Science House

A project by the Science Museum of Minnesota and the Xcel Energy Renewable Development Fund for the development and interpretation of new renewable energy.

Project Date

2/1/2002 – 12/31/2003

Total Project Costs

$981,247

Funded in part by a $100,000 Xcel Energy Renewable Development Fund Grant

Project Size

8.8 kW

PROJECT SUMMARY

The Science Museum of Minnesota's 1,476 square-foot Science House includes a solar photovoltaic roof designed and installed with the support of Xcel Energy's Renewable Development Fund (RDF). The Museum has accomplished what it set out to do with the RDF- grant and funds provided by other Science House project supporters. Below are the key goals set out for Science House in Exhibit A of the Museum's RDF contract and which were identified in the original grant proposal of August 20, 2001:

- **Net Energy Producer –** Science House has 8.8 kW of installed photovoltaic capacity rather than the 7.8 kW proposed in the Museum's original RDF proposal. It also has the wiring and inverter capacity to accommodate an additional 0.9 kW of solar laminate on the tower roof of the building. It is tied into the Museum's electrical service and the photovoltaic system has been reviewed and approved both by the St. Paul electrical inspector and Xcel Energy (Shawn Bagley, area engineer).

- **Non-Combustion Power Generation** – The ground-source heating and cooling wells and heat pump are installed and operational along with the heat-recovery ventilation.

- **Low Embodied Energy –** The lumber (structural, plywood, and interior trim) used in the construction of Science House was all FSC certified. Science House was insulated with a relatively new insulation system.

  Icynene is a soft, spray foam, low-density polyurethane that has a very high expansion rate. Installation involves spraying a thin liquid layer in wall and ceiling cavities. Within seconds, the foam expands to fully occupy the space. Icynene neither contains nor generates any ozone-depleting chemicals. Water serves as the foaming agent, reacting with the other components in the liquid to generate carbon dioxide, which expands the foam.

  Icynene is very effective at sealing air leaks in buildings. It adheres extremely well to most surfaces, and because the foam remains flexible, it expands and contracts with seasonal movement of a building to remain airtight.

- **On-line Design –** The museum established and periodical updates a website where people can follow the construction of Science House. A number of local and regional organizations provided links from their sites to the museum's SCIENCE HOUSE website (www.smm.org/Science House/).

The $100,000 in RDF support provided by Xcel Energy supported the efforts of numerous parties to accomplish the key goal of providing Science House with a solar photovoltaic roof. The largest share, $54,962, covered the work of Innovative Power Systems (IPS). IPS was the photovoltaic installer that performed the preliminary design work for the roof and provided system parameters to the architects and building energy modelers. IPS also

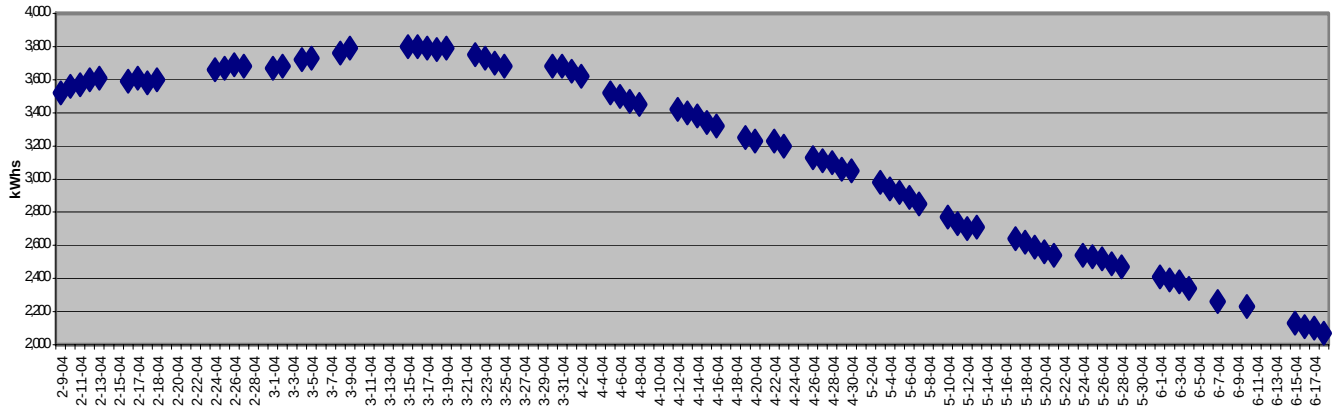
ordered and installed all the PV material and related supplies and roofing subcontractors. The remaining $44,962 was used to support the efforts of the following parties:

