

**SUSTAINABILITY TASK
FORCE INTERNSHIP
FINAL REPORT:
*BUILDING STANDARDS***

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Summary of Building Standards Project

The primary objective of this project was to create environmentally sustainable building standards and revisions that could be incorporated into Indiana University's existing standards document. Because mechanical and electrical standards provide us with the best opportunity for energy savings, these were the primary foci of this project. Moreover, mechanical and electrical systems' innovations cannot have much of an impact on energy efficiency if a building's envelope system is not functioning properly. Therefore, special emphasis was given to upgrading envelope standards as well. Note: A building's envelope system consists of the parts of the building that prevent outside air from entering the building and inside air from leaving the building, including but not limited to—windows, doors, insulation, roofing and wall systems.

The process for obtaining this objective has involved reviewing IU's existing building standards and comparing them with those from other universities, especially those universities who have strong sustainability movements. Additional research included reviewing sources such as the *United States Green Building Council* and *Labs for the 21st Century* for case studies on specific "green" attributes of buildings comparable in size and function to those found at IU. Another integral part of this project involved interviewing IU architects and engineers for input and guidance on revising the standards that they work with on a daily basis. This project could not have been completed without their assistance.

The purpose of this project is to ensure that the buildings being designed for and constructed at IU have a minimal effect on the natural environment of and that surrounding the campus. Worth noting here is the idea that "universities consume energy like mini-cities" and because of this, IU has a responsibility, as a public institution residing in a community, to acknowledge and attempt to remedy its inefficiencies.¹

The results of this project follow and include:

1. The addition of a foreword to preclude Indiana University's building standards
2. Revisions and additions to IU's building standards for divisions 1, 7, 8, 15 and 16
3. An appendix to IU's building standards to be added when the foreword and revisions are added
4. A list of recommendations for future work to be done in this area

¹ <http://www.eere.energy.gov/buildings/info/university/>

Building Standards Revisions

FOREWORD

On February 2nd 2007, acting president of Indiana University, President Herbert, challenged IU's Vice President and Chief Administrative Officer to secure LEED certification on buildings at IU whenever possible.² This challenge was put into action during the summer of 2007 when the newly created Indiana University Sustainability Task Force initiated an in depth survey and rewrite of existing IU building standards. The revisions made to the university's building standards reflect the move towards a more sustainable campus.

Indiana University recognizes the U.S. Green Building's Council's (USGBC) Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ as a valid approach to rate the design and construction of its campus buildings. The University has been a member of the Council since September 2006.



All new construction and major renovations should, at a minimum, meet each of the LEED prerequisites, including design build projects, as they pertain to issues such as site, water, energy and atmosphere, materials and resources and indoor air quality. Furthermore, the University wishes to maximize the number of LEED credits obtained and move beyond certification and into the silver, gold, or platinum levels of certification wherever possible.

Depending on the project either LEED for New Construction or LEED for Existing Buildings, the most recent versions, shall be used. For the most current versions of the rating systems see [LEED New Construction](#) or [LEED for Existing Buildings](#). Consult with the UAO if it is unclear which version should be used.

The A/E shall determine the most cost effective method to achieve LEED certification and shall provide, for the university to review, a LEED Project Checklist outlining the points sought and the means for achieving them. Because of the nature of the LEED rating system and its heavy reliance on documentation, it is very important that the A/E create a responsible party checklist early in the

² [February 2nd, 2007 Board of Trustees Meeting](#)

construction process so that it is clear which parties are responsible for each of the potential credits.

Any variance from the LEED prerequisites or a change in the number of LEED points sought must be approved by the UAO.

DIVISION 1 GENERAL REQUIREMENTS

1. Indiana University is committed to sustainable building design and the following standards have been revised to reflect this commitment. Please refer to the foreword to these standards for more information (insert link to foreword here).
2. Energy density benchmarks
 - a. Buildings must be energy efficient and shall strive to achieve a maximum energy consumption rate of:
(insert benchmarks here)
3. Metering standard
 - a. All new buildings shall have utilities metered. Contact UAO and Utilities department for details.
4. In order to ensure the construction of sustainable buildings, but still allow A/E to retain flexibility in design, the University requires a 25% improvement in building performance over existing Indiana Code requirements.
 - a. Energy modeling
5. Construction waste management plan
 - a. Responsible planning and design can greatly reduce the amount of construction waste through use of standard sizes for construction materials, minimization of applied finishes and careful consideration of manufacturing methods.
 - b. Diverted waste goals should follow those outlined in LEED standards
6. Indoor air quality management plan
7. Detailed, 3rd party, commissioning plan

[Virginia Tech](#)

[Virginia Tech](#)

DIVISION 7 MOISTURE PROTECTION

1. Building Insulation³

- a. Note: A 25% improvement in building performance over current Indiana Code requirements is required. To help achieve this goal, maximize insulation value.
 1. Energy modeling
- b. The use of insulation with recycled content is encouraged.
- b. The use of insulation containing formaldehyde, ammonium sulfate, or hydro chlorofluorocarbons (HCFCs), is discouraged.

[Virginia Tech](#)

2. Roofing⁴

- a. For flat roofs, light colored roofing materials are preferred. However, consideration for ease of maintenance must be taken into account.
- b. For roofs that have to be shingled, where appropriate and/or at the direction of UAO, incorporate light-colored shingles.
- c. Consider the benefits of green roofs and use if appropriate.

