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An Introduction to Sustainable Design for Buildings

By

J. Paul Guyer, P.E., R.A.

Course No 0005474
2 PDH HOURS

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Guyer Partners
44240 Clubhouse Drive
El Macero, CA 95618
(530)7758-6637
jpguyer@pacbell.net

J. Paul Guyer, P.E., R.A.

Paul Guyer is a registered civil engineer, mechanical engineer, fire protection engineer, and architect with over 35 years experience in the design of buildings and related infrastructure. For an additional 9 years he was a senior-level advisor to the California Legislature. He is a graduate of Stanford University and has held numerous national, state and local positions with the American Society of Civil Engineers and National Society of Professional Engineers.

PRINCIPLES OF SUSTAINABLE DESIGN FOR BUILDINGS

J. Paul Guyer, P.E., R.A., Fellow ASCE, Fellow AEI

1. THE SUSTAINABLE DESIGN CHALLENGE

Sustainable design seeks to reduce negative impacts on the environment, and the health and comfort of building occupants, thereby improving building performance. The basic objectives of sustainability are to reduce consumption of non-renewable resources, minimize waste, and create healthy, productive environments. Design and construction of buildings and related infrastructure create major direct and indirect impacts on the environment. For example, in the United States, buildings:

- **Consume 39% of total energy use**
- **Consume 12% of total water consumption**
- **Consume 68% of total electricity consumption**
- **Cause 38% of carbon dioxide emissions**

In recognition of this growing issue the concept of “sustainable design” has arisen in recent years. Unfortunately this approach is frequently described as “integrated” or “synergistic” or “holistic” or similar terms that are not particularly definitive.

Utilizing a sustainable design philosophy encourages decisions at each phase of the design process that will reduce negative impacts on the environment and the health of the occupants, without compromising the bottom line. It is an approach that encourages compromise and tradeoffs. Such an approach positively impacts all phases of a building's life-cycle, including design, construction, operation and decommissioning.

Government agencies at all levels as well as increasing numbers of private companies are committed to incorporating principles of sustainable design and energy efficiency into all of its building projects. The result is an optimal balance of cost, environmental, societal and human benefits while meeting the mission and function of the intended

facility. Sustainable design should ideally be incorporated as seamlessly as possible into the existing design and construction process.

This course is about an approach to sustainable design that is structured and lends itself to incorporation into the building design process. It consists of….

- **PRINCIPLES**
- **OPPORTUNITIES**
- **RESOURCES**

Principles are the road map of sustainable design. Opportunities are things that may be done to optimize a specific project in recognition of one of the Principles. Resources are published manuals, guides and data bases that are available to assist in optimizing implementation of an opportunity.

2. THE SIX PRINCIPLES OF SUSTAINABLE DESIGN

There are six **PRINCIPLES** of sustainable design….

- **OPTIMIZATION OF SITE POTENTIAL**
- **OPTIMIZING ENERGY USE**
- **PROTECTION AND CONSERVATION OF WATER**
- **SELECTION AND USE OF ENVIRONMENTALLY PREFERABLE PRODUCTS**
- **ENHANCEMENT OF INDOOR ENVIRONMENTAL QUALITY**
- **OPTIMIZATION OF OPERATIONS AND MAINTENANCE PRACTICES**

In this course we will be looking at the **OPPORTUNITIES** that may exist in the building design and construction process that will optimize a specific project in recognition of these **PRINCIPLES**, and **RESOURCES** that may be available to provide guidance in applying these **OPPORTUNITIES**.

3. PRINCIPLE: OPTIMIZATION OF SITE POTENTIAL

Creating sustainable buildings starts with proper site selection, including consideration of the reuse or rehabilitation of existing buildings. The location, orientation, and landscaping of a building affect the local ecosystems, transportation methods, and energy use. Siting for physical security has become a critical issue in optimizing site design. The location of access roads, parking, vehicle barriers, and perimeter lighting must be integrated into the design along with sustainable site considerations.