- The Weidt Group – The firm that performed the energy modeling calculations on the anticipated PV roof power production and building energy loads in order to provide recommendations to the architects on how to design the building to maximize the potential for energy production and consumption to balance out on an annual basis.
- Barbour & LaDouceur – The architects of record who incorporated the requirements of the PV system into the overall design of Science House and who prepared the construction documents which included the PV-integrated roof system.
- LS Black Constructions – The general contractor for Science House that coordinated all of the trades involved in the construction of the building, including the electrical and roofing subcontractors.
- Peoples Electric – The electrical subcontractor to Science House that served as the licensed electrician on the installation of the PV-integrated roof for the building.
- Progressive Building Systems – The roofing and siding subcontractor that installed all exterior surfaces on Science House and coordinated its work closely with IPS on the installation of the PV-integrated roof and all fascia and soffit details necessary for the electrical runs for the PV system.
- Sterns & Associates – The Science Museum's owner's representative that represented the museum on all questions and issues concerning the construction of Science House in general and the solar photovoltaic roof in particular.

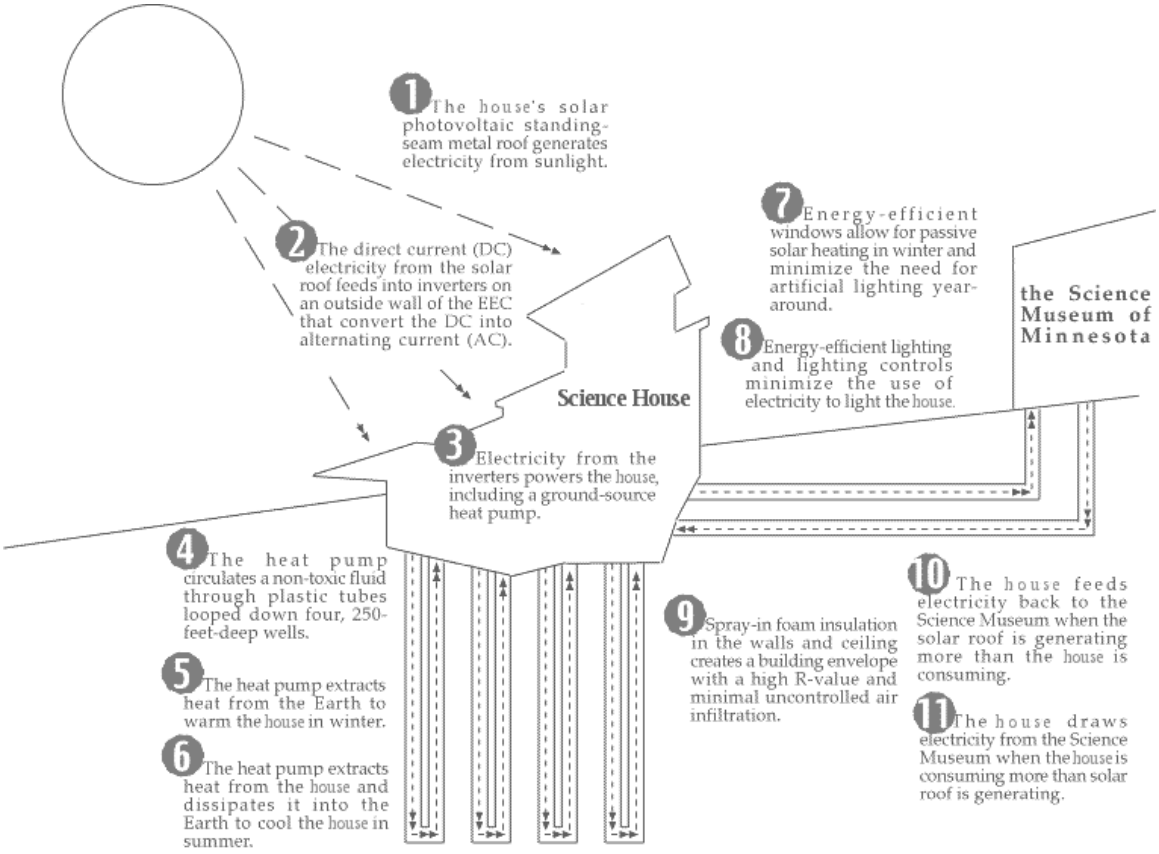
The Installation of the solar photovoltaic roof on Science House and its integration with the buildings electrical and mechanical components was a complex undertaking. The team of companies and individuals listed above, however, rose to the task and worked well together to accomplish the project on time and with the financial resources available. Science House serves as an innovative learning center in a highly visible and accessible public setting. It is a major component of the Science Museums outdoor science park, ***The Big Back Yard***.

