Sustainable Facility Guide

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Sustainable Facilities Guide

Sustainable: Meeting present needs without compromising the ability of future generations to meet their own needs.

- Worldwatch Institute

"The biggest problem is that we architects have been using too narrow a balance sheet to evaluate our decisions. That sheet is not complete; it doesn't include total efficiency and environmental costs. A building may be cheap and pretty, but will it go on to become an environmental and financial burden to those who occupy and maintain it?"

- Randolph Croxton
The Croxton Collaborative Architects

OVERVIEW

Over 30% of America's total energy usage, 60% of it's electricity and financial resources, and 26% of the contents of its landfills are linked to buildings. A total of 54% of the energy used in the United States is attributed to the built environment. Moreover, 80% of the average American's time is spent inside. Thus, enhancing the energy efficiency and the environment in buildings is a powerful way to save money, clean up the environment, and improve the quality of life.

Buildings represent more than 50 percent of the nation’s wealth. In 1993, new building construction and renovation amounted for $800 billion, about 13% of the gross domestic product. New construction, renovation and maintenance of our existing buildings require the expenditure of greater and greater resources.

In the past the expenditure of resources was inevitably linked to a commensurate amount of ecological damage. Each step from extracting natural resources, to converting resources to products, to transporting products to a construction site and then throughout a building’s life, has also had an ecological and financial cost. Finally when a building has served it’s useful life, most of the materials that went into its construction end up in the landfill.

It doesn’t have to be this way.

The overarching goals of Sustainable Facility Design are to create buildings that are warm in winter, cool in summer, and comfortably illuminated; that promote the health and well being of occupants; and that are resource efficient to build and operate. This guidebook will show that these common sense goals are achievable today using "off the shelf" technologies.

A sustainable facility shall:
- use land wisely
- use energy water and materials efficiently
- enhance human health and well being
- be economical to operate

- promote recycling

Sustainable (or green) buildings cost about the same as conventional buildings and reduce costs in the long run. For example, increased insulation can reduce the cost of mechanical systems. Smaller mechanical systems can use smaller ducts; smaller ducts can reduce the size of a ceiling cavity, thus reducing the overall size of a building. The simple decision to increase insulation can have a significant impact on the overall cost of a building if the designer follows the implications of that decision. Another example is choosing energy efficient, high-quality lighting. If lighting quality is good, it requires less energy to provide the same level of visibility.

Sustainable buildings are less expensive to heat, cool, and light. Because they use less energy, they produce less pollution. What is more important, sustainable buildings are healthier places in which to work and live. Case studies by the Rocky Mountain Institute, a national organization considered a leader in sustainability, show a direct relationship between energy efficiency, indoor air quality, and lighting on one hand and human health and productivity on the other.

So, if sustainable buildings save money and promote health and productivity, why aren't all buildings designed in this manner? In short, the incentive isn't there. Architects and engineers often work in a fee-competitive environment. Building codes establish the <u>minimum</u> standard for construction, and we design to that minimum. The building code doesn't address what could be the optimum building; it addresses the minimum. Said another way, the code is the standard where if you built a building cheaper, it would be against the law.

In a parallel example, it takes roughly the same amount of material to make a Mercedes Benz as it does to make a Ford. The only real difference is the engineering and design. In construction, we ask our designers to compete for the least fee. The design fee turns out to be a pretty good determination of the amount of effort the architect/engineer (A/E) will put forward for a project.

Sustainable design is the thoughtful integration of architecture with electrical, mechanical, and structural engineering. In addition to concern for the traditional aesthetics of massing, proportion, scale, texture, shadow, and light, the facility design team needs to be concerned with long term costs: environmental, economic, and human.

The Rocky Mountain Institute outlines five principles for sustainable design:

1. Planning and design should be thorough. Sustainable design is "front loaded" compared with traditional design. Early decisions have the greatest impact on energy efficiency, passive solar design, daylighting, and natural cooling.

2. Sustainable design is more of a philosophy of building than a prescriptive building style. Sustainable buildings don't have any particular look or style.

3. Sustainable buildings don't have to cost more, nor are they more complicated than traditional construction.

4. Integrated design, that is design where each component is considered part of a greater whole, is critical to successful sustainable design.

5. Minimizing energy consumption *and promoting human health* should be the organizing principles of sustainable design. The other elements of design can be organized: energy saving architectural features, energy conserving building envelope, and energy-efficient and health-promoting mechanical, electrical, and plumbing systems.

The U. S. Air Force has implemented some strategies to save energy and prevent pollution in the planning, design, construction, operations, and maintenance of many facilities. By considering how each phase relates to all the others, the USAF will realize the benefits of synergy and come closer to the goal of creating environmentally sustainable facilities.

Sustainable design requires an integrated-systems approach to creating the built environment. In addition to realizing the programmatic goals for the facility, the term A/E should coordinate siting and landscaping decisions; mechanical, electrical, and structural engineering; thermal envelop, daylighting, and fenestration design; materials selection; indoor air quality considerations; and life cycle costs to create a cost effective, energy efficient building.

SUSTAINABLE DESIGN TOOLS

The goals of sustainable design are both altruistic and pragmatic. By making buildings that use less energy, we save costs and we protect the environment. But what tools do we have to make buildings this way? Two of these tools are energy modeling, where buildings are “built” as computer models and evaluated for their energy performance, and lifecycle cost analysis, where materials and systems can be analyzed for their overall impact on the environment.

Energy Modeling

Energy modeling, that is using an advanced computer model of a proposed building, helps architects and engineers find the best combination of materials and systems. An energy model does not necessarily contribute to an energy efficient building. An energy model is a prospecting tool which in the hands of a dedicated user can indicate which combination of building strategies is most likely to produce an energy efficient building. A properly constructed energy model will allow the design team to vary several different aspects of the construction and evaluate the impact these changes would have on the bottom line. Suggested parameters for computer modeling are: daylighting, office equipment power density (plug loads), chiller size, heat plant size, glazing, shading, insulation, and air tightness. When energy modeling, be creative, push the envelope, try new things. Read case studies of very efficient buildings (See Rocky Mountain Institute in Resources Section) and try to emulate their success.

All new buildings and remodeling projects should be modeled on the computer in a way that allows the facility design team to iterate quickly through several energy scenarios. Smaller buildings can be modeled using simple programs such as the Passive Solar Industries Council "Energy 10" software; larger buildings should be modeled using more capable software such as the Department of Energy program DOE-2. Computer models are invaluable in sizing equipment for large atria and multi- story spaces. (See Resources section.)

The facility design team shall analyze their design using DOE-2 or other approved building modeling software. The computer model should be used to provide a cost/benefit analysis from the early design stages through completion of construction documents. The facility design team shall make print-outs of the computer models available for review and comment at 30%, 60%, 90%, and 100% completion.

The facility design team shall, as a minimum standard, follow but not necessarily participate in the Department of Energy Green Lights program and the Energy Star Building programs.

Software

Blast

Performs hourly simulations of buildings, air handling systems, and central plant equipment in order to provide mechanical, energy and architectural engineers with accurate estimates of a building's energy needs. The zone models of BLAST (Building Loads Analysis and System Thermodynamics) are based on the fundamental heat balance method, are the industry standard for heating and cooling load calculations. BLAST output may be utilized in conjunction with the LCCID (Life Cycle Cost in Design) program to perform an economic analysis of the building/system/plant design.

Climate Consultant

Graphically displays climate data in dozens of ways useful to architects including temperatures, wind velocity, sky cover, percent sunshine, psychrometric chart, timetable of bioclimatic needs, sun charts and sun dials showing hours when solar heating is needed and when shading is required. The psychrometric analysis recommends the most appropriate passive design strategy as outlined in Man, Climate and Architecture by Givoni. It also develops the kind of data incorporated in Climatic Design by Watson and Labs.

DesiCalc

Allows users to easily run hour-by-hour simulations to compare the energy needs and costs of using desiccant-based equipment with those of competing electric air-conditioning equipment. The tool provides templates for 11 building types and annual weather data sets for 236 U.S. locations. The tool is fast, user friendly, and Windows-compatible. This software, available on CD-ROM, projects potential energy and cost savings provided by using desiccant-based equipment.

Energy-10

Design tool for smaller residential or commercial buildings that are less than 10,000 ft2 floor area, or buildings which can be treated as one or two-zone increments. Performs whole-building energy analysis for 8760 hours/year, including dynamic thermal and daylighting calculations. Specifically designed to facilitate the evaluation of energy-efficient building features in the very early stages of the design process.

LCCID

Comparison and evaluation of the economic feasibility of building options, including energy conservation, competing for capital investments. LCCID (Life Cycle Cost in Design) can analyze all building types (proposed or existing), sources of energy (electricity, gas, oil, etc.), and other cost issues (maintenance and repair, disposal, equipment replacement). Results of the life cycle analysis can illustrate least overall cost options as well as showing ranking of various options at the building cost level. Designed for use in federal sector life cycle costing, as required by law and Executive Order. Can be used as general life cycle costing analysis tool. Has option for the Energy Conservation Investment Program (ECIP) reporting requirements.

