Miscellaneous *(Includes $860.32 for Standing Seam Metal roofing and $758.68 for vision glass)*	$1,619.00	1%
Subtotal - BIPV Equipment and Installation	**$153,653.00**	**57%**
BIPV Consultant	$15,536.00	6%
BIPV Net Cost Study	$21,000.00	8%
Data Acquisition System	$9,712.00	4%
Education and Outreach Activities *(Includes two BIPV training sessions, estimated at $2,490 each)*	$33,128.00	12%
Internet Site Development *(Includes estimated 430 hours of development time and labor costs)*	$25,000.00	9%
TOTAL	**$268,029.00**	**100%**

[1] Wisconsin Public Service http://www.buildingsolar.com/design.asp
[2] Information source: Jeff DeLaune, Wisconsin Public Service
[3] Wisconsin Public Service http://www.buildingsolar.com/budget.asp

Case Study: Urban Ecology Center

Passive solar design, solar photovoltaics and daylighting
Non- LEED



Building Name: Urban Ecology Center
Building Location: Riverside Park, 1500 E. Park Place, Milwaukee, WI 53211
Project Size: 20,000 SF
Building Type(s): classrooms, offices, exhibit, meeting, and lab spaces.
Project Type: New Construction
Total Building Costs: $3.3 million[1]
Owner: Urban Ecology Center, non-profit community center
Building Architect/Project Team:
Architect: Kubala Washatko Architects Inc.
Contractor: Jansen Group Inc.
Project Contact:
UEC: Ken Leinbach, kleinbach@urbanecologycenter.org
We Energies: Carl Siegrist, Carl.Siegrist@we-energies.com
Website: http://www.urbanecologycenter.org/

The Urban Ecology Center, completed in July 2004, was built to display green building techniques and technology, as well as to reflect the center's commitment to the environment. This educational facility's features include: Library of Sustainability, rainwater collection, gray water flushing toilets, solar photovoltaics, passive solar design, advanced daylighting and a roof garden.

The Urban Ecology Center's 44.4 kilowatt solar photovoltaic system, added in 2007, is the largest in the state of Wisconsin at the time of installation. It is comprised of 256 Kyocera solar panels and it is expected to produce over 55,000 kilowatt-hours a year, or 40 percent of the Center's annual energy total use of 140,000 kWh. The system is complete with 16 SMA Sunny Boy 2500U inverters and a Unirac Solar mount structure attached to the standing seam roof.

PHOTO COURTESY OF SOLARBUZZ.COM

Additional Information

Leinbach, Ken and Judy Krause. "Solar PV Experience at the Urban Ecology Center" Wisconsin Solar Decade Conference, November 30, 2006.
www.solardecade.com/system/files/u3/l_Solar_Electric_Case_Study_Urban_Eco_Center.pdf

[1] Wisconsin Builder http://www.wibuilder.com/tp-2004/shades-of-green.html

Case Study: ERSystems

Solar photovoltaics and wind
Non- LEED

Building Name:
Building Location: Rockford, Minn.
Project Size: 48,000 SF
Building Type(s): Commercial office, manufacturing plant, test facility
Project Type: New Construction
Total Building Costs: $2.4 Million
Owner: TTJK, LLC
Building Architect/Project Team:
Architect: Jed Larson
Contractor: Kraus-Anderson Construction
Solar Systems: Conservation Technologies
Project Contact: Tim Leonard tim@ersystems.com
Website: www.ersystems.com/

PHOTO COURTESY OF GREENROOFS.COM

Elastomeric Roofing Systems, Inc (ERSystems) is a national leader in cool roofing technology and a strong supporter of sustainable and renewable building technologies. ERSystmes shares this manufacturing and office facility with is sister company, Prairie Technologies. The corporate headquarters building and site were designed to meet the needs of a functioning, fast-growing corporation while mitigating the environmental effects. ERSystems' manufacturing facility showcases technologies that reduce urban heat island impacts, conserve water, reduce stormwater runoff, and generate renewable energy. The rooftop doubles as a test lab for experiments with green roof plant spacing and various elastomeric coatings. Rooftop instrumentation logs surface and HVAC air intake temperatures, with data monitoring via the internet[1].

ERSystems facility not only includes a 5000 square-foot extensive green roof[2], but also a 4.9 kW net-metered photovoltaic array which generates about 5,800 kWh/yr. Additionally, six small-scale wind turbines totaling 2.4 kW on rooftop are used to charge an uninterruptible power supply unit (UPS).

Other green building materials and technologies used include: over 15,000 pervious paving (InVisible Structures), three bioswales, native landscaping, rainwater collection, low-flow plumbing, high efficiency HVAC systems, third-party energy commissioning, purchase of renewable energy certificates, zero-VOC paints, low-emitting carpet and adhesives and wheat board chair rails.

In February 2005, the building was awarded the "2005 Excellence in Design Award" by the National Roofing Contractors Association for its innovative roof design. The building has also received the ENERGY STAR® label for buildings based on the guidelines provided by the U.S. EPA and DOE.

