Renewable Energy in Commercial Buildings

Design Guidelines for Integrating Renewable Energy in Commercial Buildings

By Loren Abraham, AIA, LEED AP

Part VIII

Conclusions

- Renewable Energy is Cost Effective *NOW!*
- Set Aggressive Energy Goals Early.
- Use Whole Building Design Practices to reduce energy consumption first and…
- ...design “SOLAR READY” - *Design for renewable energy even when it is not planned!*
- We can change the *Future* and we must.
- The problem is not one of ideas but of ***will***.

Conclusions: Questions you should ask

- When do I need to hire a renewable energy consultant?
- Why should this particular client be incorporating renewable energy? site…finance…sales…?
- What tools can help me to integrate renewable energy into my projects successfully and cost effectively.
- What's the next step?
- What if Most people just carry on *"Business as usual?"*

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Part VIII

Conclusions

Will we simply wait for the *next* generation to act?

…or will we take the needed measures now?

That is up to *you.*

Click on image to play concluding video.

Credits

Re-Arch: The Initiative for Renewable Energy in Architecture

Renewable Energy in Commercial Buildings

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Modern Marvels: Renewable Energy

MODERN MARVELS® shows how air, water, earth, and fire are transformed into clean, reliable sources of energy. This incisive hour takes an in-depth look at the most proven and reliable sources: solar, wind, geothermal, biofuels, and tidal power. From the experimental to the tried-and-true, renewable energy sources are overflowing with potential... just waiting to be exploited on a massive scale. And unlike fossil fuels, they'll always be there.

And from:

Discovery Times: Addicted to Oil

Pulitzer Prize-winning foreign affairs columnist, Thomas L. Friedman, explores his ideas for a "geo-green alternative," a multilayered strategy for tackling a host of problems, from the funding of terrorist supporters through our gasoline purchases, to strengthening our economy through innovative technology.

Resources

American Solar Energy Society is a national membership organization whose mission is to attain a sustainable U.S. energy economy and accelerate the development and use of solar and other renewable energy resources.
http://www.ases.org/

Energy Information Administration produces very detailed reports on the solar energy industry and use of solar water heating, including the Solar Collector Manufacturers Activity Report.
http://www.eia.doe.gov/

National Renewable Energy Laboratory (NREL) produces a wealth of information regarding solar technology including excellent maps and tables of the solar resource in the U.S. and around the world. http://www.nrel.gov/

Solar Energy Industries Association offers a directory of solar manufacturers, distributors, contractors, and design consultants. There are also several state SEIA chapters that are useful resources and sources of regional bidders on projects.
http://www.seia.org/

US Dept. of Energy - Energy Efficiency and Renewable Energy website offers a wide range of information and resource including a High Performance Building Databaase.
http://www.eere.energy.gov/buildings/

Minnesota Renewable Energy Society is the local chapter of the American Solar Energy Society and a great resource for information, advocacy, solar tours, etc.
http://www.mnrenewables.org/

Midwest Renewable Energy Association provides information, advocacy, training, professional certification and education on a wide range of renewable energy issues.
http://www.the-mrea.org/

References:

SOLAR THERMAL

The Solar Rating and Certification Corporation (SRCC) is an independent, nonprofit trade organization that creates and implements solar equipment certification programs and rating standards. SRCC developed a solar water heating system rating and certification program, short-titled OG 300, to improve performance and reliability of solar products. http://www.solar-rating.org/

Summary of SRCC Certified Solar Collector and Water Heating System Ratings, which lists performance ratings for the certified products, is available free of charge. http://www.solar-rating.org/

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Gestaltungspotenzial von Solarpaneelen als neue Bauelemente Sonderaufgabe Baudenkmal von der Fakultät Gestaltung der Universität der Künste Berlin zur Erlangung der Würde eines Doktor-Ingenieurs genehmigte Dissertation vorgelegt von Dipl.-Ing. Susanne Rexroth aus Karlsruhe; Prof. Dr. Heinrich Tepasse, UdK Berlin, Prof. Dr. Robert Suckale, TU Berlin, Prof. Dr.-Ing. Bernhard Weller, TU Dresden; Tag der Disputation: 26. August 2005

Design Aids for Small PV Power Systems, Solarex Corp.

