**A suggested syllabus for Passive Solar Architecture**

Instructor information:

***The course***

This course reviews the foundations and principles of passive solar architecture and sustainable building It reviews the opportunities for more sustainable buildings that provide better comfort, more healthful conditions and increase productivity while improving management of resources, particularly energy, water, and materials. The goal of this course is to help students develop a better understanding of the practice of passive solar architecture, sustainable building, ecological economics, and approaches that can be used to manage resources more sustainably while improving the quality of life for people. Class activities will include lecture, lab, discussion, and field trips. Knowledge building and skill development in research, analysis, design and communication are key elements of this course.

The world's 9 billion people all need buildings that have been redesigned to fit into the landscape without harming the environment or human health. The basic approach is to consider buildings as living systems, with lessons learned from natural ecosystems applied to the built environment. Renewable energy is key, and energy, water and other resources are used, reused and eventually recycled with minimal leakage into the environment or movement into landfills.

Increasing awareness of the challenges of global climate change, resource shortages and environmental decline have made this imperative. Lessons from the past are being rediscovered and increased interest in more sustainable systems and improved understanding the methods of heating, cooling, ventilation and lighting with natural energy flows has made this much easier.

The goal is to help students develop a sufficient understanding of passive solar applications for heating, cooling, ventilation and daylighting, water harvesting and conservation, electricity generation, and other resources issues to more successfully manage their own energy and water budgets at home and at work, and to aid them in developing better buildings and businesses applications while improving communities, countries, and the world. These are among the greatest challenges for the next 50 years!

**Required text:**

David A. Bainbridge and Ken Haggard. 2011. ***Passive Solar Architecture***. Chelsea Green.

**Materials:** 1 usb recording thermometer ($50), one stem type dial thermometer, good to 400°F ($25), radiant thermometer ($50), wind gauge ($27). (*if budgets allow these may be provided in lab*)

Instructor's guide for labs available on-line at www.sustainabilityleader.org. Labs often require other purchased materials.

**16 week schedule**
Suggested as a 1 hour lecture, 2 hour lab or workshop per week, but could be offered in other formats, if lab space and time are limited the three key labs are microclimate, passive solar building design, and building performance. For beginning students or lower grades the solar hot water, solar oven and passive solar home design may be better.

1. The challenge (reading : preface and Chapter 1 page i to 7)
Global change and investing for the future. Passive solar architecture, green buildings, integrated design and ecological development. The triple bottom line, true cost, life cycle cost, and ecological footprints. Focusing on comfort, health, and security as well as energy, carbon or GHG emissions. The external costs of energy – group activity

2. A brief history of energy use - from hunter gatherer to industrial revolution to today. (p 8-9). The epochal shift needed. The energy crisis in Greece and Rome and the solar cities (p 53). A first look at energy costs and subsidies. The environmental costs of energy use – the world energy crises. Energy use, cost and supply in ____. Where does energy for ____ come from and how is it generated.
Energy costs workshop – group activity (international comparison per kwh, externE, nuclear subsidies in Germany)

3. Building metabolism and embodied energy (p 10-21)
Skin and internal load dominated buildings. Energy efficient building shells. The keys to siting and orientation, magnetic north vs true north. Energy efficient materials. Carbon sequestration. Thermal analysis workshop (also p 47-52, and lab manual appendix).

4. Site and microclimate (p 22-38)
Bioclimatic design, microclimate , design with climate, solar orientation. Why microclimate is so important.
Solar orientation and microclimate lab work. Solar site evaluation.

5. Passive solar heating (39-47, 56-83)
Orientation, aperture, thermal mass, insulation.
Solar cooker lab, building a solar simulator (p54-55)

6. Solar control (90-93)
Orientation for solar control. The importance of solar control for cooling, comfort and daylighting. Shading strategies and systems, landscaping, etc.
Solar control lab (advanced course tension arbor)

7. Passive cooling using microclimate resources (86-89, 94-116)
Reducing internal and external loads, passive cooling options. Ventilation and comfort.
Radiant sky, cool pool and roof pond lab (depending on local climate and season)

8. Ventilation (117-129)
Ventilation for comfort and health, cross and stack ventilation. Augmented ventilation.
Comfort lab, air flow lab (or solar chimney construction lab)

9. Integrated design. (130-131)
Orientation and design for passive space conditioning. Heating and cooling.
Passive solar design lab – designing, building and monitoring a passive solar building. If time allows also reorient building to antisolar orientation and contrast.