3.1 OPPORTUNITIES

Sustainable site planning should seek to minimize development of open space by the selection of disturbed land or building retrofits; control erosion; reduce heat islands; minimize habitat disturbance; restore the health of degraded sites; incorporate transportation solutions; and consider site security concurrently with sustainable site issues. Here are some opportunities that should be considered in order to sustainably optimize site potential:

- ❑ **Minimize Development of Open Space**
  - Renovate and/or expand an existing building
  - Use previously disturbed land

- ❑ **Control Erosion Through Landscaping Practices**
  - Use vegetation, grading and soil stabilization measures to minimize erosion
  - Capture and retain storm water runoff on site and incorporate retention features such as pervious pavement in project design
  - Reduce runoff of site using vegetated swales and depressions

- ❑ **Consider Energy Implications in Site Selection and Building Orientation**

- Site buildings to maximize opportunities for use of active and passive solar systems
- Take advantage of natural ventilation
- Optimize daylighting opportunities
- Examine the potential impacts future development adjacent to the site may have on opportunities such as solar systems and daylighting

❑ **Use Building Design and Landscaping Techniques to Reduce Heat Islands**

- Use new and existing trees to shade parking lots, walkways and other open areas
- In warm, sunny climates consider covering parking lots, walkways and other areas that are paved or constructed with low reflective materials
- Use roofing systems with a top layer of light colored and/or high-reflectance and high emissivity material to reduce cooling load
- Use roofing products that meet or exceed *Energy Star* standards

❑ **Minimize Habitat Disturbance**

- Minimize land disturbance and retain prime vegetation to the extent possible
- Reduce building and paving footprints
- Minimize disturbance of site around building perimeter, such as by locating it closer to existing utilities
- In cold climates, site parking lots and walkways so they have sun exposure to assist in melting snow
- In cold climates, use ice and snow removal methods that are non-toxic

❑ **Restore Degraded Sites**

- Minimize land disturbance and retain prime vegetation
- Optimize utilization of native and drought-resistant plants

❑ **Design for Sustainable Transportation**

- Site the building to coordinate with public transportation systems
- Use porous paving materials where practicable
- Reduce on-site parking to encourage use of public transit
- Incorporate features to encourage bicycling, car pooling, walking
- Provide refueling/recharging facilities for alternative energy vehicles

❑ **Coordinate Site Sustainability with Safety and Security**

- For example, site features such as retention ponds and berms can also limit access to a building
- Existing and new trees and vegetation can conceal buildings and people for security reasons

3.2 RESOURCES….

Here are some resources you can use to take advantage of opportunities to sustainably optimize the potential of a building site. "Googling" the publication title will usually get you to a site that provides access to the publication…. sometimes at no cost, sometimes at a cost.

❑ Federal Green Construction Guide for Specifiers

❑ U.S. Army, ERDC – CERL – Sustainable Design and Development Resource website

❑ DOE Office of Energy Efficiency and Renewable Energy (EERE), Building Technologies Program

❑ DOE Office of Energy Efficiency and Renewable Energy (EERE), High Performance Buildings

❑ DOE Office of Energy Efficiency and Renewable Energy (EERE), High Performance Buildings Database

❑ DOE Greening Federal Facilities Guide

❑ GSA LEED Applications Guide

- ❑ EPA Managing Your Environmental Responsibilities: A Planning Guide for Construction and Development

4. PRINCIPLE: OPTIMIZING ENERGY USE

On an annual basis, buildings in the United States consume 39% of America's energy and 68% of its electricity. They generate 38% of the carbon dioxide, 49% of the sulfur dioxide, and 25% of the nitrogen oxides found in the air. The vast majority of this energy is produced from nonrenewable, fossil fuel resources. With America's supply of fossil fuel dwindling, concerns for energy supply security increasing, and the impact of greenhouse gases on world climate rising, it is essential to find ways to reduce load, increase efficiency, and utilize renewable fuel resources in federal facilities.

