The Energy Design Process for High Performance Buildings

Richard B. Hayter

ASHRAE Presidential Member

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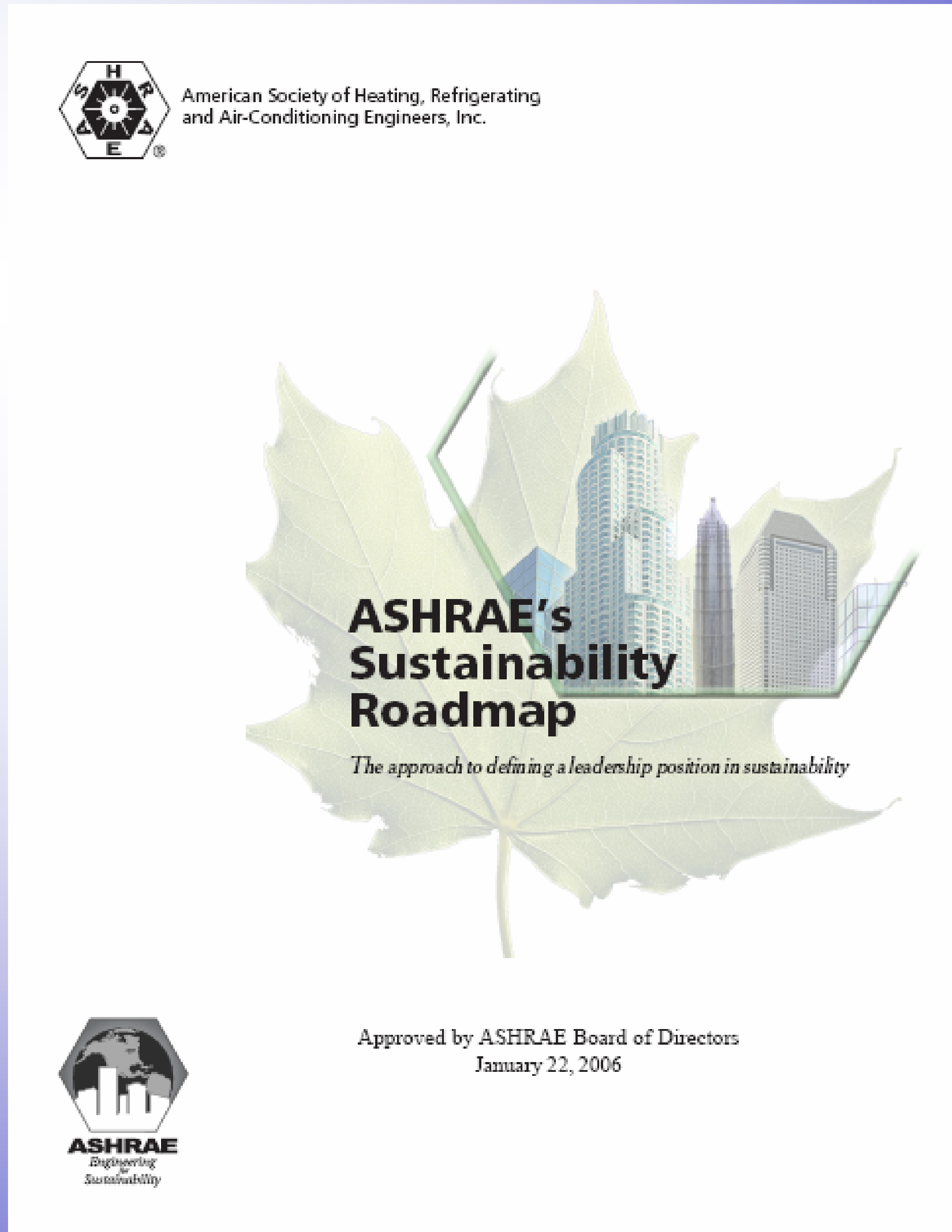
CONTINUING EDUCATION AIA

Learning Objectives

- Understand a key component of a high performance building, the occupant.
- Recognize the importance of an all-inclusive design team.
- View the building as a system.
- Learn a process for designing a high performance building.


American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

ASHRAE's Sustainability Roadmap

The approach to defining a leadership position in sustainability

Approved by ASHRAE Board of Directors
January 22, 2006

ASHRAE Engineering for Sustainability

ASHRAE→About ASHRAE→Vision & Goals

ASHRAE
Engineering for Sustainability

Home

ASHRAE's Green Tips

Sustainability Resources

Position Statement

Satellite Broadcast

ASHRAE Membership & Activities

A new roadmap adopted by ASHRAE will help members lead the march toward a sustainable built environment through use of advanced technologies.