10. Building analysis. (263-264 and Vital Attributes)
Evaluating building performance. Thermal performance, comfort, evaluation.
Solar house lab results after 1 week, remodeling for next week

11. Daylighting (136-147)
Basics of natural lighting, sources of natural light, glare, goals for daylighting. Passive house monitoring continues.
Daylighting lab – room with equator facing wall and roof (153)

12. Daylight 2 (148-162)
Sidelighting with light shelves, toplighting, atria, light wells, and other techniques for natural lighting
Daylighting lab – room with east facing wall and roof as only daylight opportunities.

13. Resource harvesting buildings (163-175)
Positive impact development, inputs and outputs of buildings. Waste = resource.
Solar water heater lab

14. Water (186-200)
Water for homes, institutions, commercial and industrial buildings. Internal use, landscaping, efficiency and cost. Water harvesting, treatment and recycling (biological water treatment, solar disinfection, etc.)
Water harvesting and sizing calculation workshop

15. Electricity (176-185)
Electricity production options, PV panel types, design considerations, installation challenges, code requirements. Grid connected versus stand alone systems. Managing battery banks and maintaining PV systems.
PV lab

16. Community design for sustainability and resource efficiency (221-259)
Integrated design for on-site resource use. Sustainable area budgets, true costs and subsidies. The critical challenges ahead. The transition to sustainable buildings, building operation, manufacturing and recycling. The success of Curitiba, Cradle to Cradle, ecocomposite materials.
Design lab: Sustainable area budget, redeveloping a village in the third world, emergency housing, rethinking a US neighborhood or community.

**Course requirements and grading**

| | % | Date |
|---|---|---|
| Labs and workshops (only 3 or 4 labs may be possible) | 48 | |
| *(workshops and groups can be done in classroom with wifi)* | | |
| External cost of energy teams workshop | | |
| Energy cost group activity (US and world review, kwh) | | |
| Building thermal analysis workshop | | |
| **Solar orientation-microclimate lab** | | |
| **Solar cooker lab** | | |
| **Cooling lab (as appropriate)** | | |
| **Solar control lab** | | |
| **Comfort/ventilation lab** | | |
| **Passive solar building lab—integrated design project** | | |
| **Performance result review and remodel (2 parts)** | | |
| **Daylighting 1st lab** | | |
| **Daylighting 2nd lab** | | |
| **Solar water heater lab** | | |
| Water harvesting calculation workshop | | |
| **Electricity-PV lab or workshop** | | |
| Sustainable community sustainable area budget group project | | |

**Assignments**

| | |
|---|---|
| A 1: Research project (improve research and critical thinking skills) | 10 |
| A 2: Integrated passive solar design project (and/or paper) | 10 |
| A 3: Presentation of a short talk on a passive solar architecture | 10 |
| Midterm – multiple choice and essay (lectures, labs, reading) | 10 |
| Final exam—design challenge, essay questions and definitions | 12 |
| Total | 100% |

**Assignment #1: Research** **10 points**

This is training for effective internet research. Conducting research effectively and managing information well is essential to succeed in most careers, and especially important in the rapidly evolving field of sustainable building and passive solar design. Research helps you find out how, why, what, where, and when. Understanding successful projects around the world and through history is essential. Critical thinking skills are needed to choose design strategies, materials and equipment, and design assistance service providers wisely.