4.1 OPPORTUNITIES

During the facility design and development process, building projects must seek to reduce heating, cooling, and lighting loads through climate-responsive design and conservation practices; employ renewable energy sources; specify equipment and systems that consider part-load conditions and utility interface requirements; optimize building performance by employing energy modeling programs and optimize system control strategies; and monitor building performance through metering and reporting. Here are some opportunities that should be considered in order to sustainably optimize energy use:

- **Reduce Cooling, Heating and Lighting Loads by Using Climate-Responsive Design and Conservation Practices**
  - Use passive solar design
  - Orient, size and specify windows to maximize energy efficiency
  - Use high performance materials in building envelope based on thermal properties and durability
  - Locate landscaping with solar energy and building load requirements in mind

- **Employ High-Efficiency and Renewable Energy Sources**
  - Solar water heating

- Photovoltaic devices
- Biomass
- Geothermal heat pumps
- Consider purchasing electricity from renewable and low-pollution sources

❑ **Specify Efficient HVAC and Lighting Systems**

- Specify systems and equipment that meet or exceed 10 CFR 434
- Lighting systems < 1 watt/SF
- Energy Star® approved products, exceed DOE standards
- Consider energy recovery systems
- Consider co-generation, fuel cells, thermal storage, etc.

❑ **Optimize Building Performance and System Control Strategies**

- Employ energy modeling programs early in design process
- Use sensors to control systems based on occupancy, schedule, daylight and natural ventilation
- Evaluate use of modular components such as boiler, chillers, etc. to optimize part-load efficiency
- Use smart controls and building automation systems

❑ **Monitor Project Performance**

- Use a building commissioning plan extension throughout life of the project
- Use metering to confirm building energy and environmental performance throughout life of the project

4.2 RESOURCES

Here are some resources you can use to take advantage of opportunities to sustainably optimize the use of energy in a building. "Googling" the publication title will usually get you to a site that provides access to the publication…. sometimes at no cost, sometimes at a cost.

- ❑ Federal Green Construction Guide for Specifiers
- ❑ LEED® Version 2.1 Credit / WBDG Resource Page Matrix
- ❑ Energy Design Resources
- ❑ Energy Star®
- ❑ DOE Federal Energy Management Program
- ❑ DOE High Performance Buildings
- ❑ DOE National Renewable Energy Laboratory
- ❑ Renewable Energy Policy Project
- ❑ Center for Renewable Energy and Sustainable Technology
- ❑ GSA LEED® Applications Guide
- ❑ GSA LEED® Cost Study
- ❑ GSA P100 Facilities Standards for the Public Buildings Service

5. PRINCIPLE: PROTECTION AND CONSERVATION OF WATER

In the U.S. expenditures for water and sewer are billions of dollars annually. Reducing water consumption and protecting water quality are key objectives of sustainable design. This is critical because consumption of water in many areas of the country exceeds the ability of the supplying aquifer to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site.

5.1 OPPORTUNITIES

The protection and conservation of water must be considered throughout the life of the building, and federal agencies must seek to reduce, control, and treat surface runoff; use water efficiently; improve water quality; recover non-sewage and gray water for on-site use; and establish waste treatment and recycling centers; and apply best management practices to conserve water. Here are some opportunities to protect and conserve water that should be considered:

- **Reduce, Control, Treat Surface Runoff**
  - Use vegetated swales and depressions to reduce runoff
  - Reduce and filter surface runoff
  - Use integrated pest management to reduce water pollution from pesticides
  - Consider incorporating green roofs into project
  - Consider transient storm water events in the overall management of surface water runoff (such as use of retention and groundwater recharge basins
  - Use EPA's Green Infrastructure guidelines

- **Use Water Efficiently**
  - Incorporate efficiency in construction specifications
  - Use ultra water-efficient plumbing fixtures and integrate other water saving devices into building

- Landscape with drought resistant native plants
- Meter water usage
- Install water-conserving water towers with delimiters to reduce evaporation and drift
- Eliminate leaks by caulking around pipes and plumbing fixtures and conducting annual checks of hoses and pipes
- Specify EPA WaterSense labeled water-efficient products