Read Roadmap Here»

www.engineeringforsustainability.org

Tax Incentives

Consumers
Home Shell: *Insulation, Windows, Sealing*
Heating & Cooling Equipment
Passenger Vehicles
Solar Energy Systems
Fuel Cells

Businesses
Commercial Buildings
Commerical Vehicles
Solar Energy Systems
Fuel Cells & Microturbines

Builders/Manufacturers
New Homes
Appliances

General Information
About TIAP
Events
For Program Implementers
State & Utility Incentives
Legislation
TIAP Recommendations
F.A.Q.s & Contact Us

TIAP www.energytaxincentives.org

The Tax Incentives Assistance Project (TIAP), sponsored by a coalition of public interest nonprofit groups, government agencies, and other organizations in the energy efficiency field, is designed to give consumers and businesses information they need to make use of the federal income tax incentives for energy efficient products and technologies passed by Congress as part of the Energy Policy Act of 2005.

- New- Frequently Asked Questions
- New- Updated Information on Vehicle Incentives

Tax Incentives

TIAP Business Incentives

What is the tax incentive for commercial buildings?

A tax deduction of up to $1.80 per square foot is available to owners or tenants (or designers, in the case of government-owned buildings) of new or existing commercial buildings that are constructed or reconstructed to save at least 50% of the heating, cooling, water heating, and interior lighting energy cost of a building that meets ASHRAE Standard 90.1-2001. Partial deductions of up to $.60 per square foot can be taken for comparable reductions from any one of three building systems—the building envelope, lighting, or heating and cooling system—that meets goals consistent with achieving the 50% savings for the entire building. An interim system-specific goal for lighting is provided directly in the legislation and is valid until and unless the IRS issues a different final regulation. The interim lighting provision allows prororated deductions from 30 cents to 60 cents per square foot for lighting systems as described below.

These deductions are available for buildings or systems placed in service from January 1, 2006, through December 31, 2007.

Who is eligible for the incentives?

The person or organization that makes the expenditures for contruction is generally the recipient of the allowed tax deductions. This is usually the building owner, but for some HVAC or lighting efficiency projects, it could be the tenant. For government-owned buildings, the deduction may be taken by the building or system designer.

"No sensible decision can be made any longer without taking into account not only the world as it is but the world as it will be."

Issac Asimov

"Design and build buildings that do not deplete the earth's natural resources nor harm global environment or jeopardize the ability of future generations to meet their needs."

Don Holte,
ASHRAE President 1996-97

The ASHRAE Promise: A Sustainable Future

Terry Townsend,
ASHRAE President 2006-2007

The Future World

- A world population of 6B, increasing to perhaps 10B by 2050
- Rising expectations of developing countries
- Escalating demand on (finite) resources
- Political and economic instability
- Preservation of environment

Jim Schultz

Influences on HVAC&R Applications

If every centrifugal chiller had an efficacy of 0.48 kW/Ton vs. 0.56, annual power plant emissions would be reduced by:

- **Nearly 17 billion pounds of CO_2**
- **Over 64 billion grams of SO_2**
- **Over 27 billion grams of No_x**

Jim Wolf,

ASHRAE President 2000-01

Influences on HVAC&R Applications

Which is equivalent to:

- **Removing over 2 million cars from the road.**
- **Planting nearly 500 million trees each year.**

Building Energy Consumption (U.S.)

- **35% of total energy used in U.S.**
- **65% of total electrical consumption**
- **48% of energy used in buildings in U.S. is used for comfort cooling & refrigeration.**
- **50% of all U.S. homes have A/C.**
- **81% of all new homes have central air-conditioning.**

Environmental Impact of Buildings in the U.S.

114 million tons of CO_2 produced due to energy consumption in U.S. buildings.