CECS 84:96, The Installation Engineering Design Specification of Solar Photovoltaic Power System, China Engineering & Construction Standards Association, Fuzhou, China, 1996. (in Chinese)

Landau, C. R., 2001. Optimum orientation of solar panels, http://www.macslab.com/optsolar.html

Perez, P. and Coleman, S., 1993. PV Module Angles, Home Power No. 36, August/September 1993, pp. 14-16. [PDF]

SolarBuzz Solar Industry Newsletter http://www.solarbuzz.com/

Wind Power

American Wind Energy Association, http://www.awea.org. This site includes a very clear and easy to read section that covers the basics of wind energy. As a national association, the site also compiles links on wind power projects being erected around the nation.

Carleton College Wind Turbine,
http://webapps.acs.carleton.edu/campus/facilities/sustainability/wind_turbine/
The site includes information on the planning of the turbine as well as pictures of its construction.

Characterization of Wind Resources in the Upper Midwest,
http://www.state.mn.us/mn/externalDocs/Commerce/Characterization_of_Wind_Resources_in_Upper_Midwest_092804023227_WindResource_UpperMidwest.pdf
This study, completed in September 2004, evaluates Minnesota's potential for wind power and includes wind maps of most of the state.

Danish Wind Industry Association, http://www.windpower.org
The site offers a very clear "tour" of wind power that includes diagrams of the components of a wind turbine and how they work to produce energy.

Initiative for Renewable Energy and the Environment, University of Minnesota,
http://www1.umn.edu/iree/morris_photos.html
The site includes pictures of the wind
turbine constructed at University of Minnesota – Morris.

Macalester College Wind Turbine
www.macalester.edu/~envirost/Audits/audit2003wind.pdf
This report, completed by a group of Macalester students as part of an Environmental Studies class, examines the feasibility of placing another wind turbine on the Macalester campus.

Minnesota Climatology Working Group
http://www.climate.umn.edu/
For more detailed information, contact Professor Mark Seelye or data collector Dave Ruschy.

Minnesotans for an Energy-Efficient Economy,
www.me3.org/issues/wind/index.html.
Hosted by a non-profit organization committed to all types of renewable energy, this is the most comprehensive source of wind power information in Minnesota.

Urban Turbines, http://www.urbanturbines.com/. This site is currently under construction so little information is currently available. However, this organization is committed to developing wind turbines suitable for urban areas.

Windustry, http://www.windustry.com
This Minnesota based non-profit organization seeks to encourage the development of wind power as an economic base in rural communities.

Other Web Resources:

The Interstate Renewable Energy Council (IREC) and the N.C. Solar Center (NCSC)
"Connecting to the Grid"
Project web site, www.irecusa.org/connect

Database of StateIncentives for Renewable Energy (DSIRE) www.dsireusa.org.

Minnesotans for an Energy Efficient Economy
www.me3.org/issues/wind/index.html
A non-profit organization committed to all types of renewable energy

EnergySmart Schools Web Site:
www.energysmartschools.gov
Alliance to Save Energy's Green Schools Program
www.ase.org/greenschools/newconstruction.htm

US DOE's Energy Efficiency and Renewable Energy Network buildings site http://www.eere.energy.gov/

Advanced Buildings, Technologies, and Practices
www.advancedbuildings.org/

National Clearinghouse for Educational Facilities
www.edfacilities.org/rl/

US EPA's ENERGY STAR for Schools
www.epa.gov/building/schools

Daylighting and Windows:
Lawrence Berkeley National Laboratory's
"Tips for Daylighting with Windows"
www.windows.lbl.gov/daylighting/designguide/designguide.html

US DOE's "Advances in Glazing Materials for Windows"
www.eren.doe.gov/erec/factsheets/windows.html

National Fenestration Rating Council: www.nfrc.org
Daylighting Collaborative: www.daylighting.org

US Naval Observatory's sun or moon altitude/azimuth table:
www.aa.usno.navy.mil/data/docs/AltAz.html

Design Guidelines:

CHPS Best Practices Manual
Chapter 6: Renewable Energy
High Performance Schools
Federal Energy Management Program

Energy-efficient design for new Federal facilities
A guidebook of practical information on designing energy-efficient Federal buildings. Prepared by the New Technology Demonstration Program

Federal Energy Management Program
Internet: http://www.eren.doe.gov/femp/
For more information, contact Paul Torcellini,
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www.nrel.gov/buildings/highperformance/

National Renewable Energy Laboratory's Center for Buildings and Thermal Systems: www.nrel.gov/buildings_thermal/