[Virginia Tech](#)

³ DIVISION 7 MOISTURE PROTECTION- New section "Building Insulation"

⁴ DIVISION 7 MOISTURE PROTECTION- Roofing

DIVISION 8 DOORS AND WINDOWS

1. Note: A 25% improvement in building performance over current Indiana Code requirements is required. To help achieve this goal maximize window performance and placement.⁵
 - a. Energy modeling
2. Windows
 - a. The use of wood framed windows is limited to historical buildings
3. Daylighting
 - a. Daylighting strategies are required for all projects. See *Indiana University Daylighting Standards* in appendix. (insert link here).

Iowa State

⁵ DIVISION 8 DOORS AND WINDOWS- Need section on windows

DIVISION 15 MECHANICAL

1. “Energy Efficiency: Energy efficiency shall be a prime consideration in the design of mechanical systems. This concern shall be addressed in the selection of pumps, motors, etc., as well as in the selection of materials for and the sizing of piping and ducts.”
 - a. Energy conservation clause⁶ (start with narrative, give energy density targets)

2. “Design systems that provide heating and cooling year-round to accommodate the desired occupancy.”⁷
 - a. Provide a life cycle cost analysis for the proposed system.
 - i. Consider the impact of central system zoning.
 - a) Include operating costs of building as operated and not based on square foot costs alone.
 - b) Zone systems by occupant function.
 - c) Zone systems to permit shutdown of areas occupied only during Owner business hours.
 - ii. Include impact of maintenance cost as well as energy cost during system selection.
 - b. Provide each room with individual temperature control”

3. Mechanical rooms⁸
 - a. Assure that building mechanical air intakes are positioned appropriately (away from loading docks, etc)

4. Mechanical standards for laboratories⁹
 - a. Energy efficiency must be a priority when designing and specifying equipment for laboratories.
 - b. Full VAV hood control systems are preferred
 - c. Life cycle cost analysis of mechanical system options is required
 - d. Economic analysis for mechanical system must be submitted by designer
 - e. Lab ventilation rates
 - f. Dual (infrared and ultrasonic) technology sensors (minimum of two per lab area) are required

[Stanford](#)

Iowa State

[Univ. of Virginia](#)

[Cornell University](#)

⁶ Section 15010 BASIC MECHANICAL REQUIREMENTS

⁷ Section 15010 BASIC MECHANICAL REQUIREMENTS

⁸ Section 15010 BASIC MECHANICAL REQUIREMENTS (We do not have a specific section for mechanical rooms)

⁹ New section 15020 LABORATORIES

5. Building design loads and equipment capacities (submitted by designer on first mechanical drawing)¹⁰

[Virginia Tech](#)

6. Limit use of Direct Exchange (DX) systems¹¹

[Virginia Tech](#)

7. The use of water-cooled condensing units that use domestic, potable water on a single-pass cycle should be for emergency use only. Consult with IU Engineering for more information.¹²

[Virginia Tech](#)

8. Piping Insulation¹³

- a. *Enhance piping insulation requirements—see sources*
- b. Modify section to include statement on insulating different piping systems in their entirety (valves, pumps, sensors, etc) where appropriate (see IUPUI standards, Cornell’s refrigeration piping insulation standards, or Ohio State)

[Cornell University](#)

[UNC-Chapel Hill](#)

[Cornell University](#)

[Ohio State Univ.](#)

9. Water saving plumbing fixtures¹⁴

- a. Urinals
 - i. Where appropriate, specify waterless urinals. These fixtures may not be appropriate for dormitories.
- b. Water closets
 - i. Specify fixtures that exceed the 1.6 maximum gallons per flush required by code.
- c. Faucets
 - i. Specify faucets that exceed the 2.0 maximum flow rates per minute required by code.
 - ii. Specify aerators for all faucets.

[Cornell University](#)

[Iowa State](#)

[UNC-Chapel Hill](#)

10. HVAC

[Ohio State Univ.](#)

¹⁰ Section 15010 BASIC MECHANICAL REQUIREMENTS

¹¹ Section 15010 BASIC MECHANICAL REQUIREMENTS

¹² Section 15010 BASIC MECHANICAL REQUIREMENTS

¹³ Section 15250 INSULATION

¹⁴ Section 15450 PLUMBING FIXTURES- Part B Products

- a. Economic analysis of proposed energy recovery systems is required¹⁵
- b. Where cost-effective, use CO₂ controls or occupancy sensors to modulate outside airflow in classrooms and auditoriums¹⁶
 - i. Sequence of operation on these units should specify when outside air dampers can be closed and when fans can be shut off. Occupancy sensor will also restart AHU.
 - ii. EMS monitoring
- c. Restrict use of VAV systems that simply reduce outside airflow in proportion to supply airflow (“Spaces of different uses, such as offices and classrooms, may only be served by the same AHU if CO₂ sensors or other approved controls are provided in adequate quantity and location to ensure code required outside air to all spaces”)¹⁷
- d. The use of constant volume reheat systems is prohibited¹⁸
 - i. Where constant volume systems are necessary, as approved by IU Engineering, a heat recovery system is required
 - 1. Payback of no more than 10 years
- e. Energy conservation measures that reduce peak-cooling load are encouraged¹⁹
 - i. A 10 year payback is required
- f. Revision: Provide variable frequency drives for all pump motors exceeding 5 HP.²⁰