Protect Water Quality

- Install water quality ponds or oil/grit separators as part of runoff filtration system
- Eliminate materials can release lead pollutants
- Use non-toxic cleaning products

❑ **Recover Non-Sewage and Greywater for On-Site Use**

- Use non-sewage waste water for on-site landscape irrigation, where approved by local officials
- Use groundwater and roof drainage water for on-site uses
- Use groundwater from sump pumps

❑ **Design Waste Treatment and Recycling Programs**

- Use biological waste treatment systems to treat waste on-site
- Treat greywater, ground water and roof water to an acceptable standard for re-use of site

5.2 RESOURCES

Here are some resources you can use to take advantage of opportunities to sustainably protect and conserve water used in buildings. "Googling" the publication title will usually get you to a site that provides access to the publication…. sometimes at no cost, sometimes at a cost.

- Federal Green Construction Guide for Specifiers
- DOE Federal Energy Management Practices for Water Conservation
- International Storm Water Best Management Practices Database
- LEED® Version 2.1 Credit / WBDG Resource Page Matrix
- EPA Office of Water
- EPA Office of Wastewater Management
- EPA National Pollutant Discharge Elimination System
- EPA Water Use Efficiency Program
- USCG Beneficial Landscaping Guidance
- EPA Storm Water Management for Construction Activities
- EPA Low Impact Development
- Water Wiser – The Water Efficiency Clearinghouse

6. PRINCIPLE: SELECTION AND USE OF ENVIRONMENTALLY PREFERABLE PRODUCTS

The composition of materials used in a building is a major factor in its life-cycle environmental impact. Facilities must use environmentally preferable of and processes that do not pollute or unnecessarily contribute to the waste stream, do not adversely affect health, and do not deplete limited natural resources. As the growing global economy expands the demand for raw materials, it is no longer sensible to throw away much of what we consider construction waste. Using a "cradle-to-cradle" approach, the "waste" from one generation can become the "raw material" of the next.

6.1 OPPORTUNITIES

During the facility design and development process, building projects must have a comprehensive perspective that seeks to renovate existing facilities, products, and equipment whenever possible; evaluate the environmental preferability of products using the cradle-to-cradle approach; maximize the recycled content of all new materials, especially from a post-consumer perspective; specify materials harvested on a sustained yield basis such as lumber from certified forests; encourage the use of recyclable assemblies and products that can be easily "de-constructed" at the end of their useful lives; limit construction debris, encourage the separation of waste streams, and encourage recycling during the construction process; eliminate the use of materials that pollute or are toxic during their manufacture, use, or reuse; and give preference to locally produced products and other products with low embodied energy content. Here are some opportunities that should be considered in order to optimize use of environmentally preferable products and methods.

- **Renovate Existing Facilities, Products and Equipment**
  - Evaluate renovation and/or expansion of an existing building instead of constructing a new building
  - Use reconditioned products, furniture and equipment whenever economically practical and resource efficient

- Consider reusing components of an existing building (such as windows, doors, etc.) in construction of a new building or renovation of an existing one

❑ **Evaluate Environmental Preferability Using Life Cycle Assessment (LCA) Tools**

- Consider trade offs among multiple environmental impacts (resource depletion, global warming, etc.)
- Utilize LCA tools such as ATHENA and BEES
- Consider trade offs among life-cycle stages (raw materials acquisition, manufacturing, transportation, installation, use and waste management)
- Consider USDA Biobased Products

❑ **Maximize the Recycled Content of All New Materials**

- Use EPA-designated recycled content products
- Purchase products described in EPA's Environmentally Preferable Purchasing Program
- Consider environmental factors along with price and performance in purchasing decisions (the "EPP"process)
- Emphasize pollution prevention as part of the purchasing process
- Examine multiple environmental attributes throughout the product life cycle
- Compare environmental impacts when selecting products
- Collect accurate and meaningful information about environmental performance of products
- Evaluate use of materials and products with the highest percentage of recycled content
- Evaluate use of materials and products with low energy content