Step 1: Choose a research topic. This might be any one of the key topics on passive solar architecture for a specific country, such as: use of phase change drywall for passive design in Denver, Colorado; passive solar apartment design for Ladahk; sustainable building policy for Lund, Sweden; subdivision layout guidelines for the planning department in Bozeman, Montana; integrated collector systems for hot water for dairies in the Central Valley of California; the economic drivers of the *passivhaus* program in Germany; the use of large bales for straw bale building in Australia; low cost solar disinfection for water treatment in Africa; passive solar straw bale building opportunities on farms; using rainwater harvesting to augment the water supply for Amman, Jordan; sustainable building materials and passive cooling options for Ciudad Obregon, Mexico; passive solar architecture in buildings for disaster recovery. Confirm topic with instructor.

**Step 2: Develop a short list of key words for the search - include as first section of your report.**

Choosing search terms carefully and using "markers" to limit results to exact words is essential. Different browsers and data bases use different markers to set word order, adjacent words, etc. Look up and use advanced or expert searching "help." Using additional key words can limit search results to only the best resources. Use a variety of resources including Google books, Google scholar and library data bases.

Step 3: Start with the excellent resources of your library (this should provide access to a range of data bases). Try Agricola (the National Agricultural Library) and Lexis-Nexis (if available), to get current information from newspapers and legal databases, and other resources. Use advanced search and limiters such as full text on line, refereed journal, edu, gov, pdf to minimize the number of hits and improve the quality of information.

On your research history describe where you went and how many "hits" you found. List your search strategy and results. You must report results for at least ten data bases

**List results of your search for your key words with hits per database for at least 10 databases, try to find full text on line.**

Step 4. World Catalog of books (www.worldcat.org/)

World catalog provides ever improving access to libraries around the world. This includes many theses and is a good resource to start with. Do an advanced search with your key words.

**List results of your search for your key words. For example for "trombe wall" a search returned 559 hits**

Step 5. Google scholar

Try Google scholar after looking through your results at World Catalog. Using key word's and advanced searching

**Google scholar has only 29 hits for "trombe wall."**

Step 6. Google or another major search engine.

The worldwide web is a powerful research tool. Use Google or .....
Use additional key words or terms to limit results to just what you need. Always use advanced searching. In many databases including Google words can be combined using quotation marks. Work on your key word list to narrow down hits to 20 or so that are all likely to be of use.

Be specific. Don't use the words solar hot water (28 million hits) to look up integral collector systems but use "integral collector systems" (4470 hits) (without quotes 81 million hits). Add pdf and cut it down to 7.

Give greater weight to neutral and peer reviewed academic journals, edu, gov, books, industry journals and important newspapers (NY Times, LA Times). Many are now available on-line.

**List your search results. Google "integral collector system" 4470 hits. "integral collector system" pdf 7.**
**Identify the search engine, provide the URL for the web search page, the search terms you used and the number of hits. Chronicle the terms you added to reduce the number to a manageable number of sites to review. Try to dive down to less than 20 hits by adding more limiters.**

Step 7. Sample Notes

These library and web resources will help you improve your understanding of your topic. Don't plagiarize them. Good note taking requires practice. Critical thinking can help you identify the research that is meaningful and likely to help you better understand the issues. Transcribe the information and make notes in your own words. Make sure you have all essential information for a proper citation. You must turn in two samples from your research notes--which should be computer printed, providing full reference data and shelf numbers (if available for your library) or URLs as well as your notes for two sources.

**You must turn in your notes from at least two of your key sources: one from the library or a scientific or technical journal and one from the web. Include all relevant citation information. Use CSE reference format (http://bcs.bedfordstmartins.com/resdoc5e/RES5e_ch11_s1-0003.html) instead of APA. Notes should be in your words not copied from web page, magazine or book directly. These might be ½ to 1 page each.**

Step 8. Two internet site reviews on passive solar architecture or sustainable building.

For this assignment review a number of sites that address questions covered in this class and find one very good one and one very bad one - then write a short review (1/2 to 1 page) of each. These will be shared with the class so be accurate in listing the full URL. Use the review suggestions below. List the full site address, how you found it (which browser), what you like (and dislike) about it.