[Univ. of Virginia](#)

[Univ. of Virginia](#)

[Univ. of Virginia](#)

[Ohio State Univ.](#)

11. Detailed chilled water metering standards²¹

- a. TBA

[Cornell University](#)

[Univ. of Virginia](#)

12. Detailed steam metering standards²²

[Cornell University](#)

¹⁵ Section 15500 HVAC- Part A General

¹⁶ Section 15500 HVAC- Part A General

¹⁷ Section 15500 HVAC- Part A General

¹⁸ Section 15500 HVAC- Part A General

¹⁹ Section 15500 HVAC- Part A General

²⁰ Section 15500 HVAC- Part B HVAC Pumps- Number 14

²¹ Section 15650 REFRIGERATION, WATER CHILLING

a. TBA

[Univ. of Virginia](#)

13. Consider using condensing boiling equipment and system design²³

14. Revision: For standard applications- Hot water design supply temperature 180°F design return temperature 160°F
For non-standard applications- Provide low water temperature in condensing boiler applications²⁴

15. Air Handling

- a. “In selection of air handling units avoid large zones or too many zones. Multiple air handling units are preferred over a single large unit especially with variety of building uses.”
- b. Minimum energy efficiency for filters²⁵

[U of British Col.](#)

16. Ductwork

- a. Best practices shall be followed in duct work design to minimize losses and for velocity energy recovery.²⁶

[Ohio State Univ.](#)

[Virginia Tech](#)

[Ohio State Univ.](#)

17. Air compressors are limited to screw types for over 15 horsepower due to decreased maintenance and improved efficiency²⁷

[Cornell University](#)

18. Variable frequency drives for tower fans are recommended²⁸

[Ohio State Univ.](#)

19. Water Chillers

- a. For buildings running on their own chillers and without DDC VAV systems, a capacity control could be utilized for demand

[Ohio State Univ.](#)

²² Section 15750 HEATING EQUIPMENT

²³ Section 15750 HEATING EQUIPMENT- Part B Boilers

²⁴ Section 15750 HEATING EQUIPMENT- Part B Boilers- Number 4, Part e

²⁵ Section 15850 AIR HANDLING ??

²⁶ Section 15850 AIR HANDLING Section E Ductwork

²⁷ Section 15950 CONTROLS- Part M Air Compressor and Refrigerated Air Dryer

²⁸ Section 15650 REFRIGERATION, WATER CHILLING- Part C Cooling Towers

management purposes. Consider this option and discuss with IU Engineering.²⁹

20. “Controls such as carbon dioxide (CO₂) or occupancy sensors shall be used to modulate outside airflow in classrooms and auditoriums, unless demonstrated not to be cost effective. On units with CO₂ control, the sequence of operation shall specify when outside air dampers can be closed, and when fans can be shut off.”³⁰ See also Division 15, section 15500 HVAC, part a.

[Univ. of Virginia](#)

²⁹ DIVISION 15 Section 15650 REFRIGERATION, WATER CHILLING, Part B Water Chillers

³⁰ DIVISION 15 Section 15950 Controls

DIVISION 16 ELECTRICAL

1. Electrical designs shall incorporate energy conservation through the specification of energy efficient equipment, controls, and lighting.³¹
2. Revision: Occupancy sensors in labs³²
 - a. In general, occupancy sensors shall be installed in classrooms, offices, storage rooms, restrooms, **and labs. See standards for laboratories (not created yet) for more information.**
3. Other devices³³
 - a. CO₂ sensors—note that CO₂ are specified in Division 15, Section 15950
4. Lighting³⁴
 - a. Daylight harvesting is required. See *Indiana University Daylighting Standards* in appendix. (insert link here)
 - b. Exterior lighting—architectural lighting v. security lighting
 - i. The use of architectural lighting should be kept to a minimum.
 - c. The use of fluorescent dimming systems in large classrooms and conference rooms are for daylight harvesting systems are encouraged.³⁵

³¹ DIVISION 16 ELECTRICAL STANDARDS- New section- General Requirements

³² DIVISION 16 ELECTRICAL STANDARDS- Section 16140- Devices and Low Voltage Switching- Part 5. Occupancy sensors- part a

³³ DIVISION 16 ELECTRICAL STANDARDS- Section 16140- Devices and Low Voltage Switching- New section: Part 6. Other devices

³⁴ DIVISION 16 ELECTRICAL STANDARDS Section 16500 Lighting Systems- Part A- General

³⁵ DIVISION 16 ELECTRICAL STANDARDS Section 16500 Lighting Systems- Part F- Dimming Systems-- General

APPENDIX

(Note: The following section, Indiana University Daylighting Standards, came from earlier work done on IU's building standards and was created by Jeff Kaden)

Indiana University Daylighting Standards

GENERAL

In order to improve the human, energy and environmental performance of Indiana University facilities, the University Architect's Office (UAO) has developed these daylighting standards¹. It is the intent of these standards to create better-performing facilities that will:

- 1) Promote human health, comfort and performance;
- 2) Conserve natural resources and reduce detrimental effects on the environment; and
- 3) Reduce energy consumption.

These standards set forth concepts and minimum requirements for daylighting Indiana University facilities—admitting natural light of appropriate quantity and quality while controlling electric lighting in response to the daylight.