Oak Ridge National Laboratory's Building:
www.ornl.gov/roofs+walls/index.html

Passive Solar Design:
The Foundation for Low-Energy Federal Buildings
Andy Walker, National Renewable Energy Laboratory, Golden, CO
303-384-7531; http://www.nrel.gov/femp/

Thermal Envelope Systems and Materials Program - Lawrence Berkeley National Laboratory's DOE-2 energy simulation software: www.gundog.lbl.gov/dirsoft/d2whatis.html

US DOE's State Energy Alternatives:
www.eren.doe.gov/state_energy/

US DOE's Green Power Network www.eren.doe.gov/greenpower/

National Renewable Energy Laboratory:
www.nrel.gov

The Interstate Renewable Energy Council Schools Going Solar program; www.schoolsgoingsolar.org

LANL Sustainable Design Guide
National Renewable Energy Laboratory
Paul A. Torcellini, Ph.D., P.E., Otto Van Geet, P.E., Sara Farrar-Nagy, Sheila J. Hayter, P.E.; Project Leader, Amber Larson

U.S. Department of Energy, Federal Energy Management Program has produced several publications including a Federal Technology Alert on Solar Water Heating, and case studies. FEMP also periodically conducts training courses entitled "Implementing Renewable Energy Projects" with a two-hour module devoted to solar water heating. A schedule of all FEMP trainings is available at the web site above. http://www.eere.energy.gov/femp/

Design Guidelines for Integrating Renewable Energy in Commercial Buildings

Grants and Incentives:

An Overview of U.S. State-Level Incentives and Policies Promoting Fuel Cell Technologies
Rusty Haynes, NC Solar Center, NC State University
Presented at the National Hydrogen Association Conference, Washington, DC
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Interstate Renewable Energy Council (IREC)
"Connecting to the Grid" Project
State and Utility Net-Metering Rules and Programs

Database of StateIncentives for Renewable Energy (DSIRE)
www.dsireusa.org.

State Incentives for Renewable Energy: Case Studies on Program Effectiveness
Presented at ASES 2003
Susan Gouchoe, Valerie Everette, Rusty Haynes, Valerie Everette; NC Solar Center at NCSU, Austin, TX
valerie_everette@ncsu.edu

Case Study Technical Reports:

High-Performing Commercial Buildings: Designed for maximum energy efficiency, they are easy on the eyes as well as the budget; Paul Torcellini, Commercial Building Integration Team Leader: Paul_Torcellini@nrel.gov, and see www.nrel.gov/buildings/highperformance/

Energy Performance Evaluation of an Educational Facility: The Adam Joseph Lewis Center for Environmental Studies, Oberlin College, Oberlin, Ohio November 2004
NREL/TP-550-33180; S.D. Press and P.A. Torcellini

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Office of Energy Efficiency and Renewable Energy
by Midwest Research Institute & Battelle

THERMAL ENVELOPE OPTIMIZATION AND SIMULATION REPORT: GRINNELL COLLEGE CAMPUS CENTER
By Loren E. Abraham AIA,
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Other Publications:

The Application and Viability of Renewable Energy Sources for a Hotel Development in Waikiki: Wave Energy, Photovoltaics and Cogeneration
by Jill Yasuko Miyata, Loren Kawakami

Building Construction Illustrated, 3rd Edition
by Francis D. K. Ching, Cassandra Adams
Publisher: Wiley; 3 edition (October 2, 2000)

Building with Structural Insulated Panels (SIPs) : Strength and Energy Efficiency Through Structural Panel Construction by Michael Morley;
Publisher: Taunton (September 9, 2000)

Eco-Tech: Sustainable Architecture and High Technology
By Catherine Slessor, Photos by John Linden;
Publ: Thames & Hudson (2001)

Great Moments in Architecture
By David Macaulay (1995)

Heating, Cooling, Lighting : Design Methods for Architects
by Norbert Lechner
Publisher: Wiley; 2 edition (December 1, 2000)

Intelligent Glass Facades
By Andrea Campagno
Publisher: Birkhauser (2002)

Intelligent Skins; By Michael Wifggington, Jude Harris
Publisher: Architectural Press (2002)

Energy-Efficient Building (The Best of Fine Homebuilding)
by Fine Homebuilding Series (Editor), Editors of Fine Homebuilding
Publisher: Taunton (October 15, 1999)

Expedient shelter construction and occupancy experiments (ORNL-5039) (Unknown Binding) by Cresson H Kearny
Publisher: Oak Ridge National Laboratory ; available from Springfield, Va., National Technical Information Service (1976)