Web pages and the internet/worldwide web have become an important source of information and are critical for most business yet many are awful. Much of the information is poorly presented, not well organized, and often of questionable validity. Architectural firms are particularly likely to have overly designed unworkable web pages.

Consider such things as:

**1. Screen Design and Layout**
How does each page utilize the screen? Does the layout draw you in or does it look like it was just sort of dropped there? Are page/screen sizes consistent or do you have to keep resizing the window as you move through the site? Does your eye feel invited to "go with the flow" or is it assaulted? Can you print the screen? Does it fit on one page or is it so wide it drifts onto a second?

**2. Information Design**
Is the information broken up into digestible chunks? Is it broken up into segments that make sense logically? Is it "nested" logically? If there are long blocks of copy, are descriptive subheads used to help organize the info and give the reader a preview/overview? Can you jump text with buttons or links? Design firms often have very stylistic but unwieldy information design

**3. Text as a Graphic Element**
Is it readable? Too small/too big/just right? Does the typography (font) - especially that used for titles and headlines -- fit the subject matter and audience? Is its use consistent?

**4. Copy**
Does the information make sense? Is there jargon? Are there misspelled words or other typos? Does it provide the information you were expecting? Does it actively engage you? Are you bored reading it?

**5. Navigation Scheme**
Is it easy to move throughout the site? Does the navigation make sense? Do you feel like you are lost or did you actually get lost? Are the links consistent? Do you have a sense of what the icons mean before clicking? Do you get booted out? Or worse yet, locked in so you can't go back?

**6. Stylistic Unity**
Does the site maintain a consistent style? Or appropriate changes in different sectors?
**7. Graphics and music**
Are the pictures useful? Are graphics optimized or compressed properly? Do they look jaggy, shimmery, squished, have weird halos, edges that look odd, or anything else that makes them look unprofessional? Are the photos clear and crisp or out of focus with pixels showing. Does music or video load quickly?
**8. Colors**
Do the color choices make the information easy to read? Do they create an atmosphere suitable to the subject? do they work well together?
**9. Usability**
Does it load quickly? Does everything work? Can you tell that something is not appearing or not performing as it is supposed to? Do you get error messages? Overly large files often hamper architecture and design firm web sites.
**10. Links**
Are there links to other related sites? Do they work? How is the quality of the links?

**Overall: Information quality and authority**
Does this site have credible, reliable and understandable information? Is it referenced? Is the research plausible and are sources of information identified? What possible bias might it have? Does it draw you in, keep you interested, and prevent you from getting lost and confused? Does it tell a story? Would you recommend it? How could it be improved?

**Assignment #2. Research Paper or Design Project** **10 points**

Research Paper typed, 1.5 spacing in 12 point Times or similar font, 1.25 inch margin on the left and 1 inch margins on all other sides. Except in cases where original investigations are done, your paper will be a report on investigations by others so you must be sure to give credit where it is due with proper citations and references. The penalties for plagiarism are spelled out in the student handbook--zero for the assignment plus other penalties if serious. **1000 words (+ or - 20 words)**

You must use at least **five reputable solar or sustainable building journals, magazines or reports or five scholarly papers or books** as sources of information for your paper, you may also add up to ten internet sources in addition to the "permanent" references. Use professional journals (Solar Energy, Building and Environment, Transactions ASABE...), magazines (Solar Today, Home Power, Solutions), government documents, and scholarly books as primary source materials. If your library is lacking, try the local bookstore.

When you use an investigator's data, state his/her ideas, paraphrase his/her conclusions, or quote him/her directly, cite the reference as follows at the end of the sentence the first time their work is used in a paragraph (Haggard, 1995). Use the reference format information for the journal Solar Energy (on-line at www.elsevier.com/wps/find/journaldescription.cws_home/329/authorinstructions).