SunAngle

Calculates solar angles based on location, date, and time. It's useful in passive solar building design, PV and solar thermal system design and analysis, and other applications such as photography.

http://www.susdesign.com/sunangle

TRACE 600

Lets you model virtually any building, air handling system, heating or cooling equipment, and economic/utility scenario - then helps you quickly compare them. TRACE 600 (Trane Air Conditioning Economics) lets you model virtually any building, air handling system, heating or cooling equipment, and economic/utility scenario - then helps you quickly compare them. The program takes you step by step from basic building parameters, such as geographic location (TRACE 600 includes over 480 global weather profiles), to powerful system modeling, such as ice storage systems.
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Streamline data entry using extensive pre-built libraries and "master cards." Apply any one of seven different ASHRAE cooling-and-heating-load calculation methodologies, including ASHRAE's Exact Transfer Function Methodology. Design ASHRAE Standard 62 compliance into your occupied spaces. Optimize your cooling tower. Model complex equipment plants including decoupled chiller systems with heat recovery. Analyze the effects of cogeneration, variable-frequency drives, and daylighting.

TRACE Load 700

Combines the power of the building and load design portions of TRACE 600 with the simplicity of a Windows-based operating environment. Like its predecessor, TRACE Load 700 uses ASHRAE-standard algorithms to assure calculation integrity. It also enables nonsequential data entry that encourages -what if- analysis. You can edit building construction details in any order and easily change the building model as the design progresses. The extensive predefined (but editable) libraries and templates of construction materials and building load information increase the speed and accuracy of the modeling process. You can export the completed project file to TRACE 600 for a detailed energy analysis.

VisualDOE

Windows interface to the DOE-2.1E energy simulation program. Through the graphical interface, users construct a model of the building's geometry using standard block shapes or using a built-in drawing tool. Building systems are defined through a point-and-click interface. A library of constructions, systems and operating schedules is included, and the user can add custom elements as well. If desired, the program assigns default values for parameters based on the vintage and size of the building. VisualDOE is especially useful for studies of envelope and HVAC design alternatives. Up to 20 alternatives can be defined for a single project. Summary reports and graphs may be printed directly from the program. Hourly reports of building parameters may also be viewed.

BTS: Building Energy Software Tools

http://www.eren.doe.gov/buildings/tools_directory/database/page.cfm?Desc=Alphabetical+List

Life Cycle Analysis /Environmentally Preferable Purchasing

Life cycle analysis (LCA) uses a whole-systems approach to examine all elements, processes, inputs, and outputs that go into making any item. In the context of sustainable design and construction, LCA is used to discover the total impact any materials or system might have on the environment. LCA covers “cradle to grave” analysis from raw materials acquisition to manufacture to installation and finally re-use, recycling, or disposal. LCA as outlined in the American Institute of Architects Environmental Resource Guide covers:

1. Goal setting, where objectives are set
2. Inventory, quantifying raw materials and energy used at all stages of manufacture plus quantifying output materials and by-products and pollutants
3. Impact Assessment, which characterizes and evaluates the ecological impact and health impacts of energy, resource, and waste identified in steps 1 and 2
4. Alternatives assessment, which evaluates opportunities for prevention or reduction of environmental costs.

The A/E Design Team and Environmental Flight shall review all materials for their life cycle cost and embodied energy, with the goal of reducing the total energy usage over the life of the building.

Much life cycle analysis of building materials and methods of construction has been done and is available for evaluation. The criteria used to evaluate materials vary, depending on the parties performing the analysis. (See "AIA Environmental Resource Guide 1996, Appendix A" in the Resources section.)

Environmental Executive Orders

The Executive Orders listed below provided additional incentives for DOD’s incorporation of environmentally preferable purchasing language in its ID/IQ construction contract. To obtain copies of the Executive Orders, please visit <www.pub.whitehouse.gov/search/executive-orders.html>.

• Executive Order 13123, Greening the Government Through Efficient Energy Management, June 8, 1999: This order strengthened and replaced several Executive Orders in place during the early phases of DOD's ID/IQ construction contract planning, including Executive Order 12902, Energy Efficiency and Water Conservation at Federal Facilities, and Executive Order 12845, Requiring Agencies to Purchase Energy Efficient Office Equipment. Executive Order 12902 mandated energy and water conservation in federal buildings and directed agencies to make profitable investments in energy efficiency to benefit the environment and the economy. It also directed agencies to designate a “showcase” facility incorporating these measures. Executive Order 12845 mandated that federal agencies purchase personal computers, monitors, and printers that meet EPA Energy Star requirements for energy efficiency, and “sleep” when they are inactive to conserve additional energy.

• Executive Order 13101, Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition, September 14, 1998: This order strength-ened and replaced an earlier order, Executive Order 12873, Federal Acquisition, Recycling and Waste Prevention. Executive Order 12873 required Federal agencies to purchase recycled-content products designated by EPA and to buy other environmentally preferable products according to guidance developed by EPA's EPP Program.

• Executive Order 12856, Federal Compliance with Right-To-Know Laws and Pollution Prevention Requirements, August 3, 1993: This order directs agencies to cut toxic emissions 50 percent to improve indoor and outdoor air quality.

Software

There is a powerful technique for selecting cost-effective, environmentally preferable building products. BEES (Building for Environmental and Economic Sustainability) is based on consensus standards and designed to be practical, flexible, and transparent. The Windows-based decision support software, aimed at designers, builders, and product manufacturers, includes actual environmental and economic performance data for a number of building products.

BEES measures the environmental performance of building products by using the environmental life-cycle assessment approach specified in the latest versions of ISO 14000 draft standards. All stages in the life of a product are analyzed: raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Economic performance is measured using the ASTM standard life-cycle cost method, which covers the costs of initial investment, replacement, operation, maintenance and repair, and disposal. Environmental and economic performance are combined into an overall performance measure using the ASTM standard for Multi-Attribute Decision Analysis. For the entire BEES analysis, building products are defined and classified according to the ASTM standard classification for building elements known as UNIFORMAT II.

BEES, Building Energy Software Tools

http://www.eren.doe.gov/buildings/tools_directory/software/bees.htm

SUSTAINABLE DESIGN PROCESS

The process of creating and sustaining our built environment contributes significantly to global environmental problems. As we move toward more sustainable methods of construction, we must re-evaluate the processes by which we design.

The sustainable design process differs from current design practices in that it is more collaborative and there is a greater emphasis on building science and engineering.

Healthy Buildings

Building ecology refers to the constructed environment inside a building as it relates to human health. Building ecology is concerned with indoor air quality, acoustics, and daylight. Building ecology is effected by a number of constituents: overall building tightness, heating, cooling and ventilation systems, interior finishes, adhesives, cleaning, and maintenance.

Indoor Air Quality

The air inside buildings has been measured to be worse than the polluted air outside. Building elements, particularly new building elements, "offgas" or emit chemical compounds. Adhesives, paints, particleboard, carpeting, vinyl flooring, and furnishings can contribute significantly to the airborne contaminants found inside new buildings.

The facility design team shall design a building that promotes indoor air quality through the selection of nontoxic and least toxic building materials and through the design of mechanical and electrical systems that circulate and evenly distribute fresh, clean air.

The steps to promote good quality indoor air are:

1. Minimize the sources of off gassing. Select low- or zero-VOC (volatile organic compound) paints and adhesives.

2. Provide a source of clean fresh air.

3. Design good ventilation into habitable rooms.

4. Design a good air filtration system.

5. Choose low-VOC emitting furnishings.

6. Choose nontoxic cleaning products.

7. Regularly clean high-humidity areas so mold and mildew can't develop.

8. Monitor the facility for leaky pipes and roof leaks.

Acoustics

The acoustic performance of a space can contribute to an occupant's feeling of well being. Unwanted noise can create conditions that make it difficult to concentrate. Consider acoustically isolating a building from its environment if that environment is too noisy.

Acoustic nuisances include mechanical system noise, plumbing noise, and electrical noise. Acoustic privacy, that is the ability to speak without being overheard, is desirable but rarely achieved in environments that use systems furniture.

The Value of Daylight

Daylight is an important factor in a building's environmental performance. If properly used, daylight can reduce electrical demand, reduce cooling requirements, and contribute to improved occupant performance. (See Rocky Mountain Institute reference in Resources section.)

Environmentally Responsible Materials

Specifying recycled content construction materials is one of the easiest first steps an A/E can take to improve the environmental impact of a building.
Recycled content construction materials require less energy to produce than their virgin material counter parts, and they reduce our demand for raw materials. Specifying recycled content construction materials creates greater demand, thus stimulating the infrastructure for recycling.

The facility design team shall incorporate recycled content construction materials wherever possible if these materials perform as well, involve comparable costs, and can be delivered as timely as conventional construction materials. EPA's "Guideline for Procurement of Building Insulation Products Containing Recovered Materials" (40 CFR 248) requires that any procuring agency using Federal funds to procure the item(s) containing the highest percentage of recovered materials practicable. The facility design team should also follow the EPA 24 Guidelines for recycled content construction materials.

Specific recycled content construction materials can be researched by using the Harris Database, the REDI guide, and the National Park Database. (See resources section of this Guide.)

In the planning phase of a project the A/E should make a list of materials most likely to be used for the project. Check those against materials listed in the Harris Database. Of the materials available with recycled content, choose materials that perform well in terms of cost, durability, fire resistance, and energy performance.

Recycling

An in house recycling system should be considered from the onset of the design. In large multi story building, a system of chutes can carry recyclables to a central processing area. Loading docks should be designed to allow space for recycling containers. In low-rise buildings consider locating recycling stations at strategic locations throughout the building.

Other considerations: Will there be a need for recycling bins or special containers? Will carts be used to collect recyclables or will each individual be responsible for taking recyclables to a central location?

Maintenance

"No maintenance, no building"
-Stewart Brand

Building maintenance is critical to the long-term success of any facility. If a building is sustainably designed and built, it needs to be thus maintained. If a roofs leaks or furnace filters go unchanged or lights are not properly maintained, the resulting poor quality air or bacteria growing in the insulation or poor quality light will negate much of the positive effect of building in a sustainable manner. This is not to say that sustainable facilities are more susceptible to poor maintenance, rather that good maintenance is rare.