67,000 tons of SO_x

35,000 tons of NO_x

Four Components Critical to the Creation of a Sustainable Building

1. The occupant
2. The design team
3. The building as a system
4. The design process

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Annual Operating Costs

- **Energy: $2.00 to $4.00/ft²**

Annual Operating Costs

- Energy: \$2.00 to \$4.00/ft^2
- Maintenance: \$2.00 to \$4.00/ft^2

Annual Operating Costs

- Energy: $2.00 to $4.00/ ft^2
- Maintenance: $2.00 to $4.00/ ft^2
- **Owning or Leasing: $10.00 to $40.00/ ft^2**

Annual Operating Costs

- **Energy: \$2.00 to \$4.00/ft^2**
- **Maintenance: \$2.00 to \$4.00/ft^2**
- **Owning or Leasing: \$10.00 to\$40.00/ft^2**
- **Personnel: \$200.00 to \$400.00/ft^2**

Indoor Design Conditions

3.2 2003 ASHRAE Applications Handbook

Table 1 General Design Criteria[a, b]

General Category	Specific Category	Inside Design Conditions: Winter	Inside Design Conditions: Summer	Air Movement	Circulation, air changes per hour
Dining and Entertainment Centers	Cafeterias and Luncheonettes	70 to 74°F 20 to 30% rh	78°F[d] 50% rh	50 fpm at 6 ft above floor	12 to 15
	Nightclubs and Casinos	70 to 74°F 20 to 30% rh	74 to 78°F 50 to 60% rh	below 25 fpm at 5 ft above floor	20 to 30
	Kitchens	70 to 74°F	85 to 88°F	30 to 50 fpm	12 to 15[g]
Office Buildings		70 to 74°F 20 to 30% rh	74 to 78°F 50 to 60% rh	25 to 45 fpm 0.75 to 2 cfm/ft²	4 to 10

General Design Conditions

Office Buildings	70 to 74°F 20 to 30% rh	74 to 78°F 50 to 60% rh	25 to 45 fpm 0.75 to 2 cfm/ft²	4 to 10

Indoor Design Conditions

Notes to Table 1, General Design Criteria

[a] This table shows design criteria differences between various commercial and public buildings. It should not be used as the sole source for design criteria. Each type of data contained here can be determined from the *ASHRAE Handbooks* and *Standards*.

[b] Consult governing codes to determine minimum allowable requirements. Outside air requirements may be reduced if high-efficiency adsorption equipment or other odor- or gas-removal equipment is used. See ASHRAE *Standard* 62 for calculation procedures. Also see Chapter 45 in this volume and Chapter 13 of the 2001 *ASHRAE Handbook—Fundamentals*.

[c] Refer to Chapter 47.

[d] Food in these areas is often eaten more quickly than in a restaurant; therefore, turnover of diners is much faster. Because diners seldom remain for long periods, they do not require the degree of comfort necessary in restaurants. Thus, it may be possible to lower design criteria standards and still provide reasonably comfortable conditions. Although space conditions of 80°F and 50% rh may be satisfactory for patrons when it is 95°F and 50% rh outside, inside conditions of 78°F and 40% rh are better.