INTEGRATED DESIGN APPROACH

The concepts underlying these daylighting standards are an attempt to balance the contradictory influences of the sun's energy in contributing to heat, lighting, comfort and glare. Achieving a practical balance requires that these issues be understood and approached through an integrated, interdisciplinary process from the earliest stages of design. An integrated approach requires that the architect consider HVAC, electrical and lighting loads in making fundamental decisions about the basic building concept, functional relationships and architectural form (including orientation, massing, [fenestration](#), treatment of façade, interior finishes and lighting).

Indiana University expects the prime A/E to evaluate and challenge program requirements that add to HVAC and electrical loads and to demonstrate commitment and leadership towards achieving the goals and daylighting strategies stated herein. The mechanical, electrical and lighting subconsultants are expected to be involved early and to provide critical and timely feedback on architectural issues affecting energy use. Through such an interactive, multi-disciplinary approach the design team will find creative, common sense, synergistic solutions that satisfy these performance criteria, as well as the functional program requirements of the users.

OBJECTIVES

Compared to conventional, code-compliant buildings, Indiana University expects its facilities to be designed to achieve the following general objectives without significantly increasing total construction cost:

- Promote user health and comfort, and enhance satisfaction and productivity;
- Incorporate more sustainable, environmentally-responsible design and construction practices;
- Reduce peak electrical demand;
- Reduce total installed air-conditioning capacity and total fan power;
- Reduce total installed lighting power density;
- Reduce building-related energy use significantly below building code requirements;

- Minimize lifetime building utility, maintenance and repair costs.

APPLICABILITY

These daylighting standards apply to all buildings with windows, air-conditioning, and significant daytime occupancies. Indiana University expects that all new construction and renovation projects that involve the installation, replacement, reconfiguration or re-glazing of windows will incorporate these daylighting performance criteria, as possible. Compliance with the “Acceptable” performance level shown in Table 1 is required. The “Preferred” levels of compliance listed in Table 1 are encouraged, but not mandated at this time.

If the A/E believes that a particular program requirement will be compromised by these daylighting standards, Indiana University expects the A/E to discuss the special circumstances with the Indiana University Project Architect prior to beginning design. The A/E shall balance these daylighting requirements against program requirements on a space-by-space basis.

COOLING LOAD AVOIDANCE

One of the primary goals of these daylighting performance standards is reducing cooling loads. Appropriate fenestration, reducing the amount of glazing (which is generally more costly than solid exterior wall construction), improving glass performance, and decreasing the connected lighting power can significantly reduce peak cooling loads. This, in turn, will permit downsizing of HVAC equipment, one of the main objectives of [cool daylighting](#)³⁶. Equipment downsizing, along with subsequent reductions in supply air fan horsepower and duct sizes, will reduce the first cost as well as life-cycle cost of the building, and will typically offset the cost of the necessary high-performance glazing, window treatments and lighting systems. It is generally more economical on a life-cycle basis to mitigate lighting and solar cooling loads architecturally than by adding capacity to the HVAC system.

LIGHTING QUALITY AND DISTRIBUTION

Another primary goal of these design standards is enhancement of the indoor visual and thermal environment. Human health, comfort and productivity should always be enhanced, and never compromised, in the fulfillment of these requirements. For each project Indiana University expects designers to carefully examine the stated program goals related to lighting, glazing, views, and activities which require or shun light, in the context of the practical lighting needs of the contemporary computer-equipped office and computer/video-based learning environment. Too much light is as unacceptable as too little. Lighting quality and contrasts are as important as simple foot-candle requirements³⁷. Localized user control of both daylight and electric light should also be considered in order to enhance user satisfaction as well as energy savings.

Avoiding unwanted glare and heat gain sometimes results in architectural solutions with minimal window areas. However, human health and performance are enhanced by a significant degree of transparency and exposure to natural light and views to the changing outside environment. Effective “transparency” means that there are multiple view lines outward, allowing views of horizon and sky. The A/E shall

³⁶ These daylighting standards are based on the “Cool Daylighting” approach promoted by Lightforms, Inc (lightforms@aol.com) and The Daylighting Collaborative of The Energy Center of Wisconsin (www.ecw.org). Indiana University gratefully acknowledges their support and the support of the Wisconsin Department of Administration Division of State Facilities as well as the technical assistance of Midwest Sustainable Collaborative (<http://www.midwestsustainablecollaborative.com/>) in the development of these guidelines.

³⁷ A/E's are advised to refer to The *IESNA Lighting Handbook, 2000, Ninth Edition*, for further information on Vision and Perception (Chapter 3) and Lighting Design Guide and Quality of the Visual Environment (Chapter 10). The *Advanced Lighting Guidelines, 2003 Edition*, published by New Buildings Institute, Inc. is another useful reference.

endeavor to provide natural light and views to the greatest possible number of occupants—meaning that space is planned with enclosed offices located toward the interior, leaving open offices along the perimeter, and service spaces (toilets, storage, vertical circulation, etc.) and intermittent occupancies located deeper within the windowless interior. Interior glazing should be used to allow views above and through perimeter offices for occupants of interior zones. Architectural form can be extended/narrowed to increase the percentage of perimeter to core space.