The people who are actually maintaining the building should be considered from the beginning of a project. Facilities managers, operators, and maintainers should take part in determining materials to be used and in determining maintenance protocols using nontoxic and least-toxic cleaning materials. Facilities maintainers should identify, budget, and purchase the proper materials to ensure optimal efficiency.

The facility design team shall create a facility maintenance and operation manual covering optimal operation of mechanical and electrical equipment and methods of cleaning using nontoxic cleaning agents. Incorporated into this manual should be manufacturer's literature and operation manuals.

Light cleaning and replacement schedules should be determined as part of the design process. Replacement lamps should be matched for color to maintain even lighting. Sometimes high-quality fluorescent tubes are replaced with cheap ones, thereby degrading the light quality, reducing visibility, and increasing energy use. Since energy-efficient lamps are changed less often, they should be cleaned regularly to reduce dust build-up and lamp lumen depreciation. The heating, ventilating, and air conditioning (HVAC) system should be maintained regularly: replacing filters, checking programmable thermostats, and reviewing energy control systems.

MATERIALS AND METHODS

" The fusion of the built environment and the natural landscape can enrich both the human spirit and the diversity of nature."
- Bruce Babbitt, U.S. Secretary of the Interior

The materials and methods of construction chosen for a project have a significant impact on the overall ecological performance of a building. Lifecycle cost analysis is an important tool for determining the relative value of using one product instead of another.

Several resources are available to aid in materials selection. The American Institute of Architects Environmental Resource Guide (ERG) covers materials selection and lifecycle cost analysis. The ERG contains information about hundreds of building materials in generic terms. The Harris Directory of Recycled Content Construction Materials contains information about thousands of different recycled content construction materials, listed by manufacturer's name and searchable by name, manufacturer, or CSI division. The REDI guide is a listing of recycled content materials; low-toxicity materials, sustainably harvested wood, and materials made from “natural” resources. These resources and others are listed in the Resource section of this guide.

Construction Recycling

Considerations
The cost of construction site recycling is dependent on local conditions. Several national studies of construction site recycling show that it is cost neutral or even profitable to set up a construction site recycling program in most parts of the country.

Demolition projects should be undertaken with the goal of salvaging as much material as possible. Studies show that careful salvage of existing structures reduces the total cost of demolition while diverting significant amounts of materials from the landfills. (See resources section of this Guide.)

Recommendations
1. Reduce construction waste --
    --Avoid damage to materials on site. Store materials per manufacturer recommendations.
    --Avoid contamination of materials to be recycled.
    --Use materials efficiently. The facility A/E should design in a modular fashion. The contractor should encourage site crews to make use of scraps and use less materials overall.
    --Estimate the quantity of materials accurately
    --Design with precut and prefabricated components.
    --Choose strong durable materials.

2. Reuse --
    --Use salvaged materials
    --Reuse job site materials such as concrete forms or site fencing

3. Recycle --

--Construction site recycling programs shall be considered for all construction projects. Many recyclable materials are generated on a construction site. Use the Recycle Plus program manual or WasteSpec to set up a construction site recycling program.

Materials commonly recycled:

New Construction

Site:
Asphalt
Brick and Aggregate Materials
Land Clearing Debris
Topsoil

Construction:
Cardboard
Metals
Non-ferrous metals
Wood
Form Lumber
Pallets
Plastics

Finishes:
Cardboard
Carpet and Pad
Drywall
Pallets
Plastics/films

Misc:
Aluminum Beverage Cans
Office Cardboard
Office Paper

Demolition / Remodel Projects

Site:
Asphalt
Brick and Aggregate Materials
Land Clearing Debris
Rebar
Topsoil

Construction:
Cardboard
Metals
Non-ferrous metals
Wood
Form Lumber
Pallets
Plastics
Electrical wire, conduit, fixtures
Plumbing Fixtures

Finishes:
Appliances
Cabinets
Cardboard
Doors + Frames
Windows + Frames
Ductwork
Millwork
Siding
Flooring

--Participate in manufacturers "take back" programs. Some manufacturers of carpeting, drywall, ceiling tile, brick, concrete block and structural insulating panels will take back clean scrap material left over from construction.

Division 1- General Considerations

Considerations

The sustainable design process is characterized by teamwork, including the architects, engineers, construction agents, and facility managers. At several points during the design and construction of a new facility or renovation, the design team should meet to evaluate the work with respect to goals established for the project.

Clear communication of sustainable goals and methods is imperative. The design and construction team must take the time to educate construction trades people to insure their “buy in” to the program. A single sub contractor using unspecified materials or adhesives can foul the best intentions.

The following table chronologically organizes the sustainable design and construction process. This table should serve as a checklist of actions, goals and deliverables.

Phase	Team	Action
Pre-design	Architect Mechanical Engineer Electrical Engineer Occupants Programmer	• Identify basic elements and establish a structure for gathering information. • Document existing building conditions. (if applicable) • Describe overall building requirements • Describe project in relation to surroundings, site, climate and community. • Summarize requirements of codes, covenants and legal restrictions and zoning. • Define a comprehensive list of environmental / sustainability goals. • Collect existing information: site plan, topographic plans utility information, environmental baseline study, legal description. **Goals and Objectives** • To understand who the building is to serve • To understand programmatic goals and constraints. • To establish a comprehensive list of sustainability goals specific to project. **Phase Deliverables** • Outline program of project, approximate size, code requirements and sustainability goals.

Phase	Team	Action
Siting	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Community Planner Programmer Base Environmental Personnel	• Produce a geotechnical/soils report. • Create a site inventory. Identify vegetation, wildlife habitat interesting landforms, areas to be preserved. • Collect climate information, solar, temperature, wind, humidity, precipitation, and dominant weather patterns. • Identify how site effects energy. • Identify daylighting options. Identify average hours of daylight throughout year. • Identify impact of proposed structure on microclimate. • Identify impact of proposed structure on utilities and infrastructure. • Identify options for massing the building on site. • Identify archeological, cultural and historical concerns regarding the use of this site. • Test site for radon if in a region with potential for radon contamination. • Identify location of building within infrastructure. • Establish water conservation measures. • Identify site air quality issues. • Use integrated pest management techniques .

Goals and Objectives

- To match a building's form to it's site.
- To minimize building's negative impact on site.
- To take advantage of renewable energy available at site.
- To understand if site is appropriate for proposed development.
- To minimize / eliminate permanent irrigation systems.

Phase Deliverables

- A geotechnical /soils report.
- A site inventory.
- A climate information report.
- A water conservation measures report.

Phase	Team	Action
Programming	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Community Planner Programmer	• Prepare a listing of space requirements. • Prepare a space requirements program. • Develop adjacency requirements. • Define a program for the facility. • Establish design lighting levels for each space. • Establish design mechanical system energy usage. • Establish energy use budget. • Identify methods for handling solid waste - during construction and post construction. • Identify existing infrastructure for recycling. • Evaluate local recycling opportunities. • Establish waste reduction goals for construction. • Establish waste reduction goals for occupancy. • Establish spatial needs for waste handling. • Identify site features to be protected during construction. • Establish Indoor Air Quality Goals.

Goals and Objectives

- Establish goals for lighting levels.
- Establish goals for mechanical system energy usage.
- Create a diagram showing optimal relationship between different components or departments.
- Establish waste reduction goals for construction.
- Establish waste reduction goals for occupancy.

Phase Deliverables

- A space requirements program.
- Design criteria for lighting, mechanical and plumbing.
- An energy use budget.
- Indoor air quality goals.
- Waste reduction goals.

Phase	Team	Action
Space Schematics Flow Diagrams	Architect Mechanical Engineer Electrical Engineer Occupants	• Create diagrams showing proposed spaces and their adjacency requirements.
Schematic Design	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Contractor Base Environmental Personnel	• Create a layout that best serves the client. • Optimize layout for energy consumption. • Design for daylighting. • Choose materials appropriate to program, site, climate and context. Cross reference these materials with known resource efficient materials. Refer to materials section of this guide. • Identify probable construction costs. • Establish preliminary LCA life cycle costs of proposed materials and building systems. **Goals and Objectives** • To create preliminary LCA of the proposed building. • To minimize impervious paving and construction. • To minimize disruption to existing vegetation, water flow, and topography. • To create a preliminary energy model of the proposed building. **Phase Deliverables** • Preliminary energy model. • Preliminary LCA of materials and systems.

Phase	Team	Action
Design Development	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Contractor	• Develop energy model of proposed building. • Create master list of materials • Create master list of lighting fixtures • Create master list of mechanical fixtures • Create master list of plumbing fixtures • Create elevations and floor plans. • Perform a daylight study of the proposed building. • Optimize building insulation. • Optimize fenestration. • Consider shading, light shelves and sun controls. • Consider natural ventilation and operable windows. • Minimize air infiltration. • Establish plug loads.

Goals and Objectives

- To define all important aspects of the construction.
- To identify all materials based on LCA.
- To identify insulation levels, fenestration characteristics,
mechanical, plumbing and electrical systems based on LCA and energy modeling.

Phase Deliverables

- An energy model of building.
- Master lists of materials, lighting fixtures, mechanical systems and plumbing fixtures.
- A LCA report on materials and building systems.
- A daylight study of proposed building on the site.