ELECTRICAL PRODUCTION

The following diagram charts Science House electric meter readings from 2/9/2004 through 6/18/2004.



HOW THE SCIENCE HOUSE WORKS



Buildings account for about 35 percent of all energy consumption in the world. By bringing together energy efficiency and renewable energy technologies, Science House will test the idea that even in Minnesota's climate, houses can be constructed to generate much, if not all, of their annual energy needs. Here is how Science House works:

1. Science House's solar photovoltaic standing-seam metal roof generates electricity from sunlight.
2. The direct current (DC) electricity from the solar roof feeds into inverters on an outside wall of Science House that convert the DC into alternating current (AC).
3. Electricity from the inverters powers the Science House, including a ground-source heat pump.
4. The heat pump circulates a non-toxic fluid through plastic tubes looped down four, 250-feet-deep wells.
5. The heat pump extracts heat from the Earth to warm Science House in winter.
6. The heat pump extracts heat from Science House and dissipates it into the Earth to cool Science House in summer.
7. Energy-efficient windows allow for passive solar heating in winter and minimize the need for artificial lighting year-round.

8. Energy-efficient lighting and lighting controls minimize the use of electricity to light Science House.
9. Spray-in foam insulation in the walls and ceiling creates a building envelope with a high R-value and minimal uncontrolled air infiltration.
10. Science House feeds electricity back to the Science Museum when the solar roof is generating more than Science House is consuming.
11. Science House draws electricity from the Science Museum when Science House is consuming more than the solar roof is generating.
12. The goal is that Science House produces as much energy as it consumes on an annual basis.

THE SCIENCE HOUSE

This four-season, 1,476 square-foot building located in the Science Museum of Minnesota's 1.75-acre outdoor science park, The Big Back Yard, operates as a public laboratory, classroom, exhibit area, or a special events space depending on the need at any given time. Science House is both a versatile program space and an environmental experiment. It is designed to operate as a zero-emissions building (ZEB). ZEBs produce all of their energy needs on an annual basis.

The Museum intends that Science House contribute to the civic conversation about how buildings can advance both in the benefits provided to their inhabitants and to the Earth's environment. Renewable energy is no longer a future possibility. By bringing together energy efficiency and renewable energy technologies, Science House tests the idea that even in Minnesota's climate houses can be constructed to supply much of their annual energy needs.

To accomplish the goal of being a ZEB, Science House has a solar photovoltaic standing-seam metal roof that generates electricity from sunlight. A solar photovoltaic laminate is adhered to the metal trays of the building's standing seam metal roof. Electricity generated by the solar roof is used by a ground-source heat pump that, through four, 250-feet-deep wells, uses the thermal energy present in the Earth to heat and cool the building. Science House feeds current back to the Museum when it is generating more electricity than it is using and draws from the Museum when it is consuming more electricity than it is generating.

A key tactic for achieving Science House's zero-emissions goal is maximum energy efficiency. Energy-efficient windows and doors, wall insulation, and appliances are combined with passive solar heating and careful lighting design. The strategies for making Science House a zero-emissions building were developed and computational modeled by the Weidt Group in Minnetonka. Recommendations regarding the building's orientation, size and volume, fenestration, roof area, and mechanical and electrical systems then were provided to Barbour & LaDouceur Architects in Minneapolis for development into a master architectural design.

Although much attention is focused on Science House's energy features, the building includes other environmental attributes such as Forest Stewardship Council-certified lumber, low-VOC paint, and water-conserving fixtures.

The Science Museum of Minnesota gratefully acknowledges the following for their support of Science House:

Supporters who provided general funding to Science House:

- Mississippi National River and Recreation Area, National Park Service
- State of Minnesota as recommended by the Legislative Commission on Minnesota Resources (new text - Funding from the Environment and Natural Resources Trust Fund through the Legislative Commission on Minnesota Resources)
- Andersen Foundation
- Aveda Corporation
- Alida R. Messinger
- Bayport Foundation

Supporters who provided targeted funding to Science House:

- Xcel Energy Renewable Development Fund – Photovoltaic-integrated standing seam metal roof
- State Energy Program grant from the U. S. Department of Energy and the Minnesota Department of Commerce – Energy efficiency
- Andersen Corporation – Installation of Fibrex(tm) ceiling finish inside Science House
- Barbour/LaDouceur Design Group, LLC - Installation of posts and cables inside Science House
- Twin Cities Habitat for Humanity - Building design and construction consulting services
- Vandervoort Public Affairs - Project and environmental consulting services
- Certified Wood, Inc. - Forest Stewardship Council-certified lumber discount
- L S Black Constructors - Forest Stewardship Council-certified lumber discount

Contributions of goods and services to Science House:

- Andersen Corporation– Windows, doors, Fibrex^{tm} material for the exterior deck and interior ceiling
- The Weidt Group– Building energy modeling design and consulting services
- National Renewable Energy Laboratory, U. S. Department of Energy – Energy monitoring system (hot link to http://www.nrel.gov/)
- Icynene, Inc.– Icynene insulation material
- Barbour/LaDouceur Design Group, LLC– Interior design work
- Mannington Commercial – Recycled content flooring (hot link to http://www.mannington.com/)
- Vandervoort Public Affairs – Project and environmental consulting services
- Cemstone Products Company– Concrete discount
- Certified Wood, Inc.. – Forest Stewardship Council-certified lumber discount
- L S Black Constructors – Forest Stewardship Council-certified lumber discount
- Twin Cities Habitat for Humanity– Building design and construction consulting services
- Minnesotans for an Energy-Efficient Economy – Compact-fluorescent light bulbs (hot link to http://www.me3.org/)

Citizen funders of Science House:

Ruth Agar
Bonnie Beckel and Joseph Hesla
Melissa Brown
Russ W. Fischer
Ralph Jacobson
Vernon Arnold, Jr.
Ellen Brooks and Dave Hackett
Dr. Susan L. Clarke
Heather and Jeffrey Ilse
Tom and Stephanie Koehler

Warren and Marion Lang
Deborah Pullin and Robert Spottswood
Marvin Rothfusz
David and Linda Therkelsen
Rosalie E. Wahl
Fremont A. Williams
Alice and David Langworthy
Louise Quinn
David Stevens and Elizabeth Borg
Richard and Marian Vandellen
Timothy and Carol Wahl
Frank and Raquel Wood

Further support and in-kind donations has been provided by:

- Andersen Corporation – Windows, doors, and Fibrex^{tm} material for the deck and ceiling
- The Weidt Group – Building energy modeling design and consulting services
- Mannington Commercial – Flooring
- Twin Cities Habitat for Humanity – Building design and construction consulting services
- Vandervoort Public Affairs - Project and environmental consulting services
- Icynene, Inc. – Icynene insulation material
- Cemstone Products Company – Concrete discount
- Certified Wood Products, Inc. – Forest Stewardship Council-certified lumber discount
- L S Black Constructors – Forest Stewardship Council-certified lumber discount

Beyond Science House, the Science Museum will invest $1.6 million over the next nine months to transform The Big Backyard into an outstanding outdoor education experience. Through a partnership with the University of Minnesota's National Center for Earth-surface Dynamics and with funding from the National Science Foundation, the State of Minnesota, Metropolitan Council Environmental Services, the Toro Foundation, and several watershed districts, the Museum is creating outdoor exhibits about landscape processes, river dynamics, soil science, and nonpoint source pollution. The Big Backyard will open to the public on June 26, 2004.

THE BIG BACK YARD

The Big Back Yard is the Science Museum of Minnesota's 1.2-acre, fenced, outdoor exhibit space. By June 26, 2004 when the park opens to the public, the Museum will have invested $2.6 million to transform this park into an outstanding outdoor educational experience. The Big Back Yard, with its nine holes of miniature golf , outdoor exhibits, prairie maze, and Science House lab activities will showcase University of Minnesota reseach and likely will see 100,000 visitors from July through mid-October 2004.

EarthScapes Mini-Golf and Exhibits are experiences covering 30,000 square feet of the Big Back Yard that will serve as a major public education outlet for the new field of earth-process science. The University of Minnesota in September 2002 received a five-year, $19.3 million grant from the National Science Foundation to create the National Center for Earth-surface Dynamics. Nine holes of miniature golf along with related outdoor exhibits

will serve as the centerpiece of the park and will acquaint visitors with the real landscape processes shaping the world around them.

The Prairie Maze will be a 17,000-square-foot maze that will entertain and educate visitors by combining its visual appeal and richness of information with the challenge of finding your way through a complex maze. Unlike classic hedge mazes – where the challenge of way finding is all that the maze has to offer – every dead end and every wrong turn in Minnesota's Amazing Prairie will introduce visitors to insights into the relationships between biodiversity and ecosystem productivity, which have been expounded by the University of Minnesota's Dr. G. David Tilman, and the potential for biomass energy in Minnesota, which is being investigated by the University of Minnesota's Initiative for Renewable Energy and the Environment.