[e] Cafeterias and
equipment and
ments are gen
air-conditionin

[f] In some nightc
low so patrons

[g] Usually detern

[h] Peak kitchen
although in lu
dining areas, p

[i] Methods for re

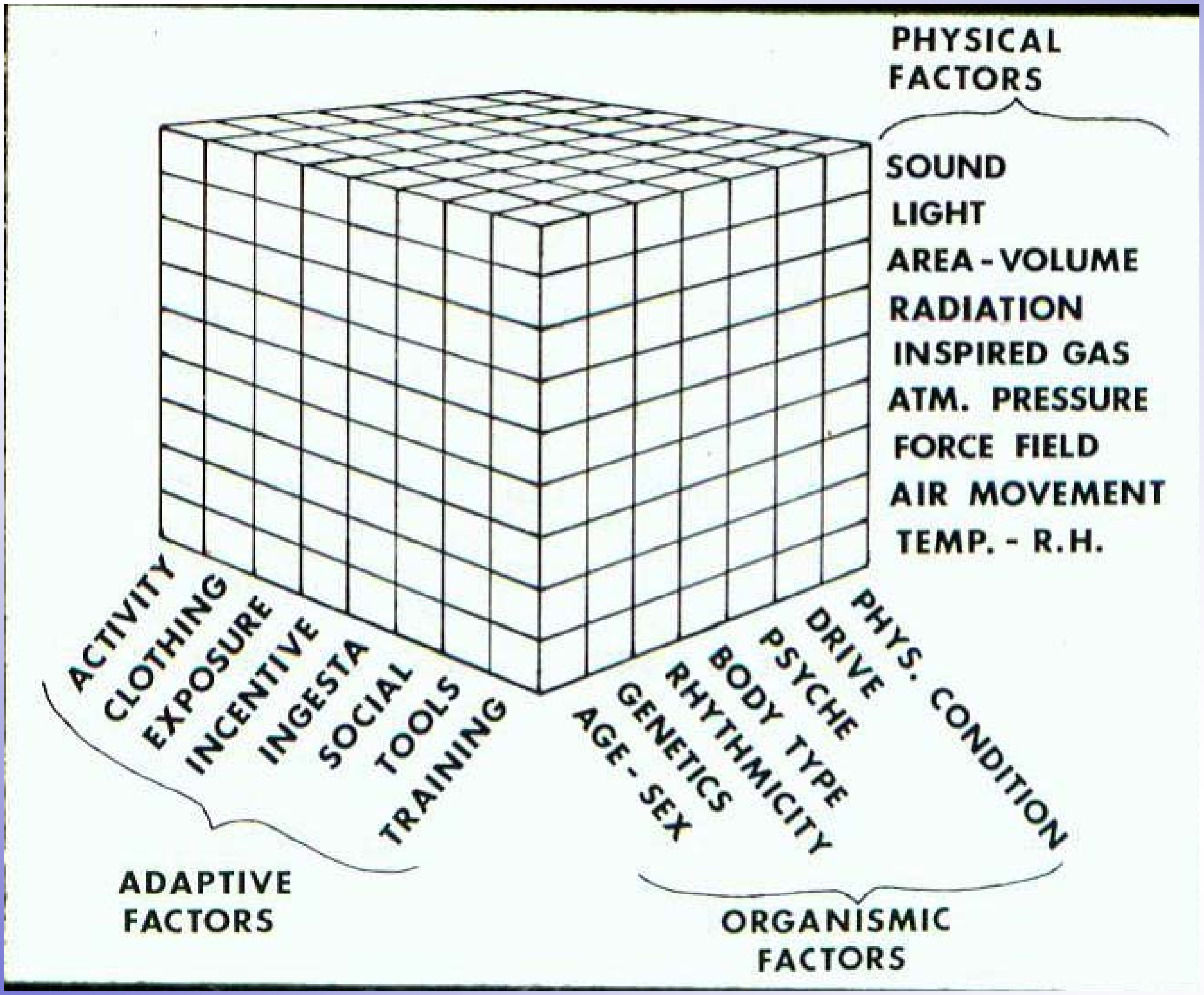
[j] Also includes s

Fundamentals of Thermal Comfort

<u>“Thermal Comfort:</u>

That condition of mind which expresses satisfaction with the thermal environment.”

Variables Affecting Comfort



Principles of Heat Transfer

- **Humans transfer sensible heat by conduction, convection and radiation.**

- **Humans transfer latent heat by evaporation from the skin (evaporation of perspiration) and through respiration.**

Metabolism

- Ranges from approximately 340 Btu/Hr (sendentary) to 3400 Btu/Hr (strenuous).
- Metabolic capacity of trained athlete can reach 20 times their sendentary rate.
- More typical maximum is 12 times sendentary for age 20 and 7 times sendentary for age 70.

Thermal Equilibrium

Is achieved when the metabolic rate equals rate of heat loss less work.*

* Thermal equilibrium does not necessarily mean comfort.

Physiological Responses

- Sweating = Increased Evaporation (little benefit from dripping sweat)

  Note: If heat production is greater than heat loss, first mechanism is vasodilatation which can double or triple heat loss.

- Shivering = Increases Metabolism

Thermal Neutrality

- That condition where no physiological response is needed other than vasomotion to maintain a normal body temperature.
- Normally achieved between T_o = 73^{o}F to 81^{o}F for clothed sendentary and 84^{o}F to 88^{o}F unclothed.

Discomfort

- Localized discomfort will overshadow comfort even under conditions of thermal neutrality.