DAYLIGHTING PERFORMANCE AND CRITERIA

Successful daylighting design takes many forms, varying with building type, site parameters and program requirements. Specific design solutions, features and methods are not as important as overall results. Incorporating these strategies holistically into every design will prevent the most common problems associated with daylighting—increased cooling loads, peak power demands and visual glare. The following cool daylighting criteria, listed in order of importance, represent a simple, straightforward, integrated approach. This approach is intended to permit great flexibility and to encourage innovation. The design team is encouraged to use additional means to achieve these goals.

REQUIRED DAYLIGHTING STRATEGIES:

The following seven daylighting performance criteria, summarized in Table 1, are the foundation of the cool daylighting approach and are mandatory for Indiana University facilities.

Criterion 1: Glass Area

While transparency and daylighting are important, over-glazing is possible and must be avoided. A typical contemporary office building with fenestration based on traditional visual and aesthetic criteria commonly has more glazing than required for adequate daylighting. Sizing and placement of glass must be judicious, intentional and without waste. Decreasing the ratio of windows to exterior wall area is one of the most cost-effective architectural design strategies for enhancing the energy performance of internal-load-dominated commercial buildings. The [window-wall ratios](#) (WWR) must be applied at the schematic design stage, since they have a significant effect on a building's appearance as well as energy performance. The window-wall ratios must be checked regularly throughout schematics and design development and kept within the limits of Table 1.

The window-wall ratio is the ratio of [window area](#) to [gross exterior wall area](#). Window area includes glass plus framing for all windows and glazed doors. The gross exterior wall area is the total exterior wall surface from the lowest floor level up to the top of the roof deck for all spaces that will be mechanically cooled. The WWR is calculated for each elevation separately.

If special site or program requirements conflict with these window-wall ratios, the A/E may propose alternatives for Indiana University approval. Indiana University may then authorize an increase in the WWR of the east, south or west side of the building, if a corresponding decrease is made on another side or sides (E, S or W). The window-wall ratio is an important design consideration, but it must be balanced with other energy design strategies, daylighting features and glazing performance. On the north elevation heat loss and occupant comfort are of more concern than heat gain, so the WWR is less restrictive. For east, and especially west elevations, it is desirable to reduce below these design targets.

The use of skylights (non-vertical glazing, 60° or less from horizontal) is generally not recommended, because of the significant heat gain they contribute and the difficulty of adequately shading them. For some buildings or spaces—large, single-story, high-bay, non-air-conditioned spaces, such as warehouses, sheds, or gymnasiums—top lighting may be an appropriate strategy.

Fenestration has a great effect on the distribution of light within a space. The A/E must attempt to optimize the placement of glass to provide uniform interior light. Locating glass as high as possible will generally permit deeper penetration of light and take better advantage of ceiling reflection. Placement of glass near side partitions can also provide advantageous light reflection into the space. Glass that is too

low is essentially “wasted” for daylighting purposes; therefore, windowsills should generally not be lower than desk height.

For optimal overall cooling load avoidance and advantageous daylighting of primary building spaces, the ideal building configuration will orient the primary spaces toward north and south, often resulting in a building form that is elongated in an east-west direction.

Criterion 2: Glass Performance

Glass that controls glare and unwanted solar heat gain improves human performance and energy efficiency. Glass type must be selected relatively early in the design process, since it has a significant impact on cooling loads and therefore on the design of the HVAC system and sizing of equipment and ductwork. The selection of glass involves a thoughtful balance between limiting solar heat gain (appropriate shading coefficient) and controlling glare/brightness (appropriate visible transmittance), while still providing a sense of transparency. Spectrally neutral, insulating, low-e glass is recommended. The use of reflective glass should be minimized.

View Glass

Without exterior shading, the key to limiting solar heat gain is the [shading coefficient](#) (SC) of the glass. Indiana University requires strict adherence to the maximum SC of .38 given in Table 1. A low shading coefficient, however, does not necessarily control brightness and glare. If [visible light transmittance](#) (V_T) is too high, the window opening will appear too bright, and occupants will have a tendency to close window blinds, thereby defeating the attempt to provide natural lighting. On the other hand, if V_T is too low, a dull or “dreary” environment can be created, even when there is adequate light on the work surface.

At primary entries or at ground level areas (for multi-story buildings) where a stronger visual connection between outside and inside is desired, and there are no activities/tasks that are sensitive to glare, clearer glass may be permitted, exceeding the maximum V_T in Table 1. If V_T is increased under such circumstances, then solar heat gain is not to be increased.

Daylighting Glass

Since daylighting glass is by definition out of the normal field of vision, restricting the visible light transmittance is less a concern, as long as glare and excessive brightness ratios are avoided. Limiting solar heat gain is *equally* important with both [view glass](#) and [daylighting glass](#). If for some reason the A/E wishes to use higher V_T for daylighting glass, then glare and direct-beam sunlight must be controlled by architectural form (interior light shelves or fixed interior louvers, with or without fixed exterior shading). The cost of these architectural features must be compared to the cost of using the low- V_T glass. Indiana University expects that using the glass recommended herein will generally be more cost-effective.

Criterion 3: Lighting Power Density

Most offices and classrooms can be illuminated with better-quality light and less power (one watt per sq. ft., or less) than typical current practice. An approach combining ambient and [task lighting](#) is recommended whenever possible.

For [ambient lighting](#) the A/E shall specify high-quality, energy-efficient [luminaires](#) that:

- Provide indirect light where possible, with 84% or more of lamp lumens leaving the luminaire;
- Are lamped with high-quality electric lamps selected for compatibility with daylight. Minimum [color rendering index](#) (CRI) of 83 is expected.
- Are arranged and controlled parallel to the daylighting glass, whenever possible.