❑ **Specify Materials Harvested on a Sustainable Yield Basis**

- Use timber products verified from sustainably managed forests

- Evaluate substitution of bio-based materials or products (such as agricultural fiber sheathing) for inert or non-recycled alternatives
- Specify rapidly renewable materials that regenerate in 10 years or less (such as bamboo, cork, wool and straw)

❑ **Encourage the Use of Recyclable Assemblies and Products**

- Evaluate the use of demountable or deconstructable products and assemblies
- Establish a waste management plan in cooperation with users to encourage recycling
- Consider providing locations at the project site for organic waste composting

❑ **Limit Construction Debris**

- Require development and implementation of a plan for sorting construction waste for recycling
- Use products that minimize disposable packaging and storage
- Consider designing a facility for ultimate deconstruction (rather than demolition)

❑ **Eliminate the Use of Materials that Pollute or are Toxic During Their Manufacture, Use or Reuse**

- Use materials and assemblies with the lowest level of volatile organic compounds (VOCs)
- Eliminate the use of asbestos, lead and PCBs in products and materials
- Eliminate the use of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) as HVAC refrigerants

❑ **Eliminate the Use of Materials that Pollute or are Toxic During Their Manufacture, Use or Reuse (continued)**

- Consider specification of products and materials whose manufacture does not pollute or create toxic conditions for manufacturing workers
- Avoid ground-level ozone in buildings to protect health of building occupants and prevent damage to vegetation and ecosystems

❑ **Give Preference to Locally Produced Materials with Low Embodied Energy Content**

- Consider locally produced products and materials to reduce impacts associated with transportation from remote locales
- Consider the use of products and materials that have minimal embodied energy (energy required for their manufacture, harvest, extraction, transportation, installation and/or use)

6.2 RESOURCES

Here are some resources you can use to take advantage of opportunities to optimize use of environmentally preferable products and materials in a building project. "Googling" the publication title will usually get you to a site that provides access to the publication…. sometimes at no cost, sometimes at a cost.

- ❑ Federal Green Construction Guide for Specifiers
- ❑ ASTM E2129 Standard Practice for Data Collection for Sustainability Assessment of Building Products
- ❑ ISO 14040 Series: Life Cycle Assessment Standards
- ❑ DOD Green Procurement Requirements Overview
- ❑ DOD Green Procurement Program (GPP)
- ❑ GSA Facilities Standards for the Public Buildings Service
- ❑ GSA Construction Waste Management Data Base
- ❑ LEED® Version 2.1 Credit
- ❑ NREL U.S. Life-Cycle Inventory (LCI) Database
- ❑ DLA Green Procurement Program

7. PRINCIPLE: ENHANCEMENT OF INDOOR ENVIRONMENTAL QUALITY

In order to build cost-effective and sustainable buildings it is easy to forget that the ultimate success or failure of a project rests on its indoor environmental quality (IEQ). Employees and occupants are invariably more satisfied and productive in a quality indoor environment. Unfortunately this compelling truth is often lost, for it is simpler to focus on the first-cost of a project than it is to determine the value of increased user productivity and health. With increased interest in sustainability of buildings it is even more difficult to focus on providing a quality indoor environment. Engineers and designers need a renewed appreciation of the importance of providing high-quality, interior environments for all users.

7.1 OPPORTUNITIES

During the facility design and development process, federal projects must have a comprehensive perspective that seeks to facilitate quality IEQ through good design, construction, and operating and maintenance practices; value aesthetic decisions, such as the importance of views and the integration of natural and man-made elements; provide thermal comfort with a maximum degree of personal control over temperature and airflow; supply adequate levels of ventilation and outside air to ensure indoor air quality; prevent airborne bacteria, mold and other fungi through heating, ventilating, air-conditioning (HVAC) system designs that are effective at controlling indoor humidity, and building envelope design that prevents the intrusion of moisture; avoid the use of materials high in pollutants, such as volatile organic compounds (VOCs) or toxins; assure acoustic privacy and comfort through the use of sound absorbing material and equipment isolation; control disturbing odors through contaminant isolation and careful selection of cleaning products; create a high performance luminous environment through the careful integration of natural and artificial light sources; and provide quality water. Here are some opportunities that should be considered to enhance indoor environmental quality:

- **Value Aesthetic Decisions**

- In addition to code requirements, appreciate the importance of providing windows in occupied spaces for natural ventilation and view.
- Appreciate the aesthetic dimension of buildings.