The History of Solar; US Dept. Of Energy, Energy Efficiency and Renewable Energy; Courtesy of New Vision Technologies, Inc.; Images © 2000 NVTech.com

Passive Solar Design Handbook by Bruce Anderson
Publisher: Van Nostrand Reinhold Company (June, 1998)
Language: English; ISBN: 0442208103

The Passive Solar Energy Book; by Edward Mazria
Publisher: Rodale Press; Expanded professional ed edition (1979)

Renewable Energy Annual June 2006
Energy Information Administration
U.S. Department of Energy, Washington, DC 20585

The Return of the Solar Cat Book
By Jim Augustyn, Illust. By Hildy Paige burns
Publisher: Patty Paw Press (1979, 2003)

Other Publications:

Sun, Wind & Light: Architectural Design Strategies, 2nd Edition
by G. Z. Brown, Mark DeKay; Publisher: Wiley; 2 edition (2000)

Using renewable energy in commercial buildings
Focus on Energy for Wisconsin; www.focusonenergy.com

Thermal Envelope:
Builder's Guide to Cold Climates
Lstiburek, Joseph, Building Science Corporation, 2000.
Newton, CT: Taunton Press, 2000.

Photovoltaics:
Design of a Cradle to Cradle Biophotovoltaic System
A solution to aid leapfrogging to sustainable electrical energy supply from zero infrastructure, Nathan Eng, RYERSON UNIVERSITY

Environmental life-cycle assessment of multicrystalline silicon solar cell modules; G.J.M. Phylipsen, E.A. Alsema, Department of Science, Technology and Society Utrecht University

Photovoltaics and Architecture
Thomas, Randall, editor, New York: SPON Press, 2001

An Empirical Perspective on the Energy Payback Time for Photovoltaic Modules; Karl E. Knapp, Ph.D., Energy & Environmental Economics, Inc.; Theresa L. Jester, Siemens Solar Industries
terry.jester@solar.siemens.com

PROGRESS IN LOW-COST ELECTRODEPOSITION OF Cu(In,Ga)(S,Se)2 : THE CISEL PROJECT
J. Kessler1,2, J. Sicx-Kurdi1, N. Naghavi, J.-F. Guillemoles, D. Lincot1, O. Kerrec, M. Lamirand, L. Legras, P.Mogensen

PV Primer - Building Science Consotium
www.buildingscience.org
OFFICE OF BUILDING TECHNOLOGY STATE AND COMMUNITY PROGRAMS OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Thin-Film Photovoltaic Partnership — CIS-Based Thin Film PV Technology
Final Technical Report September 1995 — December 1998
National Renewable Energy Laboratory
1617 Cole Boulevard, Golden, Colorado 80401-3393

Solar: passive & active systems
Behling, Sophia and Sefan. Solar Power. New York: Prestel, 2000.

Chiras, Daniel D. The Solar House: Passive Heating and Cooling
Vermont: Chelsea Green Publishing Company, 2002.

A Consumer's Guide: Heat YourWater with theSun
The National Renewable Energy Laboratory,
Office of Energy Efficiency and Renewable Energy
1000 Independence Avenue, S.W., Washington, D.C. 20585

Steve Winter Associates, edited by Michael J. Crosbie.
Passive Solar Design and Construction Handbook.
New York: John Wiley & Sons, 1998.

Lechner, Norbert. Heating, Lighting, and Cooling (second edition), "Shading", New York: John Wiley, 2001.

Moore, Fuller. Environmental Control Systems: Heating, Cooling, Lighting, "Passive Cooling", New York: McGraw Hill, 1993.

Stein, Benjamin and John Reynolds. Mechanical and Electrical Equipment for Buildings (ninth edition). New York: John Wiley & Sons, 2000.

References:

7th world solar challenge 2003 Web site, http://www.wsc.org.au/

American Chemical Society Web site, http://www.chemistry.org/portal/Chemistry?PID=feature_pol.html&id=be062a06f8df11d6f1c06ed9fe800100

American Solar Energy Society, Renewable Hydrogen Forum: A Summary of Expert Opinion and Policy Renewable Hydrogen," http://www.nsf.gov/od/lpa/news/03/pr0369.htm.

Appliance R&D at ORNL's Buildings Technology Center Web page, http://www.ornl.gov/ORNL/BTC/appl_randd.htm.