For offices, an indirect lighting system is recommended, providing ambient [illuminance](#) levels based on *The IESNA Lighting Handbook* "Lighting Design Guide". Indirect lighting can decrease lighting power requirements while maintaining or improving illumination levels. Where there is extensive use of computers, ambient lighting levels less than IESNA recommendations may be appropriate. For classrooms, direct/indirect luminaires with superior lamp shielding and 82%-85% efficiency or higher are recommended, where possible. Lighting design should take maximum advantage of the reflectiveness of the room cavity. See also "Indiana University Electrical Standards" for other lighting design requirements.

Low-wattage task lighting (desktop, as part of systems furniture, or built-in fixtures) is an essential component of these lighting recommendations. Desktop task lights will be budgeted as movable equipment and provided by the user-agency; therefore the A/E, user-agency and Indiana University Project Architect must discuss and reach a common understanding during the Schematic Design Phase of what will be provided and by whom. Indiana University expects the A/E to make recommendations regarding task lighting. Office task lights using energy-efficient compact fluorescent lamps that provide excellent glare control and user adjustability are available and recommended.

The A/E may assume *annual* luminaire maintenance for purposes of figuring the luminaire dirt depreciation factor. Dirt accumulation on lamps, lenses and reflectors is a primary contributor to loss of lighting efficiency and Indiana University expects the user-agency to be pro-active in providing the annual cleaning on which the lighting design will be based. User-agencies are referred to *IESNA Lighting Handbook* Chapter 28 "Lighting Maintenance".

Criterion 4: Window Treatments

On predominantly east, south and especially west-oriented view windows, there is a need to reduce glare from direct sunlight, while trying to maintain transparency. Therefore, specify window treatments that will, in the closed position, eliminate glare from sunlight, but still maintain some view and connection to the outdoors.

Dark and medium-colored, perforated, interior manual roller screens accomplish this very well on all exposures. Horizontal blinds will provide acceptable performance on south exposures. Slats should be at least an inch wide and may be perforated to provide visual connection to the exterior. On east and west exposures vertical blinds are better than horizontal for screening low-angle sun (true for exterior shading on these exposures, also). Provide separate, dedicated window treatments for view glass and for daylighting glass, so that when brightness through view glass needs to be controlled, daylighting glass can remain open to admit useful light. For maximum visual comfort for computer/video-based tasks, light "leaks" may be prevented by detailing the roller screen to overlap mullions and/or walls.

Note: Interior window treatments for *daylighting* glass may not be necessary, if exterior shading is provided and room darkening for a/v presentation purposes is not needed.

Criterion 5: Ceiling Heights

Proper ceiling heights are fundamental to good daylighting design. Increased ceiling heights enhance openness and permit deeper penetration and better distribution of daylight. Higher ceilings also facilitate indirect lighting schemes using higher-quality, pendant-mounted, indirect or direct/indirect electric light fixtures. Reducing the building's cooling loads generally results in smaller perimeter air supply ducts, requiring less "plenum" space, so that ceiling heights may be increased without necessarily increasing floor-to-floor height. Minimum ceiling heights listed may be averaged across the room for a ceiling that is sloping inwardly downward. If pendant-mounted light fixtures are provided with sloped ceilings, then it will be necessary to have *at least* 9'-0" ceiling height at all fixture locations.

Criterion 6: Interior Finish Reflectances

The reflectance of interior finish materials is very important to efficient lighting design and effective daylighting. Standard acoustic ceiling tiles are available which will meet the "Acceptable" standard; high reflectance ceiling tiles are not required. If lighter colors are undesirable for the entire wall, Indiana University recommends incorporating [picture rails](#) on upper walls with flat ceiling-white paint above and

other preferred colors below. The finishes of office cubicle partitions (systems furniture) and tops of upper cabinets should also comply with indicated minimum reflectances.

Criterion 7: Lighting Controls

Use simple, inexpensive, easy-to-commission-and-maintain electric lighting control strategies to automatically turn off unnecessary electric lighting in the daytime, particularly at building perimeter. Daytime power densities for perimeter daylighted spaces must drop to 2/3 or less of the indicated one w/sf [lighting power density](#). The HVAC engineer must be made aware at the earliest stages of design that cooling loads may be calculated on this basis. If lighting will be switched off at perimeter [daylighted zones](#) during peak daylight hours, then the cooling loads for those zones should not include the lighting heat gain.

Stepped or multilevel on/off switching controlled by photo-sensors is a viable technology that is significantly less costly than continuous dimming controls. Because of cost and maintenance issues, continuous dimming controls are not required. Occupancy sensors shall be specified, as required under “Indiana University Electrical Standards“, and shall override photo-sensors in individual rooms.

Assuring that all elements of the system perform interactively, as designed, and that users understand how the system is intended to function, is crucial to the success of daylighting design. Indiana University expects the A/E to carefully review and edit, as appropriate, provisions in the project specifications Section 16 to include:

- Additional site visits by the electrical contractor after substantial completion for the purpose of adjusting lighting controls;
- Specific training for operations and maintenance personnel.

Indiana University also recommends that specific training and/or informational material be provided to users/occupants, explaining design intent and use of lighting controls and window treatments, as appropriate.