❑ **Provide Thermal Comfort**

- Use *ASHRAE Standard 55 -Thermal Environmental Conditions for Human Occupancy* as the basis for thermal comfort
- Consider the use of under-floor air distribution using an access-flooring system for flexibility, focused personal comfort control and energy utilization efficency
- Understand the importance of moisture control in roof and wall assemblies
- Evaluate options and benefits to be derived from specifying high-thermal performance windows

❑ **Supply Adequate Levels of Ventilation and Outside Air**

- Design ventilation systems to meet or exceed the requirements of *ASHRAE Standard 62 – Ventilation for Acceptable Indoor Air Quality*
- Protect key ventilation system components (ducts, etc.) from contamination during construction
- Commission HVAC systems to ensure they perform as designed (CFMs, temperatures, etc.).
- HVAC systems should be installed with filters with Minimum Efficiency Reporting Value (MERV) of 7

❑ **Supply Adequate Levels of Ventilation and Outside Air (continued)**

- Evaluate thermal efficiencies that can be realized with separate outside and conditioned air distribution systems
- Ensure that outside air intakes are located away from contamination sources such as loading docks, fume exhausts from the building, etc.
- Prevent vehicles from idling near outside air intakes

- Consider installing purge fans at contaminant sources, such as parking garage exist kiosks

❑ **Supply Adequate Levels of Ventilation and Outside Air (continued)**

- Consider installation of a permanent air quality monitoring system to ensure acceptable air quality levels are maintained (CO_2 < 1000 PPM, CO < 2 PPM, etc.)
- Consider building security when locating and designing outside air intakes
- Ensure that air filters are of the proper type and are changed/cleaned on a regular schedule

❑ **Prevent Airborne Bacteria, Mold, and Other Fungi**

- Ensure HVAC system is designed to control interior humidity at the 1% humidity ratio and mean coincident dry bulb temperature, under both extreme and low load conditions
- Building envelope must contain moisture barriers to prevent moisture infiltration
- Ensure the spore count in interior air is less than that in outdoor air, and should be < 700 spores/m^3

❑ **Limit Spread of Pathogens**

- In hospitals and other facilities at risk of pathogen contamination, ensure proper maintenance procedures are maintained
- In hospitals and other facilities at risk of pathogen contamination, consider designing restrooms without doors (with appropriate access paths and screens to block sightlines from occupied spaces such as corridors, offices and waiting rooms) to reduce chance of acquiring infection

❑ **Avoid Use of Materials Containing High Levels of Pollutants**

- Limit the use of cleaners, paints, adhesives and sealants containing high levels of volatile organic compounds (VOCs)

- Avoid products such as wall panels, cabinetry and carpet that contain formaldehyde
- In existing buildings where asbestos is present, remove it or contain it (such as by encapsulation) to prevent future exposure
- In areas where radon is a significant presence, include measures to control and mitigate its buildup

❑ **Avoid Use of Materials Containing High Levels of Pollutants**

- Provide safe and secure storage spaces for cleaning supplies
- If a portion of a building is being renovated, consider isolating it and maintaining a negative pressure in it during construction to dust, fumes and odors disturbing remaining occupants
- Ensure that office equipment does not emit objectionable odors pollutants or noise

❑ **Assure Acoustic Privacy and Comfort**

- Minimize noise using sound-absorbing materials
- Provide walls, floors and ceilings with high sound loss transmission coefficients
- Consider sound masking or “white-noise” systems that introduce an unobtrusive background sound that reduces interference from distracting office noise.
- Note that an unobtrusive level of noise from an HVAC system can in some cases effectively provide good sound masking