Phase	Team	Action
Construction Documents	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Contractor	• Create final materials selection list. • Create a final computer model with written analysis • Detail project for ease of construction. • Detail building to minimize thermal bridging. • Specify a construction site recycling program. • Specify landscape maintenance program. **Goals and Objectives** • To have construction documents and details that achieve goals stated in Schematic Design. **Phase Deliverables** • Final materials selection list. • Final computer model with written analysis

Phase	Team	Action
Bidding and Negotiations		• Communicate clearly with all subcontractors and suppliers about sustainability goals.
Construction Contract Administration	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Contractor Base Environmental Personnel	• Outline specific sustainable features and methods of construction and present at pre-construction meeting. • Require Indoor Air Quality management plan for construction. Refer to "IAQ Guidelines for Occupied Buildings Under Construction" issued by SMACNA. • Perform pre-occupancy IAQ testing • Establish construction site recycling program. • Avoid unnecessary compaction of soils. • Develop storm water pollution prevention program. • Implement a construction site recycling program. **Goals and Objectives** • To have construction achieve sustainable goals outlined in Schematic Design. • To achieve stated goals of construction site recycling. **Phase Deliverables** • Indoor Air Quality management plan. • Pre occupancy IAQ test report. • Storm water pollution prevention program.

Phase	Team	Action
Post Construction	Architect Mechanical Engineer Electrical Engineer Occupants Landscape Architect Civil Engineer Contractor Base Environmental Personnel	• Establish maintenance schedules for mechanical, plumbing and electrical systems. • Establish non toxic cleaning protocols • Start up building recycling program. • Provide training for facilities operations staff. • Provide a comprehensive Operations and Maintenance manual which explains why as well as how to maintain existing facilities. • Perform a post occupancy evaluation of design and sustainable features.

Goals and Objectives

- To maintain building in optimal condition.
- To achieve "buy in" for sustainable goals by operations staff.
- To learn which materials and systems perform best.

Phase Deliverables

- Training of operations staff
- Operations and Maintenance Manuals.
- Post occupancy evaluation report.

Division 2 - Sitework

" The fusion of the built environment and the natural landscape can enrich both the human spirit and the diversity of nature."
- Bruce Babbitt, U.S. Secretary of the Interior

Considerations

Sustainable site design does not impose a building design on a site, rather the site informs the design with its unique ecological and cultural status. Sustainable site design integrates the building, environment and site into a coherent whole.

Site design has significant impact on a building's performance. Public access, handicapped access, energy conservation, water conservation, active and passive energy systems, and appropriate materials selection are all influenced by site design. Much of a building's energy can be derived from the site by using passive and active solar strategies, orienting the building to take advantage of the prevailing winds and using daylighting strategies.

The amount of material used for sitework varies considerably with location, climate, zoning, and regulations. Often more material is used in sitework than in constructing a facility. Choose site materials -- asphalt, concrete, paving stones, gravel, and topsoil -- that are durable and have low embodied energy and high recycled content.

Strive to upset as little of the site as possible. In an ideal world, all water that falls on a site would be allowed to percolate into the aquifer or flow off the site in the same manner as it did prior to construction. This is seldom achievable; therefore, try to minimize the amount of hard surfaces and paving and allow water to perk into the aquifer wherever possible.

Long term maintenance should be considered when choosing landscaping materials and plantings.

Recommendations

1. Identify microclimate data: topography, hydrology, solar radiation, prevailing winds, passive heating and cooling potential.

2. Design the site plan to minimize paved areas and building footprint.

3. Interface with the local transportation system.

4. Develop previously disturbed sites.

5. Modify microclimates to maximize human comfort outdoors. Encourage public use of outdoor space.

6. Research and design with glass cullet, recycled asphalt, or crushed concrete as backfill material.

7. Wherever practical allow storm water to percolate into the aquifer on site. If storm water run off is unavoidable, use natural filters such as grasses.

8. Encourage the use of native planting. Select and place new plants to blend with the existing ecosystem. Planting should be water-efficient and attractive. Use organic fertilizers or pesticides. Use integrated pest management to accomplish pest control. (See DoDI 4150.7, DoD Pest Management Program.)

9. Use plantings to encourage a desirable microclimate around the facility. Shade the building and adjacent paved surfaces to reduce the heat load from summer sun. Consider earth berms for control of view, winter wind, and unwanted noise.

10. If available, layer compost from the Base into the topsoil.

11. Protect existing natural conditions as much as possible during construction.

12. Prepare protocols for site maintenance to reduce material toxicity, minimize virgin materials used, and minimize waste. Compost on-site vegetative waste.

13. Avoid making “heat islands” where dark paving and dark roofs heat the surrounding air.

Division 3 - Concrete

Considerations

Minimize the use of concrete whenever possible because the production of concrete releases greenhouse gases. If you must use concrete, specify carefully to insure durability. Where concrete is specified, Federal facilities are required to use EPA Guideline Items, which state that concrete must contain coal fly ash or blast-furnace slag.

Cement manufacture is the most energy intensive process in the production of concrete. Ready-mix concrete has an embodied energy ranging from 1,138,000 Btu/cu yd to 2,594,338 Btu/cu yd.

Fly ash, a waste product from coal fired power plants, can be put to good use in concrete. Over 84,000,000 tons of fly ash are produced in the United States every year. This waste material can replace up to 30% of the Portland cement without negatively impacting strength or workability. The final product will take a little longer to cure and has slightly different workability characteristics.

Recommendations

1. Specify recycled content concrete. Concrete can have recycled crushed concrete as part of it's aggregate and it can have fly ash, a by-product of the coal fired combustion process. The facility design team should be aware of ASTM - C-618 for type C or F fly ash. (See EPA recycled content guidelines.)

2. Concrete reinforcing steel in the United States is universally made from 90+% recycled content.

3. Expansion-joint filler should be made with a minimum 80% recycled content.

4. Where possible, reduce the amount of material used by substituting concrete block for poured concrete walls or use autoclaved aerated concrete (AAC). (See recommendations in Division 4 - Masonry.)

5. The facility contractor shall plan concrete work such that small excess amounts of concrete can be utilized on the project otherwise arrange for concrete plant and transit company will accept return concrete for remixing.

Division 4 - Masonry

Considerations

Brick masonry consumes 8,000,000 Btus per ton to manufacture.

Concrete block consumes 1,500,000 Btus per ton to manufacture.

A number of new technologies and products are becoming available in the United States that offer good alternatives to traditional concrete block. Autoclaved aerated concrete (AAC), wood fiber and concrete blocks, and expanded polystyrene foam form blocks all show promise as economical and sound alternatives to concrete block.

AAC has been used for condominium projects, apartments, and single family residences in the Southeast. Expanded polystyrene foam form blocks are used throughout the Midwest and along the East Coast. All of these technologies have been used in the 21st Century Townhouse project, which was sponsored by the EPA and the National Association of Home Builders. (See Resources section.)

Recommendations

1. Specify concrete masonry with recycled content. The amount varies, depending on local availability. This will require making calls to local block manufacturers.

2. Consider transportation costs.

3. Where possible, instead of using concrete block, use a material with lower embodied energy and higher thermal performance, such as recycled brick, wood stud construction, metal stud construction, or Structural Insulating Panels (SIPs).

4. In the southeastern United States, AAC is available. This material works much like concrete block and in addition it has a relatively high "R" value, about R = 1.5 per inch of thickness. Mortar, stucco, and grout all have to be designed to match AAC's low modulus of elasticity, but AAC uses less material than concrete or concrete block.

Division 5 - Metals

Considerations

Steel requires 22,000,000 Btus per ton to produce from ore. Producing steel from recycled materials requires less than half of that energy. High-quality framing steel made with 98% recycled content is available from small mills. Reinforcing steel is most commonly made up of 90% + recycled content.

Aluminum made from bauxite requires 103,500 Btus per ton. Aluminum made from recycled scrap requires about 20,000 Btus per ton, savings of almost 80%. At present about 27.5% of aluminum is recycled. Eighty percent of all aluminum used in construction is considered easily recovered in the demolition/recycling process.

Recommendations

1. The project A/E should specify framing steel with 98% recycled content. Steel studs should be specified with 50% recycled content.

2. Specify aluminum with recycled content. Keep in mind that many alloys of aluminum cannot be made from 100% recycled content.

Division 6 - Wood and Plastic

Considerations

Wood is a renewable resource. Forest management and timber harvesting practices must take into consideration biodiversity and future resource demand. The practices of clear-cutting forests and mono-cropping single species of fast- growing pulp trees lead to overall environmental degradation.

The embodied energy in wood framing is about 91,618 Btus per cubic foot or 5,726,000 Btus per ton.

The production of melamine resin used in plastic laminates requires 97,000,000 Btus per ton. The production of phenolic resins used in plastic and in particleboard requires 75,800,000 Btus per ton.

Plastic laminates are relatively inert and as such don't contribute to indoor air emissions.

Recommendations

1. Recycled content plastic/wood is a new material. Special care should be taken to design to the limitations of this material: Unless otherwise noted, plastic/wood is subject to creep deformations; the specific product should be checked for whether it can be joined to other materials and whether cutting alters its appearance unacceptably.

2. Structural insulating panels (SIPs) should be considered for exterior wall applications. (See HUD report "Innovative Structural Systems for Home Construction: Wood Structural Insulated Panels and Insulating Concrete Forms" ACCN-HUD6494.) SIPs use less wood than traditional construction.

3. To promote indoor air quality, plywood and particleboard should be specified with exterior glues only.

4. The use of recycled wood should be encouraged.

5. If particleboard is used, seal all edges with water based varethane. This will seal in noxious compounds.

6. Specify wood from sustainably harvested or recycled stock. See resource section of this guide.

Division 7 - Thermal and Moisture Protection

Considerations

The energy required to produce a pound of insulation varies tremendously. A pound of polystyrene requires 50,400 Btus; a pound of cellulose requires as little as 150 Btus per pound.