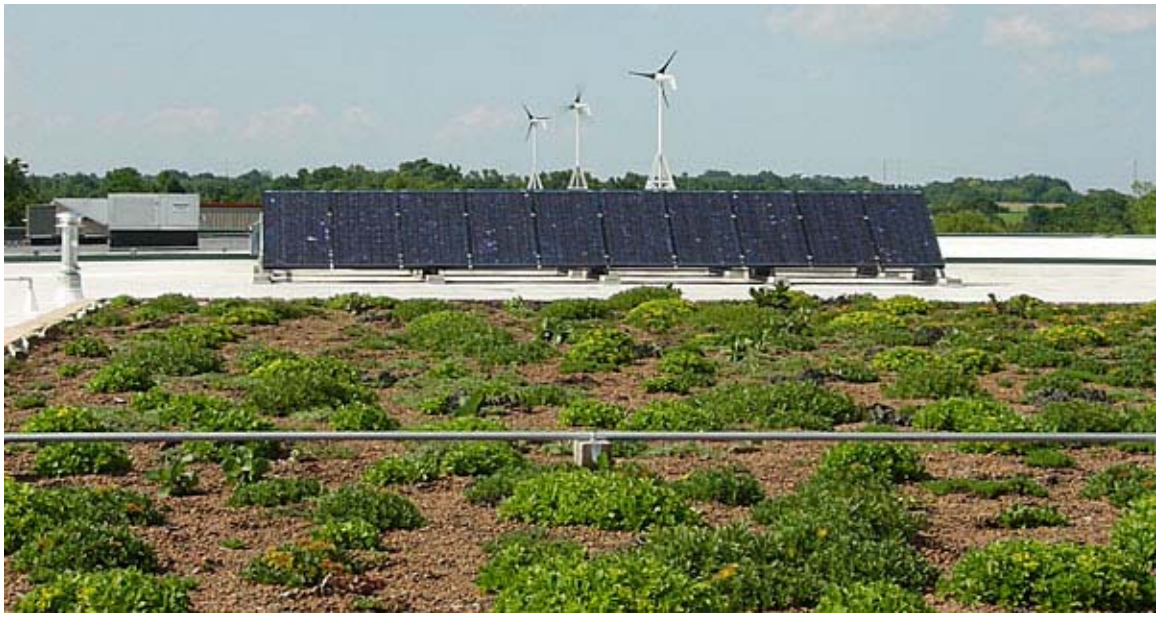


PHOTO COURTESY OF GREENROOFS.COM

Additional Information

ERSystems and Prairie Technologies Corporate HQ Case Study. GreenRoofs.com
http://www.greenroofs.com/projects/pview.php?id=291

Leonard, Tim and Tony Leonard. “A roof system on a Minnesota building demonstrates energy-saving technology” Professional Roofing Magazine, April 2006.
http://www.professionalroofing.net/article.aspx?A_ID=835

Praire Technologies – Interactive building tour
http://www.prairie-tech.com/

[1] Minnesota Office of Environmental Assistance
http://www.pca.state.mn.us/oea/greenbuilding/examples-mn.cfm
[2] GreenRoofs.com http://www.greenroofs.com/projects/pview.php?id=291

Case Study: Science House at the Science Museum of Minnesota

Passive solar design, zero-energy design, solar photovoltaics and geothermal
Non- LEED

Building Name: Science House
Building Location: 120 West Kellogg Boulevard, St. Paul, MN
Project Size: 1,530 SF
Building Type(s): Education; classroom, laboratory
Project Type: New Construction
Total Building Costs: $650,000
Owner: Science Museum of Minnesota
Building Architect/Project Team:
Architect: The Weidt Group
Solar Consultant: Innovative Power Systems
Interior Design: Barbour LaDouceur Design Group
Project Contact: Pat Hamilton, 651-221-9444
Website: http://www.smm.org/sciencehouse/

Located at the Science Museum of Minnesota's outdoor science park, Science House serves as a public environmental experiment facility, classroom, and special event space. Science House was designed to be a zero-energy building; with a energy load that is 60 percent below code, and operating a 8.8 kW photovoltaic system, the building produces more energy than it consumes on an annual basis[31].

PHOTO COURTESY OF CLEAN ENERGY RESOURCE TEAMS

The Science House also uses a solar-electric powered geothermal heat pump consisting of four 250-feet-deep wells. Combined with passive solar design, all heating and cooling needs are derived from renewable sources.

Energy Audit[1]

Energy Source	Quantity	MMBtu	kBtu/ft2
Photovoltaics	7,900 kWh	26.9	17.6

PHOTO COURTESY OF CLEAN ENERGY RESOURCE TEAMS – www.cleanenergyresourceteams.org/

Additional Information

Case Study: Science Museum Renewable Energy Project. 2004. Clean Energy Resource Teams – Minnesota
http://www.cleanenergyresourceteams.org/metro/CS-Science%20Museum.pdf

Science House. Xcel Energy Case Study
http://www.xcelenergy.com/docs/corpcomm/RDFCyc1-MNSciMusHse2004FinRpt.pdf

Science House at the Science Museum of Minnesota – Case Study. US Department of Energy, Energy Efficiency and Renewable Energy Buildings Database
http://www.eere.energy.gov/buildings/database/overview.cfm?ProjectID=284

[1] US Department of Energy Building Technology Program, High Performance Buildings
http://www.eere.energy.gov/buildings/database/overview.cfm?projectid=284