❑ **Create a High-Performance Luminous Environment**

- Use daylighting wherever practicable
- Supplement natural light with high-efficiency lamps, ballasts, fixtures and controls
- Use magnetic fluorescent lamps with high-frequency electronic ballasts to reduce flickering

- Reduce direct glare from natural and man-made light sources, particularly where reflective surfaces are in the field of view….such as computer screens
- Use task lighting and light colors on walls

❑ **Provide Quality Water**

- Comply with *EPA Safe Drinking Water Act* for levels of metals and bacteria in potable water systems
- Provide proper flushing and decontamination during commissioning of new and renovated potable water systems
- Conduct periodic maintenance flushing of potable water systems to control drinking water quality issues
- Control domestic water temperature above 140^{o} in tanks and 122^{o} at faucets to prevent legionellae growth
- At cooling towers, consider a closed-loop rather than open system reduce potential for contamination

❑ **Control Disturbing Odors**

- Directly exhaust copying and housekeeping areas and provide return air grilles to control odors and limit ozone generation
- For operations and products that produce odors and cannot be eliminated, provide architectural and HVAC isolation
- Ensure maintenance procedures remove trash and recyclables on a regular basis and do not permit undue storage on site
- If smoking is not prohibited in a building space, ensure that it has a lower static pressure than adjacent spaces, complies with *ASHRAE Standard 62*, and is isolated from the return air system of surrounding spaces.

❑ **Be Aware of Exposure to Electric and Magnetic Fields (EMF)**

- EMF may be perceived as harmful, however there is currently insufficient evidence to make a conclusive judgment

- Sources of information are *EMF RAPID-Electric and Magnetic Fields Research and Public Information Dissemination Program* and the *World Health Organization, Electromagnetic Fields Website*

7.2 RESOURCES

Here are some resources you can use to take advantage of opportunities to optimize indoor environmental quality in a building project. "Googling" the publication title will usually get you to a site that provides access to the publication…. sometimes at no cost, sometimes at a cost.

- ❑ ASHRAE Guideline 1-Guideline for the Commissioning of HVAC Systems
- ❑ ASHRAE Standard 52-Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
- ❑ ASHRAE Standard 55-Thermal Environmental Conditions for Human Occupancy
- ❑ ASHRAE Standard 62-Ventilation for Acceptable Indoor Air Quality
- ❑ ASHRAE Standard 90.1-Energy Efficient Design of New Buildings
- ❑ GSA P100 Facilities Standards for the Public Buildings Service
- ❑ EPA Indoor Air Quality website
- ❑ OSHA Indoor Air Quality website
- ❑ LEED® Green Building Rating System
- ❑ IAQ Building Education and Assessment Model (I-BEAM) softwar
- ❑ NIST Multizone Modeling website
- ❑ Indoor Air Quality Information Clearinghouse
- ❑ DOE/EPA Sustainable Building Technical Manual
- ❑ DOD Minimum Anti-Terrorism Standards for Buildings
- ❑ EPA Ventilation and Air Quality in Offices
- ❑ EPA National Center for Environmental Research
- ❑ DHHS Guidance for Protecting Building Environments from Airborne Chemical, Biological or Radiological Attacks

- ❑ EPA The Inside Story: A Guide to Indoor Air Quality
- ❑ IESNA RP-5 Recommended Practice of Daylighting
- ❑ Greenguard Environmental Institute Certified Products
- ❑ GreenSeal Product Recommendations
- ❑ NAVFAC Information on Legionella or Legionnaire's Disease
- ❑ MOIST 3 software
- ❑ EPA Cleaning Products Pilot Project (CPPP)

8. OPTIMIZATION OF OPERATIONS AND MAINTENANCE PRACTICES

This discussion is an introduction to sustainable *design* for buildings. There are, of course, many steps that can be taken in *operations and maintenance* practices that will benefit the principles of sustainability, but a discussion of these opportunities and resources is beyond the scope of this undertaking. That having been said, many of the design opportunities and resources identified here may have helpful impacts on operation and maintenance practices as well.