Berkeley Lab Research News Web site: "An unexpected discovery could yield a full spectrum solar cell," http://www.lbl.gov/Science-Articles/Archive/MSD-full-spectrum-solar-cell.html.

Brown University, Brown is Green Web site, http://www.brown.edu/Departments/Brown_Is_Green/index.html.

Brown, Lester R., Paving the Planet: Cars and Crops Competing for Land, for the Earth Policy Institute, February 14, 2001, http://www.earth-policy.org/Alerts/Alert12.htm.

Brundtland Commission on Environment and Development (WCED, 1987), http://www.worldsummit2002.org/guide/brundtland.htm.

Buddycom "Ecological footprint" Web page, http://www.buddycom.com/animal/envirimg/footprint/index.html.

BuildingGreen Web site: "Enhancing Dehumidification with Heat Pipes," http://www.buildinggreen.com/products/heatpipe.cfm.

BuildingGreen.com Web site: "Solar at the White House," http://www.buildinggreen.com/news/white_house.html.

CADDET Renewable Energy Web site, http://www.portalenergy.com/caddet/retb/no46.pdf.

Capstone Web site, http://www.microturbine.com/index.asp.

References:

Department of Energy National Renewable Energy Laboratory International Co-Control Benefits Analysis Program Web site, http://www.nrel.gov/icap/.

Department of Energy National Renewable Energy Laboratory Web site, http://www.nrel.gov/.

Department of Energy Office of Energy Efficiency and Renewable Energy Web site, http://www.eere.energy.gov/.

Department of Energy Press Releases Web site, http://www.energy.gov/engine/content.do?BT_CODE=PR_PRESSRELEASES&TT_CODE=PRESSRELEASE&PUBLIC_ID=14368.

Department of Energy Sustainable National Renewable Energy Laboratory Web site, http://www.nrel.gov/sustainable_nrel/.

Department of Energy's Renewable Resource Data Center, http://rredc.nrel.gov/wind/pubs/atlas/chp3.html#s_central.

DOE Office of Fossil Energy Web site, http://www.fe.doe.gov/

Department of Energy National Renewable Energy Laboratory Web site, http://www.nrel.gov/.

Department of Energy Office of Energy Efficiency and Renewable Energy Web site, http://www.eere.energy.gov/.

Department of Energy Press Releases Web site, http://www.energy.gov/engine/content.do?BT_CODE=PR_PRESSRELEASES&TT_CODE=PRESSRELEASE&PUBLIC_ID=14368.

Department of Energy Sustainable National Renewable Energy Laboratory Web site, http://www.nrel.gov/sustainable_nrel/.

Department of Energy's Renewable Resource Data Center, http://rredc.nrel.gov/wind/pubs/atlas/chp3.html#s_central.

DOE Office of Fossil Energy Web site, http://www.fe.doe.gov/

DOE Office of Scientific and Technical Information report, http://www.osti.gov/bridge/product.biblio.jsp?osti_id=769578.

DOE/EIA-0383(2003): "Annual Energy Outlook 2003 With Projections to 2025," Energy Information

References:

DTE Energy Technologies Web site, "DTE Energy Technologies Signs Contract to Develop Microgrid at NextEnergy Site" http://www.dteenergy.com/pressRoom/pressReleases/DTechNextEnergy.html?searchType=&searchValue=DTE+Energy.

Driving PV System Costs Down, pp. 35-39, Jan/Feb 2002, Refocus, the official magazine of the International Solar Energy Society.

"Energy Efficiency for Sustainable Development" presentation by Robert Card and Dr. David Kemp, http://fire.pppl.gov/wssd_card2_083002.pdf.

Engineering Study: Thermal Energy Storage System at NASA Johnson Space Center, ZBA, Inc., ZBA 1591, Feb. 1995.

Energy Concepts Co., LLC Web site, www.energy-concepts.com.

Energy Info Source Web site: "Plug Power Completes U.S. Department of Defense Fuel Cell Demonstration Program," http://www.energyinfosource.com/dg/news.cfm?id=17849.

Energy Information Administration's "Annual Energy Outlook (2003)," http://www.eia.doe.gov/oiaf/aeo/.

Energy Source," May 8, 2003, http://www.epa.gov/newsroom/headline2_050803.htm.

Energy Star Web site, lighting products exit signs: http://www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs.

Energy, Oak Ridge National Laboratory, June 2003 (ORNL/TM-2003/37) http://www.ornl.gov/%7Ewebworks/cppr/y2001/rpt/116286.pdf.