**No footnotes**, use direct quotations rarely, and only when they are essential to your argument. In most instances you should paraphrase the information from your sources,

giving credit to authors by citing their paper or book. (Owl at Purdue is a good resource - owl.english.purdue.edu/)

Your paper topic must be about passive solar architecture and sustainable building. If it is a design strategy, how good is the science/engineering background? If it is policy related explore the economic and political factors that have led to the problem? What environmental and social costs are involved? What has been suggested as a solution? What have other cultures done?

**GRADING for PAPERS** (Papers can be corrected and resubmitted for regrading until finals week)

| | |
|---|---|
| 1) Innovation and thoughtfulness | 20 |
| **2) Analysis/understanding** | 20 |
| 3) Structure and order, focus | 10 |
| 4) Grammar | 10 |
| **5) Style-is it engaging, readable** | 20 |
| 6) Citations correctly used | 10 |
| **7) Quality of citations and searches** | 10 |
| Total score possible | **100 points** |
| Deductions for spelling errors or wrong words | -5 points for each word |
| Deductions for incorrect margins | -5 |
| No page numbers (handwritten doesn't count) | -10 |
| Inappropriate topic (doesn't answer question asked) | up to -30 |

Plagiarism (inappropriate copying of materials **- no points for paper, no rewrite)**

**Design project**

A design project may be substituted for the research paper or related to the research paper. This will also require good use of resource materials, development of a thoughtful and clear plan (microclimate and solar resource information may be required), cross sections, sketches (try Google sketchup), computer simulation or photographs taken with the solar simulator on a model to illustrate the solution proposed. Text will be provided to clarify challenges, uncertainty and opportunities for integrated passive solar design, placing the design project in context of site, microclimate, bioregion and community. Health, comfort and sustainability issues must be addressed.

**Grading:**

| | |
|---|---|
| Clarity | 10 |
| Problem statement | 20 |
| Discussion of challenges, uncertainty, opportunity | 10 |
| Concept development | 10 |
| Creativity | 20 |
| Refinement of final integrated solution | 30 |
| Total | **100 points** |

**Assignment #3. Presentation** **10 Points**

Presenting ideas is critical in business and community life. Your short talk can cover your research paper, design project or any other topic of relevance for the class. Choose something of interest and of value for your classmates. Try to pick a topic that you can use as a resume builder and mention in job interviews. Expect to talk for 9 minutes. Turn in your ppts or video. Your time as presenter is valuable - make sure it counts. Consider linking to facebook, blogs or ...

Grading criteria for presentation 5=excellent 4=very good 3=good 2=satisfactory 1=poor

**1. Clarity**

| | |
|---|---|
| Introduction of presenter and topic | — |
| Voice loud enough | — |
| Language clear (no stumbling over words) | — |
| Images clear and easy to read | — |
| Graphics appropriate for talk and audience | — |
| Photos and images clear | — |

**2. Content**

| | |
|---|---|
| Introduction | — |
| Relevant content (important background and key points) | — |
| Clear link of discussion to graphics | — |
| Appropriate topic for course | — |
| Conclusion | — |

**3. Connection**

| | |
|---|---|
| Eye contact | — |
| Talk to audience not to screen | — |
| Appropriate level of presentation | — |
| Ask for and respond to questions | — |

**4. Presentation**

| | |
|---|---|
| On time start and finish | — |
| Appearance of confidence | — |
| Smooth use of equipment and materials | — |
| Minimize nervous mannerisms | — |
| Appropriate clothing and behavior (no gum) | — |

**Overall score** **(maximum 100)** ___

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**Course goals for understanding**

1. Demonstration of a global outlook and understanding of passive solar architecture.
2. Understanding of the interconnectedness and interdependence of windows, thermal mass, building shell, microclimate and sun path, and occupant behavior on comfort and performance.
3. Understanding of the interdisciplinary nature of passive solar and sustainable architecture.
4. Skill in critical thinking to assess the quality of information and its importance.
5. Effective interpersonal communication with oral, written, quantitative, and computer skills.
6. Understanding of pending resource supply and climate change crises and implications of passive solar architecture for the future.