Criterion 8: Exterior Shading

Exterior solar shading for south-facing glass should be designed to provide four-to-five months of total shade—i.e. from May to September. If feasible, it should be year-round. Similar or even more extensive shading should be provided on the east and west than on south. Exterior solar shading has little benefit on the north elevation.

Note that Table 1 does not provide glass characteristics for *shaded view glass* because view glass, being lower in the wall, is more difficult to shade and therefore less commonly shaded. If budget will permit, full shading of all view glass is also desirable.

Exterior shading is of limited value unless the preceding criteria are incorporated; and it may be the least cost-effective daylighting element based on first cost, since the seven previously listed measures will have already greatly reduced solar heats gains. Exterior shading, therefore, is listed last. Shading does, however, make the system passive and foolproof, eliminating the need for window treatments for daylighting apertures, unless required for room darkening. For this reason, and because it is fundamentally good practice to design with the sun in mind, Indiana University strongly encourages *fixed* exterior shading. *Operable* exterior shading is not recommended.

Indiana University encourages creativity, tempered by an awareness of maintenance requirements. Horizontal louvers or grilles are not permitted unless they are designed for long-term durability, low maintenance and safety, so that ice and snow removal is not required.

TABLE 1: COOL DAYLIGHTING PERFORMANCE CRITERIA

| Criteria | Acceptable | Preferred | |
|--|---|--|-----|
| REQUIRED: | | | |
| 1. WINDOW-WALL RATIO¹ MAXIMUM ALLOWABLE EXTERIOR GLASS AREA AS A % OF GROSS EXTERIOR WALL AREA ^{2,3} | NORTH ELEVATION | 70% max | 50% |
| | EAST ELEVATION | 30% max | 22% |
| | SOUTH ELEVATION | 30% max | 26% |
| | WEST ELEVATION | 30% max | 22% |
| 2. GLASS PERFORMANCE^{1,4} | | | |
| 2A. VIEW GLASS | | | |
| Shading Coefficient, SC | 0.38 max | 0.22 | |
| Visible Transmittance, V_T | 40% max | 18% | |
| 2B. DAYLIGHTING GLASS | | | |
| SHADED Shading Coefficient, SC | 0.38 max | 0.38 | |
| Visible Transmittance, V_T ⁵ | 40% max | 38% | |
| UNSHADED Shading Coefficient, SC | 0.38 max | 0.26 | |
| Visible Transmittance, V_T | 40% max | 23% | |
| 3. LIGHTING POWER DENSITY (LPD)^{6,7} | | | |
| | 1.0 w/sf or less | 0.8 w/sf or less | |
| 4. WINDOW TREATMENTS⁸ | | | |
| | Separate daylighting & view glass mini blinds | Mini-blinds for daylighting glass & perforated roller shades @ view glass. | |
| 5. CEILING HEIGHTS (FOR DAYLIGHTED ZONES) | | | |
| | 9'-0" min. | 9'-6" to 10'-0" min. | |
| 6. INTERIOR FINISH REFLECTANCES⁹ | | | |
| FOR DAYLIGHTED ZONES | min. 80% ceiling min. 50% wall | 80-90%+ ceiling min. 80% wall OR 80%+ above picture rail 50%+ below picture rail | |
| 7. LIGHTING CONTROLS | | | |
| | Photo-sensor-controlled on/off switching | Photo-sensor-controlled multi-level switching | |
| RECOMMENDED: | | | |
| 8. EXTERIOR SOLAR SHADING | | | |
| | Some shading of daylighting glass | Shading of daylighting glass 4 to 5 months of the year | |

TABLE 1 FOOTNOTES:

- ¹ This Standard does not specify a minimum WWR or minimum V_T or SC; A/E is expected to use best judgement in balancing fenestration, lighting and other program needs (within the maximums allowed).
- ² The WWRs identified with building elevations assume a rectilinear building form, oriented within $20^\circ \pm$ of true north. If the building is oriented more than $20^\circ \pm$ off of the north-south axis, then the “30% Minimum Std. / 24% Preferred” limit applies to all elevations (SE, SW, NE, NW).
- ³ For buildings with greater than average (12' to 13') floor-to-floor height, the WWR may need to be proportionately decreased.
- ⁴ Glass performance values refer to “center-of-glass”.
- ⁵ If A/E can demonstrate that daylighting glass is fully shaded, then V_T may be increased.
- ⁶ Indoor only, excluding task lighting, and excluding special occupancies, such as labs, food service, retail, auditorium/special-purpose lecture rooms.
- ⁷ Clear day LPD target is expected to be two-thirds of total connected LPD, in perimeter zones.
- ⁸ For portions of the windows (particularly daylighting glass) that are fully shaded, window treatments may not be necessary.
- ⁹ Photo-sensors located in individual rooms or areas, subject to control by occupancy sensors.

PROCEDURES

The following procedures apply in addition to the standard procedures contained in the *Indiana University General Conditions*.

PRELIMINARY DESIGN PHASE

At the project Kick Off Meeting the A/E, user-agency and the Indiana University Project Architect will discuss daylighting—opportunities / constraints / program / functional implications.

At the conclusion of schematic design, or midway through design development, the A/E shall submit to the Project Architect the [Daylighting Criteria Form](#) (page DC-1, attached) showing how the design meets the criteria. Submittal of this form by the architect is required prior to the mechanical engineer completing preliminary cooling load calculations. Cooling load calculations shall consider cooling load reductions based on the lighting control scheme submitted by the electrical engineer.