9. AN AFTERWORD: HOW TO USE THE INFORMATION IN THIS COURSE

This framework of **Principles**, **Opportunities** and **Resources** is not definitive; the concept of “Sustainability” is too broad and imprecise for any discussion of this scope to be definitive. But it is a start….

Use the framework presented here as something of a “checklist” at the start of a project to identify sustainability issues on which you should focus your limited time and resources. Then move on to the more definitive, readily accessible information available to you….such as at EPA, ASHRAE, LEED, etc. Make use of it and you will achieve a significant level of sustainability in your building design and construction projects.

Good luck!

QUIZ

AN INTRODUCTION TO SUSTAINABLE DESIGN FOR BUILDINGS

1. In the United States, buildings consume:

    a) Less than 50% of total energy used
    b) More than 60% of total electricity consumption
    c) Cause more than 30% of carbon dioxide emissions
    d) All of the above

2. The following can be considered a principal of sustainable design:

    a) Economic comparability
    b) Referential utility
    c) Optimizing protection and conservation of water
    d) “a” and “b” above

3. The following can be considered a principal of sustainable design:

    a) Optimization of operations and maintenance practice
    b) Enhancement of indoor environmental quality
    c) Optimizing redactic products
    d) “a” and “b” above

4. Which of the following is an opportunity to control erosion through landscaping practices?

    a) Provide rebarbatic barriers
    b) Capture and retain storm water runoff
    c) Reduce runoff using restricted orifice surge chambers
    d) “a” and “b” above

5. Which of the following is an opportunity to optimize minimalization of habitat disturbance:

    a) Specie control
    b) Reduce building and paving footprints
    c) Increase thermal factorial of landscaping
    d) “a” and “b” above

6. Opportunities that may be used to incorporate high-efficiency energy resources into a project are:

a) Global positioning apertures
b) Biothermic anomalies
c) Building automation systems
d) Co-valent systems

7. Which of the following is an organizational resources that may assist you to optimize the sustainability of a specific building design project:

a) U.S. Department of Energy
b) U.S. Department of Federal Waste Management (FWM)
c) UNESCO Enthalpy Organization
d) WHO Entropy Institute

8. The following is a component of the U.S. Environmental Protection Agency:

a) Office of Microbials
b) Office of Macrobials
c) Office of Biological Contaminants
d) Office of Wastewater Management

9. With regard to environmental preferability, Life Cycle Assessment (LCA) tools consist of:

a) DHHS Biological Database (DHHBD)
b) Both “a” and “d”
c) Neither “a” or “d”
d) USDA 2006 Meta-Survey

10. To optimize energy use in a conventional office building, lighting systems should be designed to consume at most:

a) 0.25 watt/SF
b) 0.50 watt/SF
c) 0.75 watt/SF
d) 1.00 watt/SF

11. An opportunity that may be used to optimize site potential is:

a) Minimize use of orthographic tree species
b) Reduce heat islands
c) Introduce exotic species for vegetation control
d) Use roofing products that exceed minimum AASHTO standards

12. An opportunity that may be used to protect and conserve water is:

a) Use vegetated swales
b) Filter surface runoff
c) Consider transient storm events in management of water runoff
d) All of a, b and c

13. An opportunity that may be used to enhance indoor environmental quality is:

a) Provide evaporative cooling
b) Incorporate a grey water system into the building
c) Specify fluorocarbon refrigerants in HVAC systems
d) Value aesthetic decisions

14. Selection and use of environmentally preferable products may be optimized by:

a) Using the Department of Commerce's Gold Star® product list for guidance
b) Comparing environmental impacts when selecting products
c) Utilizing the GODINA© program to evaluate impact
d) Referring to the DOE Sandia database

15. To minimize the use of materials that pollute or are toxic during their manufacture, use or reuse:

a) Replace VOCs with PCBs
b) Replace PCBs with VOCS
c) Replace VOCs with SUVs
d) None of the above