Insulation Type	Embodied Energy
Fiberglass	13,004 Btus/lb
Polystyrene	50,400 Btus/lb
Polyurethane	31,040 Btus/lb
Cellulose	150 - 800 Btus/lb

Cellulose insulation performs 26% to 38% better than the equivalent thickness of fiberglass insulation in tests that measure both R value and air infiltration (Boonyartikarn, Soontorn, "Fiberglass Vs Cellulose Installed Performance, University of Colorado 1990).

Recommendations

1. Rigid Insulation can be chosen based on recycled content; however, this should be balanced against the goal of thermal performance.

2. If glass fiber insulation is required because of high humidity conditions or the insulation must be non-combustible, it can be found nationally with a minimum 30% recycled content.

3. Cellulose insulation should be used where practical by design. "Wet spray" insulation should be used for exterior walls. Ceiling cavities should be filled with blown-in cellulose insulation where this method of installation is practical. Care should be taken in areas of high humidity to isolate the insulation with a vapor barrier.

Division 8 - Windows and Doors

Considerations

Windows

Windows have a large effect on the environmental performance of a building. Windows can reduce energy use by providing passive solar heat gain and daylight. In most building types, incorporating passive solar design strategies can make windows energy producers.

Recommendations

Windows

Choose the best combination of window options for each unique window placement. Use the computer model to select glazing specific to each building elevation and glazing environment. Windows should be evaluated for their net overall contribution to energy costs over the life span of the facility. Characteristics to be evaluated:

1. Low - E coating - A thin, invisible metallic coating on the inside surface of a double-pane window.

2. Tinted glass - To reduce heat gain and solar glare windows are often tinted. Tinted windows block a lot of visible light and reduce the potential for daylighting.

3. Low-conductivity gas fill - Because heat conduction across the air space of an insulating glass unit can contribute considerably to heat loss, the performance of glass is improved by replacing the air with a low-conductivity gas, most commonly argon or krypton.

4. "Heatmirror" film. This is a low - E coated film held between two layers of glass. Heatmirror film makes a window unit perform like triple glazing without the added weight. Heatmirror glazing units built with low- conductivity gas can achieve an R=10 center-of-the-glass unit rating

5. Edge spacers - The material used to hold two layers of glass apart in an insulating glass unit is called the edge spacer. The most common edge spacer material is aluminum; however, aluminum is a highly conductive material. To improve overall energy performance in an insulating glass unit, thermally designed edge spacers are available.

Doors

Considerations

Doors must provide ease of use and accessibility. Interior doors may provide a fire separation, sound isolation or visual separation. Exterior doors must provide weather seals and resistance to heat flow. Door hardware should be assessed for its longevity and provisions for accessibility.

Recommendations

1. Specify steel doors with an average 25% recycled steel content.

2. Specify solid-core doors with 65% recycled content.

3. In areas of high heating or cooling requirements, specify exterior doors with weather-stripping and insulating cores.

Division 9 - Finishes

Considerations

Interior finishes have a large impact on indoor air quality impact on indoor air quality. The greatest sources of problem emissions of volatile organic compounds (VOCs) are interior finishes and furnishings.

Interior finishes are covered extensively in the Harris Directory of Recycled Content Construction Materials the American Institute of Architects Environmental Resource Guide and the REDI Guide. Refer to the resources section of this guide.

Recommendations

1. Specify gypsum Board with 30% recycled core material and 100% recycled paper facings.

2. Specify ceramic tile with a minimum 30% postindustrial waste. (See EPA Guideline Items.)

3. Consider linoleum in place of vinyl tile except in wet locations. If vinyl tile is used, select carefully to minimize chlorine production in the environment.

4. Select acoustic ceiling tile with a minimum 80% recycled content.

5. Follow EPA carpeting guidelines.

6. Specify low- or zero-VOC paints.

7. Specify low- or zero-VOC adhesives.

Division 12 - Furnishings

Considerations

Furnishings should be evaluated in terms of life cycle cost. Furnishings should be screened for their potential impact on indoor air quality, with a preference for furnishings that are durable and will enhance the indoor air. Furnishings often include materials like particleboard, adhesives, and fibrous materials that can act like a "sink" for other materials that offgas.

Recommendations

1. Whenever possible avoid pressed-wood furniture. Pressed wood can be a major source of off-gassing.

2. Use sustainably harvested wood for furniture construction.

3. If used plastic laminate substrates should be made with exterior grade glues. The adhesive used to stick plastic laminate to its substrate should be a low- or zero-VOC adhesive.

4. If particleboard is used, coat exposed surfaces with water-based urethane.

5. If adhesives are used avoid adhesives made with phenol compounds.

Division 15 - Mechanical

Considerations

HVAC
To insure indoor air quality, make sure the air coming into the building is clean, and use energy modeling software to analyze mechanical system options. Consider working with E-Source in Boulder, Colorado, to select the most energy efficient mechanical system.

Plumbing
Plumbing systems should be designed to use as little water as possible and still perform acceptably. Consider a gray water system where lavatory and shower water is used to irrigate the landscape. Consider a rooftop catchment system.

Recommendations

HVAC
1. Locate incoming air ducts away from driveways, loading docks, exhaust air ducts, and garbage dumpsters. If needed, install a filtration system to remove contaminants and pollutants. As a minimum, design the mechanical system to ASHRAE standards for fresh air, air circulation, and indoor air quality.

2. Through whole-system engineering -- taking into account the thermal envelop, energy efficient lighting, plug load analysis, efficient windows and passive cooling techniques, and expanding the occupant's thermal comfort envelop target reducing the cooling demand of the facility by 40% when compared with ASHRAE industry standards.

3. Install high-efficiency filters if running HVAC equipment while construction dust is in the air. Bag filters should be installed at fresh air intake if dust is a problem in the area.

4. After all interior finishes are installed and new furniture is in place, flush the building with fresh air for 30 days prior to occupancy.

5. Specify minimum indoor air quality of 50% of ASHRAE allowable quantities of carbon monoxide (CO), carbon dioxide (CO_2), Total Volatile Organic Compounds (TVOCs), and formaldehyde (HCHO) by the date the building is turned over for occupancy.

6. Specify that indoor air quality will be monitored for the first year of occupancy.

Plumbing
1. Specify toilet and lavatories with water saving technologies. Showers should be limited to 1.81 gpm at 40 psi.

2. Provide a cost/benefit analysis for solar water heating.

3. Evaluate the cost and benefits of a gray water irrigation system.

Division 16 - Electrical

"Efficient lighting is not just a free lunch, it is a lunch you are paid to eat."
- Amory Lovins, Co-Founder of the Rocky Mountain Institute

Considerations

A primary goal of sustainable design and construction is to minimize energy consumption. Over 30% of our total energy usage is electricity, and 60% of electricity is used in buildings. Designing a building to use less energy by taking advantage of daylight, insulating, and choosing energy efficient equipment saves money, reduces pollution, and improves the indoor environment.

Energy efficient lighting should be considered as part of a whole building system. Keep in mind that worker productivity is directly related to the quality of light where people work.

Everything that will use energy should be evaluated for energy efficiency and life cycle costs.

Recommendations

1. Use glare-free, well-distributed daylighting to minimize the need for electric light.

2. Use high-quality, energy-efficient electric light.

3. Carefully reduce veiling reflections.

4. Examine electrical plug loads carefully. Target a 40% reduction in plug loads compared with electrical design standards.

5. Where fluorescent lighting is to be used, design with electronically ballasted T-8 light fixtures with tri-phosphor rare-earth element lamps.

6. Incorporate motion/infrared sensors into lighting schemes.

7. Incorporate ambient light-level sensors into lighting schemes.

8. Consider the use of photovoltaics (PVs). In some cases using PVs is less expensive than connecting to the grid. The cost of PVs is falling while the cost of utilities is slowly increasing.

Resources

Austin Green Builder Program
Environmental/Construction Services Dept.
City of Austin
206 E. 9th STE. 17.102
Austin, TX 78701
512-499-3506
www.ci.austin.tx.us/greenbuilder/

The Sustainable Building Sourcebook is a 450-page guide. It covers energy, water, building materials, and solid waste. They have a code of sustainability that all municipal buildings must conform to.

The Clean Washington Center
Department of Community, Trade and Economic Development
2001 6th Avenue, Suite 2700
Seattle, WA 98121
Ph: 206-389-2808
Fx: 206-464-6902
www.cwc.org/

Recycling Plus Program Manual, a best practices manual for construction jobsite recycling. The Clean Washington Center was established to advance the use of recycled materials. This guidebook for construction and demolition recycling should be part of the standard specifications for all construction.

Environmental Resource Guide
AIA/ERG
1735 New York Ave NW
Washington, DC 20006
ph: 202-626-7331
Attn: ERG Editor
http://www.e-architect.com/

The Environmental Resource Guide is a comprehensive guide to sustainable building practices; it includes recycled content building materials, embodied energy, and much more. The ERG also includes listings of where to find additional information.

The National Park Service Sustainable Design Database
Design and Construction Database
PO Box 24287 Denver, CO 80225
ph: 303-969-2466
Fx: 303-969-2930
www.nps.gov/dsc/dsgncnstr/susdb/

National Park Service Sustainable Design and Construction Database

REDI Guide
Iris Communications
258 East 10th Ave STE E
Eugene, OR 97401-3284
ph: 503-383-9353
oikos.com/redi/

The REDI Guide is a database of natural materials, recycled content construction materials, and sustainably harvested wood. We find the REDI guide valuable despite a few errors

The Harris Database
B.J. Harris
P.O. Box 2024
Candler, NC 28715
ph: 888.844.0337
www.harrisdirectory.com/

The Harris Directory is the definitive resource for recycled content building materials, available in Macintosh or PC formats and updated regularly. We encourage anyone interested in specifying recycled content materials to purchase the Harris Directory.