**Course objectives**

1. Integrate each student's unique experience and background into this class.
2. Understand the interaction of cultures (developed/less developed), the economy, energy, the environment, and historical and future building practices and development patterns. Relate economic and environmental constraints to the role of passive solar architecture in future development patterns, redevelopment of existing cities and buildings, and sustainability.
3. Demonstrate an understanding of the design principles of passive solar architecture in different climates.
4. Develop increased respect and understanding of traditional practices, "others" and especially the skill and intelligence needed for subsistence and survival in difficult and changing environments.
5. Apply critical analysis skills to passive solar architecture design problems, research, vendoring, and resource management.
6. Identify, interpret and present important information for classmates.
7. Understand the inter-relatedness of all things and the importance of systems thinking to solve complex problems and develop sustainable buildings and planning guidelines.
8. Learn to work well with teams in analyzing and presenting discussions and displays of important concepts in passive solar architecture.

**Course assessment**

1. Class understanding, essays, presentation, design projects, lab exercises, essay questions and exam questions and design challenges.
2. Class participation, team projects, labs, research papers and design problems, exams.
3. Communication – research, analysis and presentation of a paper to class (seminar style), in class assignments.

*Recommended books for a course resource shelf*


Allard, F. and M. Santamouris. 1998. *Natural Ventilation in Buildings*.

Argue, R. 1981. *Super-insulated Retrofit Book*.

Auliciems, A. and S. V. Szokolay. 2007 [1997]. *Thermal Comfort*. www.arct.cam.ac.uk/**PLEA**/Download.aspx?p=9&rcid=10&ix=6

Bainbridge, D. A., Corbett, J. and J. Hofacre. 1979. *Village Homes' Solar House Designs*.

Boubekri, M. 2008. *Daylighting, Architecture and Health*.

Butti, K. and J. Perlin. 1980. *A Golden Thread*.

Elizabeth, L. and C. Adams. 2000. *Alternative Construction: Contemporary Natural Building Methods*. John Wiley.

Falk, B. and B. Guy. 2007. *Unbuilding*.

Geiger, R., R. H. Aron and P. Todhunter. 2009. *The Climate Near the Ground*. Older 1950 edition on line at http://www.archive.org/details/climatenearthegr032657mbp

Givoni, B. 1994. *Passive Low Energy Cooling of Buildings*.

Gleick, P. annual. *The World's Water*.

King, B. 1997. *Buildings of Earth and Straw.*

Hillel, D. 1994. *Rivers of Eden: Struggle for Water and Quest for Peace in the Middle East*.

Mazria, E. 1979. *The Passive Solar Energy Book*.

Moore, F. 1985. *Concepts and Practices of Architectural Daylighting*.

Olgyay, V. and A. 1976. *Solar Control and Shading Devices*.

Pacey, A. and A. Cullis. 1996. *Rainwater Harvesting*.

Reynolds, J. 2002. *Courtyards: Aesthetic, Social and Thermal Delight*.

Snell, C. and T. Callahan. 2005. *Building Green*.

Steen, A. and B., D. A. Bainbridge and D. Eisenberg. 1994. *The Straw Bale House*.

Stulz, R. and K. Mukerji. 1993. *Appropriate Building Materials*.

van Dresser, P. 1977. *Passive Solar House Basics*.



see also the references and recommended reading resources in **Passive Solar Architecture**, pages 271-287

**WEB RESOURCES FOR CLASS**

http://arch.ced.berkeley.edu/vitalsigns/ Excellent resources thermal mass, air flow, whole building performance, daylighting and more (40-60 page packets)

http://www.usc.edu/dept/architecture/mbs/tools/vrsolar/Help/solar_concepts.htmlwww.ecohome.com/slsg/index.html integrated project design

www.innovativedesign.net/guidelines.htm integrated project design

www.sustainabilityleader.org true costs, triple bottom line

http://esapubs.org/bulletin/backissues/087-4/oct_web_pdfs/comment4.pdf true costs

www.paecon.net/PAEReview/issue41/Bainbridge41.pdf true costs

www.stumbleupon.com/su/2tRh7W/www.sustainabilityleader.org/Sustainability_Leader/About_me.html