Engineered Systems Web site: "New centrifugal chillers an instant hit at Sony CD facility," http://www.esmagazine.com/CDA/ArticleInformation/CaseItem/0,2534,83344,00.html.

Environmental and Energy Systems Institute of Rice University Web site, http://www.ruf.rice.edu/~eesi/sustain/.

Environmental Protection Agency; Beyond RCRA: Waste and Materials Management in the Year 2020 Web site; http://www.epa.gov/epaoswer/osw/vision.pdf.

References:

EPA Colleges and Universities Web site, http://www.epa.gov/ne/assistance/univ/index.html.

EPA National Center For Environmental Research, Small Business Innovative Research Web site, http://es.epa.gov/ncer/sbir/.

EPA Web page "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition," http://www.epa.gov/ttn/chief/ap42/.

Ewert, M.K., "Terrestrial and Aerospace Solar Heat Pump Development: Past, Present and Future," ASME, Solar 98.

Ewert, M.K., et al., "Experimental Evaluation of a Solar PV Refrigerator with Thermoelectric, Stirling and Vapor Compression Heat Pumps," ASES, Solar 98.

Federal Energy Management Program Web site, Federal Success Stories, http://www.eere.energy.gov/femp/prodtech/successstories.html.

Fuel Cells 2000 The Online Fuel Cell Information Center, http://www.fuelcells.org/fcfaqs.htm.

Gajanana C. Birur, Tricia Waniewski Sur*, Anthony D. Paris, Partha Shakkottai, Amanda A. Green, and Siina I. Haapanen, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, Science Applications International Corporation, San Diego, CA, USA*, Micro/nano spacecraft thermal control using a MEMS-based pumped liquid cooling system, http://www.alumni.caltech.edu/~waniewsk/papers/waniewsk4.pdf.

Global Solar Web site, http://www.globalsolar.com/

GNET News Center Web site: "Hydrogen Research Project Delivers," http://www.gnet.org/news/newsdetail.cfm?NewsID=22050.

Green Building Program, Sustainable Building Sourcebook, http://www.greenbuilder.com/sourcebook/.

Greening the Building and the Bottom Line, Romm, Joseph J. and Browning, William D., copyright December1994 (revised 1998) by Rocky Mountain Institute.

High Power Density Photovoltaics, pg. 106, Renewable Energy World, September-October 2002, James & James Ltd.

References:

Home power: The Hands-On Journal of Home-Made Power Web site, Batteries page, http://www.homepower.com/magazine/downloads_batteries.cfm.

Hydro Cool Inc. Web site, www.hydrocoolonline.com.

Keller, J.R., "Heat-Driven Air-Conditioning Options for the Johnson Space Center," Lockheed Martin report #MSAD-03-0300, September 30, 2003.

Lawrence Berkeley National Laboratory Center for Building Science News #15 Spring 1997.

Mainstream Engineering Corporation Web site, http://www.mainstream-engr.com/.

Massachusetts Institute of Technology Joint Program on the Science and Policy of Global Change Web site, http://web.mit.edu/globalchange/www/reports.html.

Millennium Ecosystem Assessment Web site, http://www.millenniumassessment.org/.

Morton, R.D., "Fuel Cell Powered Utility Cart Report," Lockheed Martin report # MSAD-03-0245, July 28, 2003.

Mother Earth News, April/May 2002, pp. 106-108.

NASA Destination Earth Web site, http://www.earth.nasa.gov/.

NASA Glenn Research Center Solar Dynamic Power (SDP) Overview http://spacepower.grc.nasa.gov/ppo/projects/sdp/index.html

NASA's Energy Efficiency and Water Conservation Program Web site, http://www.hq.nasa.gov/office/codej/codeje/je_site/about_us/about_us.html

NASA's Energy Efficiency and Water Conservation Program Web site, http://www.hq.nasa.gov/office/codej/codeje/je_site/about_us/about_us.html

Nature, February 6, 2003, Macmillan Publishers Ltd.

Oak Ridge National Laboratory Buildings Technology Center Web site: Advanced Refrigeration, http://www.ornl.gov/ORNL/BTC/advrefr.html.

References:

Oak Ridge National Laboratory: Gabbard, Alex, "Coal Combustion: Nuclear Resource or Danger," http://www.ornl.gov/info/ornlreview/rev26-34/text/colmain.html

Official United Nations Web site for the Johannesburg Summit 2002 – the World Summit on Sustainable Development, http://www.johannesburgsummit.org.