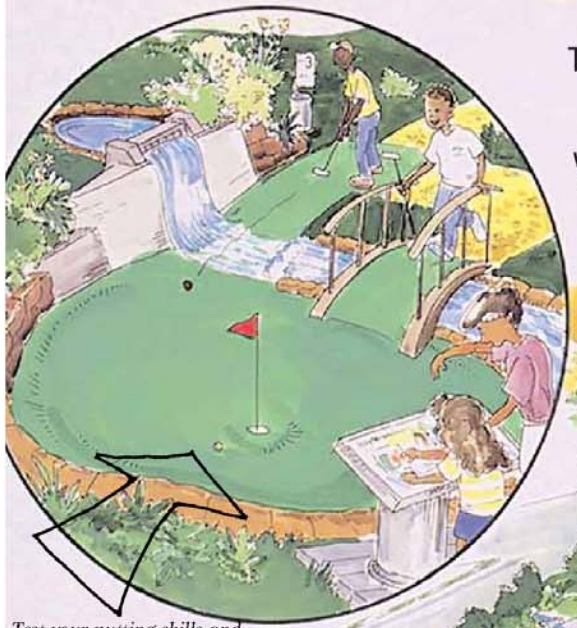
Panning for Gems is a sluice in which visitors pan for gemstones and fossils. Visitors will be able to purchase bags of sand seeded with gemstones or fossils. They can then take them to the sluice, pour them into screen-bottomed boxes, and sluice out the sand and marvel at their discoveries.

Science House is a 1,200-square-foot, year-round building that will serve as a classroom, a public laboratory, a special event space, and an operations center for the park. Science House heats, cools, and lights itself through a building-integrated solar photovoltaic roof. Science House will contain an experiment bench that will highlight the research that the University of Minnesota Drs. Mike Sadowsky and Larry Wackett are performing with a common soil bacteria, *arthrobacter*, that shows great promise for helping to remediate sites contaminated with Atrazine, a common agriculture herbicide.

Welcome to the Big Backyard!

The Science Museum of Minnesota's new outdoor attraction

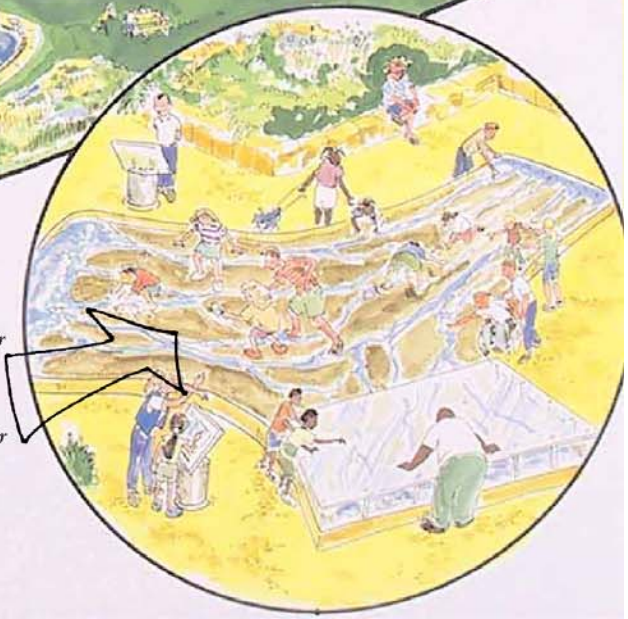
When the Big Backyard opens in June 2004, the Museum will be an ideal outdoor place to play and learn on a nice day. Nine holes of miniature golf unlike any other course ever created along with water-filled, hands-on exhibits will ensure hours of outdoor fun.



Test your putting skills and stir your mind by playing nine holes of miniature golf that explore real landscape processes that shape the world around us.

Discover the beauty and science of Minnesota's native prairies while finding your way through a maze of prairie plants.

Hold your special event in the Big Backyard and take advantage of the event shelter that showcases the latest in roof technologies that use living plants. (Summer 2005).



Why do rivers twist and turn? How do landscapes change over time? Find out using the hands-on exhibits throughout the park. Step out onto a big braided river to investigate river processes firsthand.

See Science House, a building that powers itself with a roof that makes electricity from the sun. Step inside to explore the incredible living world hidden in the soils beneath our feet.