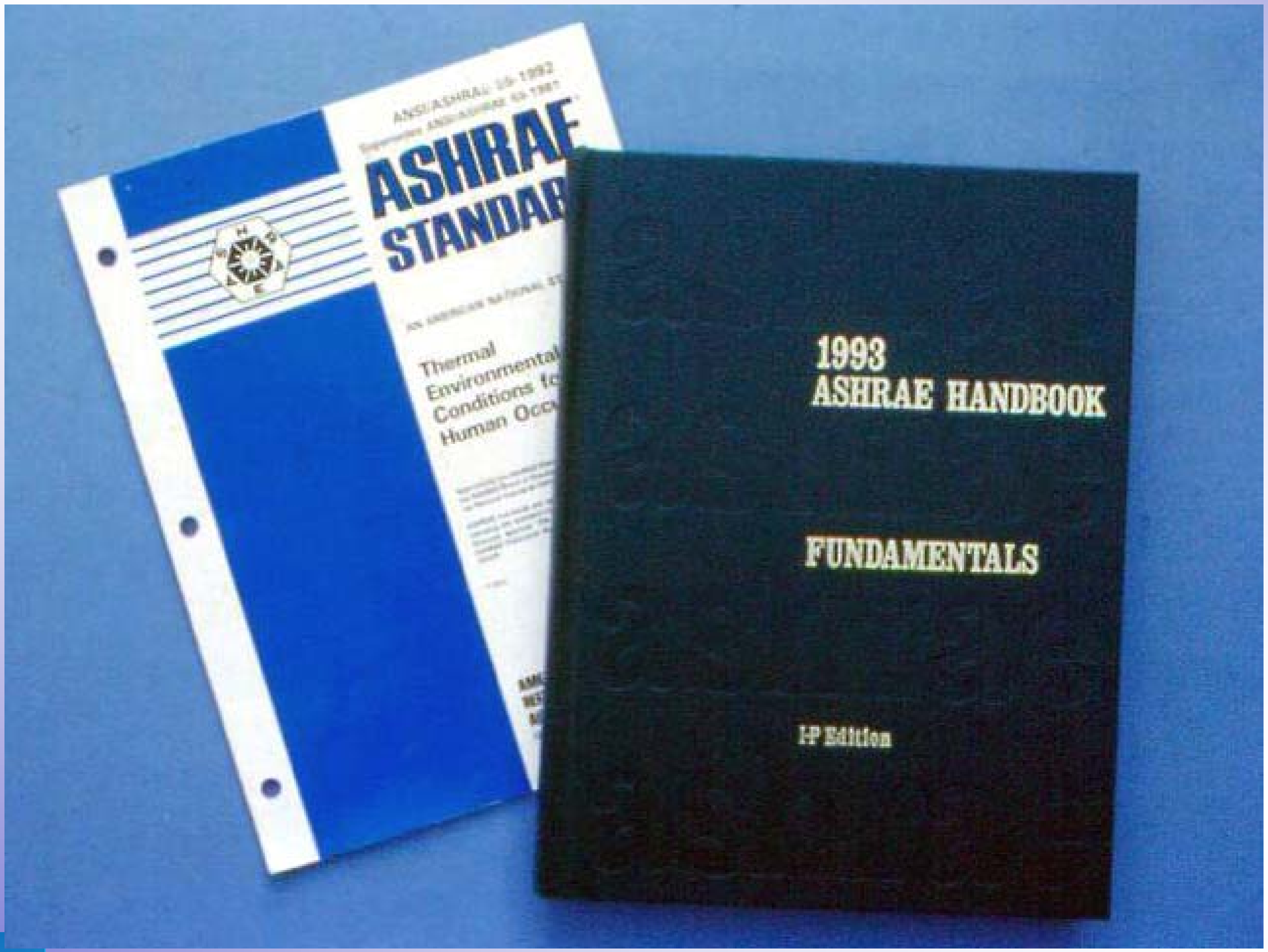
- Causes of localized discomfort include asymmetric radiation, drafts, contact with cold or hot floors, vertical temperature differences.

Discomfort Continued

- **Drafts have a disproportionate effect on comfort based on heat transfer.**

- **Dissatisfaction with the environment grows exponentially as air turbulence increases.**

ASHRAE Design Tools



ASHRAE Standard 55

ASHRAE Standard 55

Purpose:

"…to specify the combinations of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more occupants within the space."