Perlin, John. From Space to Earth: The Story of Solar Electricity. aatec Publications. 06/01/1999. Ann Arbor, Michigan.

Population Reference Bureau, "Population, Health, and Environment" Web page, http://www.prb.org/Content/NavigationMenu/Measure_Communication/Environment2/WSSD/WSSD.htm.

Power from the Desert, pp. 62-75, Renewable Energy World, James & James, Ltd., May-June 2003.

PRO-ACT "Cross Talk" edition 82, Air Force Center for Environmental Excellence, May 2001.

PRO-ACT Fact Sheet, July 2001, http://www.afcee.brooks.af.mil/pro-act.

Proton Energy Systems Web site, http://www.protonenergy.com/index.php/html/energysystems/home/index.html.

REFOCUS, a publication of the International Solar Energy Society, "High Energy," pp. 58,59, December/November 2002, Elsevier Science Ltd.

Recharging the Power Grid, p. 50, Technology Review, March 2003.

Recommendations for Achieving Sustainable Communities: Science and Solutions, A Report from the second National Conference on Science, Policy, and the Environment, December 6-7, 2001, http://www.ncseonline.org/NCSEconference/2001Conference/report/page.cfm?FID=1692.

Recommendations for Achieving Sustainable Communities, Second National Conference on Science, Policy and the Environment, December 6-7, 2001, http://www.cnie.org/ncseconference/2001conference/report/2001_conf_report.pdf.

Rocky Mountain Institute Transportation Web site: The Hypercar Concept, http://www.rmi.org/sitepages/pid386.php.

References:

Sandia National Laboratories Renewable Energy Technologies Division Web site, http://www.sandia.gov/Renewable_Energy/renewable.htm.

Science Daily Web site, http://www.sciencedaily.com/encyclopedia/Houston,_Texas.

Science Magazine: "Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet," http://www.sciencemag.org/cgi/content/full/298/5595/981.

Solar Hydrogen Energy Corporation Web site: "Government of Canada to fund Solar Hydrogen Energy Corporation's Process for Producing Hydrogen from Water Vapour," http://www.sheclabs.com/press/releases/2003Apr21press.htm.

SpaceDaily Web site: "New Technique Could Lead to Widespread Use of Solar Power," http://www.eren.doe.gov/power/success_stories/wind_cost.html

Solar Power via the Moon, David R. Criswell, The Industrial Physicist, April/May 2002.

Stoney Creek Materials Web site, http://www.stoneycreekmaterials.com/index.html.

SunDanzer Solar Refrigerators and Freezers Web site, http://www.sundanzer.com/.

SunPower Web site, http://www.sunpowercorp.com/.

Sustainable Community Roundtable "Ecological Footprint" Web page, http://www.olywa.net/roundtable/footprint/index.html.

Sustainable Community Roundtable Web site, http://www.olywa.net/roundtable/.

Sustainable Development Indicators Web page, http://www.sdi.gov.

Sustainable Measures "Ecological footprint" Web page, http://www.sustainablemeasures.com/Indicators/IS_EcologicalFootprint.html.

Sustainable Measures Web site, http://www.sustainablemeasures.com/index.html.

Sustainable Oregon Web site, http://www.oregonsolutions.net/A_university/.

References:

The Natural Step Web site www.naturalstep.org.

The State of World Population 2001 Web site, Chapter 1: Overview, http://www.unfpa.org/swp/2001/english/ch01.html.

The U.S Global Change Research Information Office, Environmental effects of ozone depletion: 1998 assessment, http://www.gcrio.org/UNEP1998/.

The U.S. Department of Energy and The Renewable Energy Report Library, Montana State Library, 1515 East Sixth Avenue, Helena, Montana 59620-I 800, November 1996, http://journeytoforever.org/biofuel_library/UCDavisSumm.html.

The Versatile Solar Greenfreeze Refrigerator for Vaccine & Food Preservation, http://www.uneptie.org/ozonaction/library/tech/solarchill.pdf.

U.S. Department of Energy Energy Efficiency and Renewable Energy Web site: Weatherization & Intergovernmental Program: Inventions & Innovation, http://www.oit.doe.gov/inventions/factsheets/energyconcepts.pdf.

U.S. Department of Energy Fact Sheet: Concentrating Solar Power: Energy from Mirrors, http://www.eere.energy.gov/erec/factsheets/csp.html.