Rocky Mountain Institute
Sustainable Building Primer
Green Development Services
Snowmass, CO 81654-9199
ph 303-927-3851
fx: 303-927-4178
www.rmi.org/

Greening the Building and the Bottom Line - A set of case studies that show productivity enhancement associated with energy and lighting upgrades. The Rocky Mountain Institute is the premiere think tank on sustainable practices. They have hundreds of publications available at their headquarters in Snowmass. Contact them for a list of their currently available publications.

Steven Winter Associates
50 Washington Street
Norwalk, CT 06854
ph: 203-857-0200
www.swinter.com/

Energy modeling and economic analysis- Steven Winter uses a variety of energy simulation programs to model new facilities.

Architects/Designers/Planners for Social Responsibility
P.O. Box 9126
Berkeley, CA 94709-0126
Ph: 510/273-2428
www.adpsr.org/

- **Topics:** green materials
- **Resources:** publications: *The Architectural Resource Guide,* which includes extensive regional and national contact information for manufacturers and distributors of sustainable construction materials; and *New Village Journal,* a semiannual journal documenting progressive leadership in planning, architecture, and community revitalization.

Center for Renewable Energy and Sustainable Technology
1200 18th St NW, #900
Washington, DC 20036
202/530-2202;
fx: 202/887-0497
solstice.crest.org/index.shtml

- **Topics:** green materials; green design
- **Resources:** publications, databases, links, listservs, and software (Green Building Advisor)

Environmental Building News
122 Birge St., Suite 30
Brattleboro, VT 05301
802/257-7300;
fx: 802/257-7304
www.ebuild.com/

- **Topics:** green design; green materials
- **Resources:** archive of back issues of the newsletter, listserv, and event calendar. Includes an excellent "Bibliography of Green Building Resources."

Environmental Support Solutions
210 North Center Street, Suite 101
Mesa, AZ 85201
800-289-6116 or 602/694-5043;
fx: 602-834-4319
www.environ.com/

- **Topics:** indoor air quality, refrigerant compliance management software, training and consulting
- **Resources:** Information on workshops, products and services, and links.

Illuminating Engineering Society of North America
120 Wall Street, Floor 17
New York, NY 10005-4001
212/248-5000 ext. 117;
fx: 212/248-5017
www.iesna.org/

- **Topics:** lighting
- **Resources:** publications and software

Iris Communications, Inc.
P.O. Box 5920
Eugene, OR 97405
541/767-0355;
fx: 541/767-0357
oikos.com/irisinfo/

- **Topics:** green design; green materials; graywater heat recovery and recycling
- **Resources:** weekly Green Building News newsletter, videos, software, publications, database of green materials

Jade Mountain
P.O. Box 4616
Boulder, CO 80306
800/442-1972; fx: 303/449-8266
technical support: 303/449-6601

- **Topics:** solar, micro-hydro, wind generators, composting toilets & greywater systems, lighting; appliances
- **Resources:** technical assistance; design and sizing of renewable utility systems; newsletter; catalog: access to 6,000+ renewable energy products

Passive Solar Industries Council
1331 H Street NW, Suite 1000
Washington, DC 20005
202/628-7400;
fx: 202/393-5043

- **Topics:** daylighting, solar heating, low-energy cooling, energy efficiency, appropriate technology
- **Resources:** weather data for U.S. cities; case studies and other publications; videos; newsletter; workshops; software

Solar Energy Laboratory, University of Wisconsin-Madison
1303 Engineering Research Building
1500 Engineering Drive

Madison, WI 53706-1687
Ph: 608/263-1586
sel.me.wisc.edu/

- **Topics:** solar; energy efficiency
- **Resources:** publications, links, and computer programs

U.S. Department of Energy/Office of Building Technology
www.eren.doe.gov/

- **Topics:** solar; energy efficiency
- **Resources:** technical assistance; publications (such as case studies and success stories); software; rules, standards, codes; links to online resources

Glossary

acid rain - Precipitation that is contaminated with acid due to sulfur dioxide and oxides of nitrogen in the air.

bauxite - the raw material mined from the earth we use to make aluminum.

biodegradable - capable of being broken down by living organisms, principally bacteria and fungi.

biomass - biomass energy is derived from plants. Alcohol fuels are produced from wood, sugarcane and corn. Firewood, crop residue and cattle dung can also be burned as biomass fuel. As long as the amount of plants regrown equals the amount of fuel burned there will be no additional carbon dioxide produced to contribute toward global warming.

Btu - a British Thermal Unit. A measure of energy in the English system measurement, roughly the amount of heat required to raise one pound of water one degree Fahrenheit. This unit of measuring heat will soon no longer be used and will be replaced in usage by "joule."

calorie - currently the most common unit for measuring heat and soon to be replaced by joules (J). The calorie is the amount of energy required to raise the temperature of one cubic centimeter of water one degree Celsius (formerly called centigrade).

carbon dioxide (CO_2) - a colorless, odorless, nonflammable gas formed during decomposition, combustion and respiration. CO_2 is used in food refrigeration (dry ice), carbonated beverages, fire extinguishers and aerosol cans. Whenever something burns -- such as gasoline, wood or a candle -- CO_2 is produced from the available oxygen combined with the carbon in the fuel.

carbon monoxide - CO colorless, odorless gas formed when carbon is oxidized in a limited supply of air. It is a poisonous constituent of car exhaust fumes, forming a stable compound with hemoglobin in the blood, thus preventing the hemoglobin from transporting oxygen to the body tissues.

chlorofluorocarbon - (CFC) synthetic chemical that is odorless, nontoxic, nonflammable but reacts with chemicals high in the atmosphere resulting in the depletion of the earth's protective ozone layer. CFCs have been used as propellants in aerosol cans, as refrigerants in refrigerators and air conditioners, and in the manufacture of foam packaging. They are partly responsible for the destruction of the ozone layer.

coal - coal is a form of stored solar energy. It is created from the remains of plants that have been concentrated by heat and pressure for millions of years. Coal is found in various forms or "grades," which depend on the ratio of carbon mass to energy content. Represented in descending order of hardness and energy content per pound, these grades are anthracite, bituminous, sub-bituminous and lignite.

cogeneration - the use of waste heat from an electrical generating plant for other purposes, such as heating. Also, the use of waste heat from a high-temperature industrial process to generate electricity.

cooling load - A measure of the energy that must be expended by a building's systems to cool the indoor to a desired temperature.
cumulative effects

crude oil - crude oil is petroleum direct from the ground, prior to refinement or processing.

daylighting - The means by which daylight is brought into a building to either supplement or replace electrical lighting in order to allow the occupants to perform their tasks.

distribution - the facilities of the electric system that deliver electricity from substations to customers. The distribution system "steps down" power from high-voltage transmission lines to a level that can be used in homes and businesses.

ecology - study of the relationship among organisms and the environments in which they live, including all living and nonliving components.

efficiency - output of a machine (work done by the machine) divided by the input (work put into the machine), usually expressed as a percentage. Because of losses caused by friction, efficiency is always less than 100%, although it can approach this for electrical machines with no moving parts (such as a transformer).

electric current - the flow of electronically charged particles through a conducting circuit due to the presence of a potential difference. The current at any point in a circuit is the amount of charge flowing per second; its SI unit is the ampere (coulomb per second).

electricity - all phenomena caused by electric charge, whether static or in motion. Electric charge is caused by an excess or deficit of electrons in the charged substance, and an electric current by the movement of electrons around a circuit. Substances may be electrical conductors, such as metals, which allow the passage of electricity through them, or insulators, such as rubber, which are extremely poor conductors.

electricity - a property of matter caused by the movement of electrons. This "movement" is initiated usually by a generator that is fueled by any number of energy resources such as coal, uranium, water (hydropower), or directly converted from solar radiation on photovoltaic cells. Electricity is not energy per se, but the "carrier" of energy that originates in fossil fuel and renewable energy sources.

electromagnetic waves - oscillating electric and magnetic fields traveling together through space at a speed of nearly 186,000 mi/300,000 km per second. The (limitless) range of possible wavelengths or frequencies or electromagnetic waves, which can be thought of as making up the electromagnetic spectrum, includes radio waves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays.

embodied energy - it takes energy to make something. Embodied energy is associated with the production of a good or service or the energy to prepare or make a product.

energy - energy can be defined as the ability to do work -- the ability to exert a force.

energy conservation - methods of reducing energy use through insulation, increasing energy efficiency, and changes in patterns of use.

fluorescent lamp - This form of lighting constitutes approximately 70% of the electrical light used in North America. Efficacy rates (lumens output / watts input) for fluorescent lamps range from 50-80 lm/w.; much higher than that of incandescent bulbs.

formaldehyde - A volatile organic compound off-gassed in paints, glue adhesives, and laminates that can cause sickness and contribute to ground-level ozone formation.

fossil fuel - fuel, such as coal, oil and natural gas, formed from the fossilized remains of plants that lived hundreds of millions of years ago. Fossil fuels are a nonrenewable resource and will eventually run out. Extraction of coal and oil causes considerable environmental pollution, and burning coal contributes to problems of acid rain and the greenhouse effect.

fuel chain - the chain of activities involved in transforming energy into forms more convenient for society. This "chain" may include some or all of the following: fuel exploration, extraction, preparation, transportation, conversion to electricity, distribution and waste disposal.