Handbook of Fundamentals

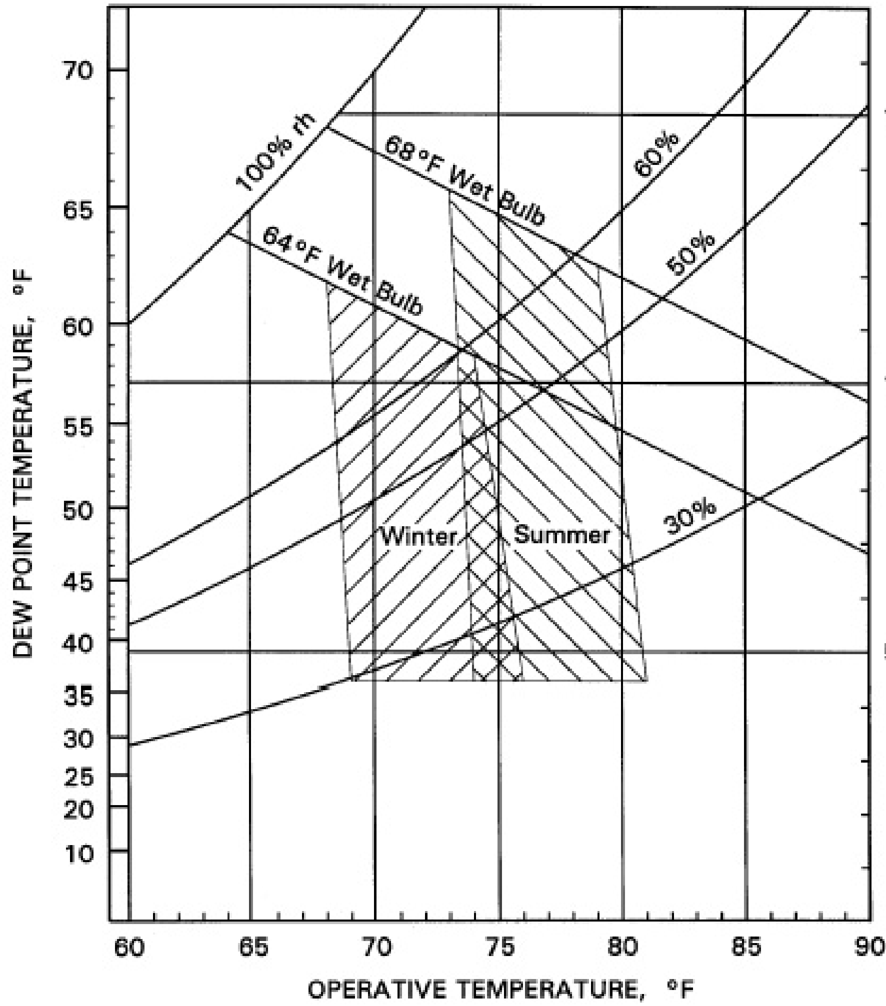


Fig. 5 ASHRAE Summer and Winter Comfort Zones

Four Components Critical to the Creation of a Sustainable Building

1. The occupant
2. **The design team**
3. The building as a system
4. The design process

The Design Team

"This requires cooperation . . . among <u>equal</u> partners of architects, engineers, contractors, building users and others."

Richard Rooley

President, ASHRAE

At a Minimum the Team Must Include

- Building Owner
- Project Manager
- Building Designers
  - ✓ HVAC&R Engineer
  - ✓ Structural Engineer
  - ✓ Architect
- Builder / Contractor
- Equipment Suppliers
- Building Operator

Additional Design Team Members

- **Lighting Designer**
- **Interior Architect**
- **Landscape Architect**
- **Lifts and Controls Engineer**
- **Energy Utilities Provider**
- **Code Official**
- **Financial Institution**
- **Insurer**
- **Educational Institution**

What will the Future Bring?

- ***"It is probable that within a very few years companies of designers, manufacturers and contractors who operate as they did in the latter part of the 20th century will be looked upon as a living museum"***

  Rooley

- ***"During your professional lifetime you may well serve on a design team of members you will never meet on a project you will never see in a country you never visit."***

  Hayter

Four Components Critical to the Creation of a Sustainable Building

1. The occupant
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3. **The building as a system**
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The <u>Building</u> as a System

The Building as a System

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The Building as a System

Four Components Critical to the Creation of a Sustainable Building

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The Design Process

Critical Initial Steps

- Form an <u>all-inclusive</u> project team
- Agree to a vision for the performance goals
- Agree to the process for making design, construction and occupancy decisions.
- Hold design charrette.

www.highperformancebuildings.gov

August 2003 • NREL/BK-710-33425

A Handbook for Planning and Conducting Charrettes for High-Performance Projects

www.highperformancebuildings.gov

/charrette_handbook.html

Gail Lindsey, FAIA
Design Harmony, Inc.