http://web.me.com/davidbainbridge/Strawbalebuilding straw bale history

http://thelaststraw.org/resources/ straw bale

http://web.me.com/davidbainbridge/Waterwalls for heating and cooling

http://web.me.com/davidbainbridge/Villagehomes integrated community development

http://web.me.com/davidbainbridge/Solarhotwater ICS

www.solar-components.com/ ICS kit, excellent glazing panels, water wall storage tubes

www.builditsolar.com/Projects/WaterHeating/ISPWH/ispwh.htm integral collector SHW

www.ncdc.noaa.gov/ national climate data center

www.wunderground.com/ climate data

http://arch.ced.berkeley.edu/vitalsigns/res/downloads/rp/airflow/HEER1-BG.PDF Air flow in buildings

www.bwk.tue.nl/bps/hensen/publications/08_apen_peeters.pdf comfort

www.nrel.gov/learning/ho_passive_solar_day.html NREL resources, some very useful

http://homepower.com/home/ a range of online resources, excellent magazine

www.kyocerasolar.com/products/pv_calculator.html PV calculator with US utility costs

www.harvestingrainwater.com/rainwater-harvesting-inforesources/water-harvesting-calculations/

American Solar Energy Society www.ases.org

International Solar Energy Society www.ises.org

Passive and Low Energy Architecture www.arct.cam.ac.uk/PLEA/about.aspx?p=9&pid=9&ix=601International

Society of Building Science Educators www.sbse.org

Center for Maximum Potential Building Systems www.cmpbs.org

Development Center for Appropriate Technology www.dcat.net

International Society for Industrial Ecology www.is4ie.org

United States Society for Ecological Economics –www.ussee.org

Lifecycle and EcoIT http://www.pre.nl/

Business Action for Sustainable Development http://basd2012.org/

Sustainable Technology Education Program www.step.org

Business and sustainable development www.iisd.org/business/

Global Reporting Initiative www.globalreporting.org

Wuppertal Institute for Climate, Environment and Energy www.wupperinst.org/en/home/index.html

Sustainable Europe Research Institute www.seri.at/

German Society for International Cooperation GIZ www.gtz.ed/en/index2.htm

Whole Building Design Guide www.wbdg.org

Engineer's toolbox www.engineeringtoolbox.com

NOTE: THE EMPHASIS ON WRITING IS INSPIRED BY EXPERIENCE. ON ONE PROJECT A MAJOR PLANNING/ARCHITECTURE FIRM WAS FIRED BECAUSE THEY WERE UNWILLING TO SPELL CORRECTLY. THIS WAS ALSO A PROBLEM IN A DESIGN CONTEST WE CONDUCTED TO SELECT AN ARCHITECTURAL FIRM FOR ANOTHER PROJECT — ABOUT HALF THE SUBMISSIONS WERE RIDDLED WITH ERRORS.
IMPROVING CRITICAL THINKING SKILLS IS ALSO IMPORTANT. TOO MANY STUDENTS ARE VERY UNCRITICAL OF SOURCES OF INFORMATION AND VENDOR CLAIMS FOR PRODUCTS. THEY CAN BE TAUGHT TO BE MORE EXPERT AT DETERMINING THE QUALITY OF INFORMATION AND THE QUALITY OF PRODUCTS AND VENDORS.

# Acknowledgements

With thanks to our partners, friends, students and colleagues who have taught, enlightened, and supported us over the years.

DB Special thanks for review by my brother Bob who taught architecture and planning for many years. And to our father for showing us that design, building, inventing and research is entertaining if not rewarding. His was perhaps the only home shop with a homebuilt mass spectrometer.

Dave's parents building their home in Colorado.

Data analysis in the old days, multi-pen recorders and endless rolls of paper Dave

Still much to be learned, this straw bale arch with Ken and Polly Cooper. was built for fun one day. The arch snapped through in a ground shaking collapse due to uneven footings and lack of reinforcing pins.
Be careful out there!