geothermal power - geothermal energy is the natural heat of the earth that is conducted or convected to the earth's surface through volcanoes and hot springs. By harnessing this energy and using it to power steam turbines, we can convert geothermal energy into electricity that we can use.

glazing - A transparent covering usually made from glass or plastic used to admit light through a window, door, skylight, or other opening.

graywater - Water drained from building such as dishwashers, clotheswashers, sinks, and showers. Graywater usually requires some degree of treatment before it can be reused because it is likely to contain soap, contaminants from the kitchen, etc., but it does not include wastewater from toilets. Today, we usually mix graywater and blackwater (sewage from toilets). The potential uses for graywater are numerous, including landscape irrigation, carwash, toilet flushing, and pool use.

grid - the transmission network (or "highway") over which electricity moves from suppliers to customers.

habitat - in ecology, the localized environment in which an organism lives. The dominant plant type or physical feature, such as a grassland habitat or rocky seashore habitat often describes habitats.

heat - form of internal energy possessed by a substance by virtue of the kinetic energy in the motion of its molecules or atoms. Heat energy is transferred by conduction, convection and radiation.

heat exchanger A mechanical system that allows the heat from outgoing exhaust air to be transferred to incoming fresh, air. This is achieved by constant fan-forced ventilation, using either flat-plate, or rotary exchangers.

hydrocarbons - an extensive group of chemicals that always include the elements hydrogen and carbon. Natural sources of hydrocarbons are the by-products of digestion and decomposition (e.g., rotting, spoiling, and putrefying). Coal, natural gas, oil, sugar, starches, and plastics are all composed of hydrocarbons. The incomplete combustion of hydrocarbons from fossil fuels contributes to our pollution and global warming problems.

incandescent lamp - A lamp that produces light by directing electrical current through a metallic medium. The efficiency of lamps is stated as an efficacy rating (lumens/input wattage). For example, a 100-watt lamp that produces 1,740 lumens has an efficacy of 17.4 lumens per watt. The average incandescent lamp typically falls in the 10-25 lumens per watt range.

joule - (symbol J) - named in honor of British physicist James P. Joule (rhymes with pool) who proved in 1843 that a specific amount of work was converted into a specific amount of heat. A joule is now a unit for all forms of energy. One joule of work is done when the force of one NEWTON is exerted on an object moving in the direction of the force, a distance of one meter. It takes about one joule to lift an apple over your head. As the transition from the English system of energy measurement to the international system of units (SI) picks up momentum, we will soon become accustomed to hearing more frequently of kilojoules (Kj) and megajoules (Mj). One kilowatt-hour = 3.6 x 106 joules. One calorie = 4.187 joules.

kilowatt - 1,000 watts of power (see watt, power). Tells you how fast an appliance utilizes energy when in use.

kilowatt - a measure of electric energy equal to 1,000 watts. Put another way, it's the amount of electric energy required to light ten 100-watt light bulbs.

kilowatt-hour - a measure of energy use over time. Utility companies typically sell energy as kilowatt-hours (kWh). A kilowatt-hour is 1,000 watts used for one hour. If you purchased a kilowatt-hour from your utility for less than a dime, you could burn ten, 100-watt incandescent light bulbs for one hour. Other electrical appliances such as stoves, heaters and blow dryers, would operate for less time for that same nickel because their energy demands are greater for their operation. (1 kWh = 3.6 x 106J or 36,000,000 J.)

kilowatt-hour - a measure of electricity consumption equivalent to the use of 1,000 watts of power over a period of one hour. Ten 100-watt light bulbs, burning for one hour would consume one kilowatt-hour of electricity.

Life Cycle Analysis - A methodology of quantitative assessment that determines the relative environmental "pluses" and "minuses" of a product, over its lifetime, on the topics of resource depletion, manufacture, installation methods, and recyclability and/or reuse.

light - electromagnetic waves in the visible range, having a wavelength from about 400 nanometers in the extreme violet to about 770 nanometers in the extreme red. Light is considered to exhibit particle and wave properties, and the fundamental particle, or quantum, of light is called the photon. The speed of light (and of all electromagnetic radiation) in a vacuum is approximately 186,000 mi/300,000 km per second, and is a universal constant denoted by c.

load profiling - the study of the consumption habits of consumers to estimate the amount of power they use at various times of the day and for which they are billed. Load profiling is an alternative to precise metering.

luminescence - emission of light from a body when its atoms are excited by means other than raising its temperature. Short-lived luminescence is called fluorescence.

megawatt - one million watts of power potential. (see watt, joule, and newton)

megawatt-hour (MWH) - one million watts used for one hour. If you purchased a megawatt-hour of energy for a nickel per kilowatt-hour, it would cost you 1,000 nickels, or $50.00. Using a kWh your could burn one, 100-watt incandescent for 24 hours a day for about 14 months, or 3 hours a day for over 9 years.

methane (CH_4) - Methane is a simple hydrocarbon composed of one carbon atom surrounded by four hydrogen atoms. It is an odorless, flammable and invisible gas and the primary ingredient in natural gas. Natural gas companies add a strong odorant to the gas for safety so it can be easily detected by smelling. Methane is a relatively clean fuel and it is commonly used to fuel vehicles in many countries, such as New Zealand and Italy.

natural gas - mixture of flammable gases found in the Earth's crust (often in association with petroleum), now one of the world's three main fossil fuels (with coal and oil). Natural gas is a mixture of hydrocarbons, chiefly methane, with ethane, butane and propane.

oil - flammable substance, usually soluble in water, and composed chiefly of carbon and hydrogen. Oils may be solids (fats and waxes) or liquids. The three main types are: essential oils, obtained from plants; fixed oils, obtained from animals and plants; and mineral oils, obtained chiefly from the refining of petroleum.

ozone - O_3 highly reactive pale-blue gas with a penetrating odor. Ozone is an allotrope of oxygen made up of three atoms of oxygen. It is formed when ultraviolet radiation or electrical discharge splits the molecule of the stable form of oxygen (O2). It forms a thin layer in the upper atmosphere, which protects life on Earth from ultraviolet rays, a cause of skin cancer. At lower atmosphere levels it is an air pollutant and contributes to the greenhouse effect.

particulates - Particulates can be suspended solids or liquids that include dust from automobile and truck brake linings, road grit, ash from factory smokestacks, some from home chimneys and aerosols. Particulates reduce visibility and can cause lung and eye damage, especially when combined with other pollutants such as sulfur oxides (SO_x) and nitrous oxides (NO_x). Many people with respiratory problems are unaware their breathing problems can result from particulate pollution.
-

passive solar system A system that relies on the natural phenomena of energy (radiation, convection, and conduction) for the transfer and storage of heat or "coolness." Some basic elements of a passive solar system are south-facing glazing for solar collection and thermal mass for absorption, storage and distribution.

photovoltaic cells - photovoltaic cells are used to directly convert solar radiation into electricity. Materials called semiconductors, usually made from pure silicon, transfer light energy (photons) into electrical energy in a process known as the photoelectric effect.

post-consumer content - Refers to the percentage of total content of a material that has passed through its end-usage as a consumer item and has been recovered or diverted from the solid waste stream for the purpose of recycling.

quad - a quadrillion BTUs (10^{15} BTUs). This is an enormous number equivalent to 3.6×10^{6} metric tons of coal, or 172,000,000 (1.72×10^{6}) barrels of oil. A quadrillion is the number one followed by 15 zeros. It would be impossible to count to such a number even if you counted by 1,000s for every second of your life until you were 100 years old. The United States used about 80 quads of energy in 1990.

R-value - A measure of thermal resistance, indicating how effective a material is as an insulator. R-value is measured in the hours needed for one Btu to flow through one inch of the material when the temperature difference (from one side of the material to the other) is one degree Fahrenheit. Its units are hour-square foot-degree Fahrenheit/Btu-inch.

raw material - the original material as taken from its source, usually the ground. A good example is bauxite ore that is used to make aluminum.

recycle - to recycle is to put into the cycle again. In other words, to take a product and reuse it when discarded. Recycling saves enormous amounts of energy and raw materials.

recyclability Technically, any material can be recycled if the amount of energy consumed in the process is not a factor. For our purposes, recyclability means any material that is in demand that requires less energy to reuse than to manufacture from virgin materials.

recycled content The percentage of the total content of a material comprised of post-consumer content and pre-consumer content.

resource - A substance for which there is an identifiable use within society.

solar energy - energy derived from the sun's radiation. The amount of energy falling on just 0.3861 sq. mil/1 sq. km is about 4,000 megawatts, enough to heat and light a small town. In one second the Sun gives off 13 million times more energy than all the electricity used in the U.S. in one year. Solar heaters have industrial or domestic uses. They usually consist of a black (heat-absorbing) panel containing pipes through which air or water, heated by the sun, is circulated, either by thermal convection or by a pump. Solar energy may also be harnessed indirectly using solar cells (photovoltaic cells) made of panels of semiconductor material (usually silicon), which generate electricity when illuminated by sunlight.

stranded cost - costs that were incurred by utilities to serve their customers with the understanding that state regulatory commissions would allow the costs to be recovered through electric rates. Stranded costs can occur either because particular customers discontinue their use of a service or because such customers are no longer willing to pay the full costs incurred to provide a service. Potentially stranded costs are the result of decisions that were reviewed and approved by government regulators and were made by utilities under the unique regulatory compact with their state and their customers. The Federal Energy Regulatory Commission (FERC) has determined that stranded costs at the wholesale level should be paid by electric customers desiring to exit a system built to serve them.