Joel Ann Todd
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NREL

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Golden, Colorado 80401-3393
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The Design Process

1. <u>Pre-design</u>: Evaluate building functions, size, site & local conditions.
2. <u>Base-case Building Model</u>: Meet prescriptive energy and building functional requirements
3. <u>Parametric Analysis</u>: Develop sensitivity analysis

The Design Process

4. <u>Create Design Options</u>: Consider building geometry, envelope, systems, energy sources, etc.
5. <u>Simulate Options</u>: Investigate variants of base-case building using options from previous step including effect of interactions.

The Design Process

6. <u>Conceptual Design</u>: Integrate energy features into architectural design. Refine based on simulation. Optimize envelope for energy use.
7. <u>Design Development</u>: Simulate options for HVAC system & controls. Investigate envelope & system trade-offs.

The Design Process

8. <u>Bid Documents & Specifications</u>: Assure that compromises are avoided such as thermal bridging, poor equipment efficiency, code violations. Simulate any modifications.

9. <u>Construction</u>: Simulate change orders. Hold regular design reviews. Maintain communications.

The Design Process

10. <u>Commissioning & Post Occupancy Evaluation</u>: Test subsystems including controls. Simulate any building-use changes from original intent to make needed system adjustments. Educate building owner/operator. Provide sufficient instructions for future users.

The Design Process

www.highperformancebuildings.gov

/lanl_sustainable_guide.html

Zion National Park Visitor Center

www.highperformancebuildings.gov/zion/

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Bookmarks Location: http://www.eren.doe.gov/buildings/highperformance/zion/zion.html What's Rela

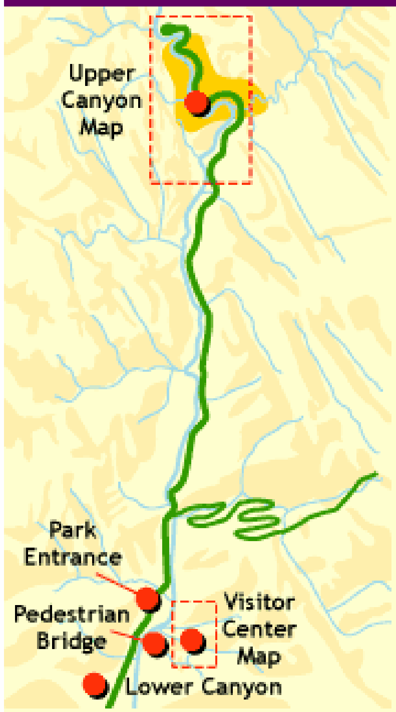
BTS Home

High Performance Buildings

Zion Visitor Center

Home

Choose a View of the Zion Visitor Center Go!



Head straight to the Quicktime™ panoramas that feature the Visitor Center's technologies

- Clerestory Windows
- Cooltowers
- Daylighting
- Energy-Efficient Landscaping
- Insulation
- Overhangs
- Photovoltaic System
- Thermal Mass Flooring
- Transportation
- Trombe Wall
- Ventilation

- Canyon Area Map
- Visitor Center Map
- Upper Canyon Map
- Site Navigation Tips
- Guided Tour

QuickTime Get 4.

Welcome to Zion!

Covering 229 square miles in southwestern Utah, Zion National Park was established in 1919 to preserve the area's natural beauty. At that time, the park welcomed 1,000 visitors a year.