U.S. Department of Energy Federal Energy Management Program Web site, http://www.eren.doe.gov/femp.

U.S. Department of Energy National Renewal Energy Laboratory, Advanced Desiccant Cooling & Dehumidification Program Web site, http://www.nrel.gov/desiccantcool/tech.html.

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy: Photovoltaics, http://www.eere.energy.gov/RE/solar_photovoltaics.html

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy: Solar Water Heating Web Site, http://www.eere.energy.gov/erec/factsheets/solrwatr.html.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Biofuels for Sustainable Transportation Web site, http://www.ott.doe.gov/biofuels/what_we_do.html.

References:

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Hydrogen, Fuel Cells & Infrastructure Technologies Program, http://www.eere.energy.gov/hydrogenandfuelcells/.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Hydrogen, Fuel Cells & Rocky Mountain Institute Web site, search for hydrogen, http://www.rmi.org/sitepages/art7516.php.

U.S. Department of State Web page Healthy Homes and Communities, http://www.state.gov/g/oes/rls/fs/2003/19942.htm.

U.S. Environmental Protection Agency Landfill Methane Outreach Program Web site, http://www.epa.gov/lmop/.

U.S. Energy Information Administration, http://www.eia.doe.gov/oiaf/aeo/

U.S. Fuel Cell Council Web site, http://www.usfcc.com/

U.S. Green Building Council Web site, http://www.usgbc.org/.

UN Department of Economic and Social Affairs, Division for Sustainable Development Web page, http://www.un.org/esa/sustdev/.

UN Environment Programme, Division of Technology, Industry and Economics Web page, http://www.uneptie.org/.

United States Environmental Protection Agency Energy Star Web site http://www.energystar.gov.

United States Environmental Protection Agency Environmental Technology Verification Program Web site, http://www.epa.gov/etv/.

United States Environmental Protection Agency Labs21 Web site, http://www.epa.gov/labs21century.

United States Environmental Protection Agency Office of Research & Development Web site, http://www.epa.gov/ord/.

Other SELECTED WEBSITES:

American Institute of Architects, www.aia.org

Architects/Designers/Planners for Social Responsibility, www.adpsr.org

Architects for Humanity, www.afh.org

Awakening Earth: Sustainability and Simplicity, www.simpleliving.net/awakeningearth/links.asp

Building Benchmarks and Beyond (B3), University of Minnesota, www.csbvr.umn.edu/B3/index.html (browse).

Daylighting Design Collaborative, www.daylighting.org

InformeDesign: where research informs design, www.informedesign.umn.edu

Dovetail Partners, www.dovetailinc.org

Earth Trends: environmental information portal, http://earthtrends.wri.org

Ecotecture: Online Journal of Ecological Design, www.ecotecture.com

Energy Efficient Windows Collaborative, www.efficientwindows.org

Envirolink: online environmental community, www.envirolink.org

Efficient Window Collaborative; www.efficientwindows.org/technologies.cfm (brows all sections under “window technologies”).

Environment Web Directory, www.webdirectory.com

Environmental Building News, CALA subscription (see Mary for access information)

Environ Design Collaborative, www.environdc.com

Green links on Simple Living, www.simpleliving.net/awakeningearth/links.asp

Green Building, www.buildinggreen.com

Global Living Project, www.globallivingproject.org

Greener Buildings, www.greenbiz.com/sites/greenerbuildings/index.cfm

Leadership in Energy and Environmental Design (LEED), U.S. Green Building Council, www.usbc.org/LEED/LEED_main.asp (browse).

Map of the Nation’s Platinum and Gold LEED-Certified Buildings, www.fundinggreenbuildings.com

Minnesota Green Communities Initiative, www.greencommunitiesonline.org

Minnesota Office of Environmental Assessment, Green Buildings, www.moea.state.mn.us/greenbuilding/waste.cfm

Minnesota Sustainable Design Guide, University of Minnesota, www.sustainabledesignguide.umn.edu (browse).

Minnesotans for an Energy-Efficient Economy, www.me3.org

Minnesota Renewable Energy Society, www.mres-solar.org

Natural Step: www.naturalstep.org

Oikos: green building source, www.oikos.com

Sustainable Design Resource Guide: Denver AIA, www.aiacolorado.org/SDRG/home.htm

United States Green Building Council (USGBC), www.usgbc.org

World Resource Institute, environmental issues, www.wri.org