sulfur dioxide (SO_2) - a corrosive gas produced both by nature and technology in nearly equal amounts. Burning fuels, such as coal and oil, that contain sulfur produces SO_2. It is also produced from sea spray, organic decomposition and volcanic eruptions. When combined with water in the air, it produces a weak, corrosive sulfuric acid -- an ingredient of "acid rain."

sustainable The Worldwatch Institute defines "sustainable" as "meeting present needs without compromising the ability of future generations to meet their own needs." For example, wood harvested from a "sustainable forest" means that the wood is derived from a forest managed in a manner so that the trees harvested will be replaced at a rate that matches the rate of removal. In this regard, the forest will continue producing wood for successive generations.

toxins - Chemical or natural substances that can cause harmful effects on humans; toxins include heavy metals such as cadmium, lead, and mercury, as well as organic compounds like petroleum products, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PAHs)

U-value - U-value is the overall coefficient of heat transmission. It is a measure of the rate of heat flow through any given combination of materials, air layers, and air spaces. It is equal to the reciprocal of the sum of all resistances (R). In other words, the U-value can be calculated for a particular wall, roof, or floor system by finding the resistances (R-value) of each of its materials, its air layers, and its internal air spaces, then adding all of these resistances and finding the reciprocal. The lower the U-value, the lower the heat loss or the higher the insulating value. The units are Btu/hour/square foot/degree Fahrenheit.

vapor retarder - a material or coating, impermeable to moisture, designed to impede passage of water or water vapor.

volatile organic compounds (VOCs) - VOCs are chemical compounds common in many building products: solvents in paints and other coatings; wood preservatives; strippers and household cleaners; adhesives in particleboard, fiberboard, and some plywoods; and foam insulation. When released, VOCs can contribute to the formation of smog and can cause respiratory tract problems, headaches, eye irritations, nausea, damage to the liver, kidneys, and central nervous system, and possibly cancer.

watt - a unit of power defined as a joule of energy per second.

The authors would like to thank the following, whose glossaries were particularly helpful in compiling our own:

Moore, Fuller Environmental Control Systems: Heating, Cooling, Lighting McGraw-Hill, Inc. 1993 Charleston, SC 29413-1655 (803) 577-2103

The Green Building Products Directory

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SEYMOUR JOHNSON AFB
F-15E SQUADRON OPERATIONS FACILITY

SUSTAINABLE FACILITIES BRIEFING

History

John Barrie Associates were contracted to provide Sustainable Design Consulting services to the Air Combat Command in early 1996. Our specific goals were to provide sustainable design consulting services for the Seymour Johnson Air Force Base F-15E Squadron Operations Facility, and to prepare a concise set of guidelines for sustainable construction. We started our contribution to the SJAFB Squad Ops. facility in February 1996. At that time, sustainability was a new and emerging concept. The application of sustainable principles to construction was even newer. Our role as Sustainable Design Consultant was to advise the Project A/E in the process of sustainable design and then to follow the project through to its completion. We met regularly during the design process to review progress and to make recommendations. We then met with the construction team at Seymour Johnson AFB to review construction and to provide guidance. Simultaneously we have been developing the Sustainable Facilities Guidebook, a "no nonsense" approach to making better buildings.

Process

Sustainable design requires an integrated-systems approach to creating buildings. In addition to realizing the programmatic goals for the facility, the A/E must coordinate siting and landscaping decisions; mechanical, electrical, and structural engineering; thermal envelop, daylighting, and fenestration design; materials selection; indoor air quality considerations; and life cycle costs to create a cost effective, energy efficient building.

Preliminary Design

Starting with the Customer Concept Document, JBA met with the project A/E firm, Clark Nexsen, several times throughout the design process to establish sustainable goals, measure progress and to make suggestions. Together with the project A/E we developed a list of sustainability strategies. (appendix A). It is important to note that these strategies were developed in consultation with every design discipline associated with the project; Architect, Mechanical, Structural, Electrical and Civil engineers, and Interior Design. Each discipline has unique challenges and in this case each discipline provided insightful strategies for the development of the project.

Design Development and Construction Documents

After carefully considering hundreds of strategies listed in the sustainable strategies document, we incorporated the following into the construction documents. See Appendix A, Clark Nexsen Strategies

Sitework

- The landscape will use native and drought resistant plantings.
- Recycled content asphalt and concrete were specified.
- Sewer pipe with recycled content was specified.
- Jobsite recycling of 75 % of construction and demolition debris was specified.

Jobsite Recycling

Material	Amount Recycled
Cardboard	1,000 lbs.
Dimension Lumber	1,000 lbs.
Other Wood	14580 lbs.
Land Debris	14,000 lbs.
Concrete	5,553,200 lbs.
Concrete Masonry Units	234,000 lbs.
Asphalt	502,000 lbs.
Metals	2440 lbs.
Gypsum Board	13900 lbs.
Insulation Board	1344 lbs.
Total Jobsite Recycling	6,337,454 lbs.

One might ask, “Where does all this stuff go?” Well, wood and land debris were taken to the base compost facility. The Seymour Johnson AFB compost facility has a grinder which is capable of handling the mix of wood materials (save CCA treated wood) generated on a construction site. Some concrete was crushed and re-used on site as cover for erosion control, and the rest was taken and used to raise Wayne Auto Salvage above the flood plane. Asphalt was recycled at a close by asphalt batch plant.

Materials

- Recycled content construction materials are used to the greatest extent possible.

- Materials with low embodied energy are incorporated.

- Materials were chosen based on durability and low maintenance requirements.

- Recyclable materials were chosen wherever possible.
-

Energy Efficiency

- The mechanical system was designed as part of the total building system. The design takes into consideration the glazing, insulation and mass of the structure. It also takes into consideration the people who will occupy the building.

- The lighting system is very energy efficient, using primarily T-8 electronically ballasted fixtures. The lighting controls take into account occupancy and ambient light levels.

Indoor Air Quality

- Two strategies were incorporated to control indoor air quality. First, to control sources of indoor air problems, and second to supply fresh air to all spaces in the building.

- To control sources of indoor air problems, we specified low VOC (Volatile Organic Compound) paints and adhesives. We also chose construction materials that don't "off gas".

- To keep clean air circulating in the building, we specified high quality air filters for the mechanical system, and adjusted the system to bring in ample fresh air. The mechanical system utilizes sheet metal ductwork without a fiberglass lining.

Construction

A key to this project's success was the pre-construction meetings where base personnel and particularly base environmental personnel "bought in" to the project. The base environmental personnel were able to provide recycling support to the contractor which otherwise would not have been possible.

Site

- The site incorporates native plantings. The soil on site was in part supplemented with compost from the base compost program.

- Construction and demolition debris was achieved successfully and economically.

- The asphalt and concrete paving incorporates recycled materials.

- As an unforeseen benefit from this project, we were able to plug an underground leak of an existing water main. No one was able to estimate how long the pipe had been leaking.

- We achieved the very highest level of jobsite recycling.

Energy

- The Seymour Johnson AFB F-15E Squadron Operations Building is 30 - 40 % more energy efficient than traditional construction. (estimated by computer model). This was achieved by carefully modeling the whole building and then changing different parameters within the model.

- Daylighting was incorporated into almost all areas in the building.

- The lighting system will require less than half of the energy typically spent on lighting a building of this size.

- Motion sensors and ambient light sensors are incorporated throughout the building.

- The roof of the building incorporates significantly more insulation than required by code. This helps with energy efficiency and thermal comfort.

- The roof is highly reflective and thus a barrier to radiant heat.

- The wall insulation has a radiant heat barrier that reflects heat outward.

Materials

Recycled content materials were specified throughout the project.

It is nearly impossible to account for all of the recycled content materials, so we present some representative numbers.

Material	Recycled Content
Concrete Masonry	493,837 lbs.
Masonry Insulation	292 lbs.
Gypsum Wallboard Framing	10,708 lbs.
Gypsum Wallboard	TBD
Roof Insulation	402 lbs.
Manufactured Roof Panels	2,586 lbs.
Floor Tile	1,560 lbs.
Ceiling Tile	9,112 lbs.
Structural Steel	33,600 lbs.
Concrete Masonry Units	211,200 lbs.
Concrete	40,000 lbs.
Asphalt	1,069,000 lbs.
Total Reported Recycled Content	1,872,297 lbs.

Lessons Learned

In trying something new, it is important to step back and evaluate what worked and more importantly, what didn't work. Not all of the goals that we set back in 1996 in the early design phase were realized in the construction process. In particular we had problems with these areas:

Paint was specified as containing 1 gram per liter of Volatile Organic Compounds. It was difficult for the contractor o find paint locally available which met this criteria. We settled for paint which meets EPA guidelines.

The sitework was originally designed as all native plantings, however to blend in with other buildings at Seymour Johnson, non-native grass was planted.

There were hundreds of strategies outlined in the strategy document, however only a fraction of these were incorporated into the building.

This building was designed and constructed "hard metric". The hard metric requirement caused delays in receiving materials, and problems during construction with workmen who carried standard tape measures. Some materials simply were not available at all in metric. The requirement for hard metric caused some delays in the project, and some additional cost.

Conclusions:

There is a break down between goals being established in the beginning and the final product. All of our missed opportunities can be attributed to specification production. Specifications need to incorporate the selection criteria used in choosing an environmentally responsible material, and for open specifications, the architect needs to list several manufacturers that meet their specs.

Sustainability is a difficult goal to achieve. We don't have any objective measurements of how sustainable a building really is. With this in mind, the Seymour Johnson AFB F-15E Squadron Operations building has achieved a great deal in terms of indoor air quality, environmentally responsible materials, and energy efficiency at little or no additional cost to the project. This has to be considered a great success.

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