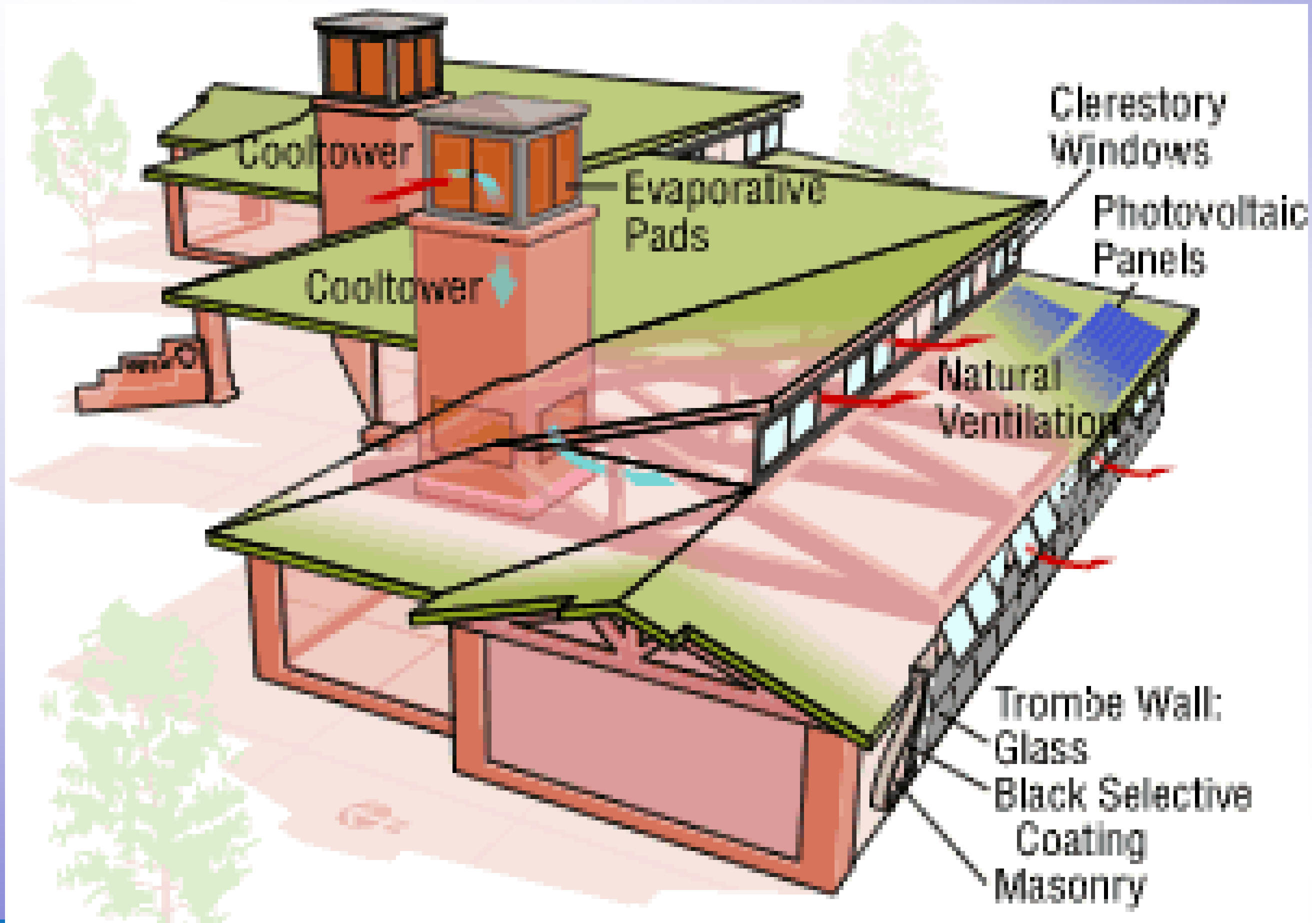
Today, with nearly 2.5 million visitors, the National Park Service has worked with the U.S. Department of Energy to minimize impact on Zion's environment while saving energy and reducing costs. The new Visitor Center, opened in May 2000, was designed

Document: Done

Zion National Park Visitor Center – The Conditions

- **Hot & Dry Climate (100ºF daytime high)**
- **Night temperatures in wider areas of canyon will drop to 59ºF**
- **Slot canyon (2000’ deep)**
- **Canyon provides significant shading**
- **Wet canyon walls provide evaporative cooling**

Zion National Park Visitor Center – Design Features



Goal – Use 70% less energy than ASHRAE Standard 90.

Zion National Park Visitor Center – Downdraft Cool Towers

Zion National Park Visitor Center – 7.2-kW PV System

PV provides 30% of daytime electrical load & 100% of basic functional requirements.

Zion National Park Visitor Center - Construction

- **Construction costs 30% less than planned for conventional building.**

Zion National Park Visitor Center – Lessons Learned

- Cooltowers with natural ventilation work best when serving open spaces. Offices with closed doors tend to overheat.
- White-washed ceiling less reflective than original design.
- No task lighting in original plan. Added later.

Conclusion

So what is your vision for a sustainable future?

or

Conclusion

"Vision without action is merely a dream and action without vision just passes the time, but vision with action can change the world."

Joel Barker

THANK YOU

This concludes the ASHRAE & AIA Continuing Education Systems Program

Please go to the website for the course evaluation

www.ashraemadison.org/crc2007

Questions or Comments??

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