At the completion of the Schematic Design Phase the A/E will re-submit the *Daylighting Criteria Form* with providing updated information. If any of the building characteristics indicated on the form change after the completion of Schematic Design, the net effect of those changes shall not increase building energy use without specific explanation by the A/E and approval by Indiana University’s Project Architect. (For example, if glass area is increased then the shading coefficient could be improved to offset the increase in glass area).

CONSTRUCTION DOCUMENT PHASE

At completion of Construction Documents, with the Final Review submittal to Indiana University, the A/E will re-submit the *Daylighting Criteria Form*, confirming and updating these criteria based on the final design. At this time window treatments and actual, specified interior finish reflectances will be included, if not previously.

CONCLUSION

Indiana University expects all applicable building types/occupancies to meet the “Acceptable” performance level. A/E’s efforts to achieve the “Preferred” performance level will be recognized in the Indiana University Consultant Performance Review.

Indiana University wishes to support A/E’s efforts to successfully implement these daylighting concepts into the design of state facilities. For a better understanding of the cool daylighting principles and desired lighting quality, Indiana University strongly encourages the A/E and user-group(s) to visit a room or

building so designed. Locations and other information may be found at The Daylighting Collaborative (www.daylighting.org) web site.

SPECIAL NOTE

The A/E may propose alternative solutions to these daylighting criteria. The alternate proposal must be supported by energy modeling (DOE 2 or similar) which demonstrates that equivalent or better performance is achieved, compared to a base case using Table 1 "Acceptable" criteria.

GLOSSARY

| | |
|---------------------------------|--|
| Ambient Lighting | General illumination throughout an area. |
| Color Rendering Index (CRI) | A measure of a lamp's ability to make the color of things appear as expected. |
| Color Temperature | A measure of the color appearance of a light source. |
| Cool Daylighting | The practice of admitting light from the sun and sky into a building in a way which controls heat gain and glare and reduces the use of electric lighting. |
| Commissioning (CX) | A systematic process to assure that all elements of the daylighting system perform interactively and continuously according to documented design intent and needs of the state. |
| Daylighted Zone | Any room or space where all or part of the lighting needs are met with natural light. |
| Daylighting Glass (or aperture) | Glazed opening above the normal field of view with the primary purpose of admitting light. |
| Fenestration | The design and placement of windows in a building. |
| Gross Exterior Wall Area | The gross area of exterior wall separating air-conditioned spaces from the outdoors as measured on the exterior above grade, including window and door areas. Penthouses, active louvers/grills, parapets and exterior wall area below grade are excluded. |
| Illuminance/Illumination | The amount of light incident upon a surface (foot-candles). |
| Lighting Power Density (LPD) | A measure of the amount of electric lighting in a space or building as measured in watts per square foot. |
| Luminaire | A complete electric lighting unit; a light fixture. |
| Picture Rail | A horizontal molding fixed to the wall near the ceiling, often at the height of the door head, traditionally used for picture hanging. |
| Shading Coefficient (SC) | The ratio of total solar heat gain through a window to that through 1/8" clear glass. |
| Task Lighting | Lighting provided for a specific task. |
| View Glass | Glazed opening placed at or near eye level for the primary purpose of allowing views to the outside. |
| Window Area | The area of the surface of a window, plus the area of the frame, sash, and mullions. |
| Window-Wall Area (WWR) | The ratio of the window area, including glazed areas of doors, to the gross exterior wall area. |
| Visible Light Transmittance(VT) | The percentage of visible light that is transmitted through the glass. |

* * *

DAYLIGHTING CRITERIA FORM³⁸

USED TO SHOW COMPLIANCE WITH INDIANA UNIVERSITY DAYLIGHTING STANDARDS FOR STATE FACILITIES

| Criteria | | Schematic Design ³⁹ | Preliminary Design | Final Design |
|--|-------------------------------------|--------------------------------|--------------------|--------------|
| 1. WINDOW-WALL RATIO | NORTH ELEVATION [70%/50%] | | | |
| | EAST ELEVATION [30%/22%] | | | |
| | SOUTH ELEVATION [30%/26%] | | | |
| | WEST ELEVATION [30%/22%] | | | |
| 2. GLASS PERFORMANCE | | | | |
| 2A. VIEW | | | | |
| | SC [.38 Std./0.22 Pref.] | | | |
| | V _T [38% Std./18% Pref.] | | | |
| | U-VALUE (optional) | | | |
| 2B. DAYLIGHTING GLASS | | | | |
| SHADED | SC [0.38 Std./0.38 Pref.] | | | |
| | V _T [38% Std./38% Pref.] | | | |
| | U-VALUE (optional) | | | |
| UNSHADE D | SC [0.38 Std / 0.26 Pref.] | | | |
| | V _T [38% Std./23% Pref.] | | | |
| | U-VALUE (optional) | | | |
| ORIENTATION OF BUILDING DEGREES E OR W OF NORTH/SOUTH AXIS | | | | |

³⁸ For large structures (esp. if multi-wing and/or irregularly shaped) the needed information may not neatly or clearly fit into this form. It is the A/E's responsibility to submit multiple forms, or to re-format so that typical conditions for the entire building are *clearly* shown.

³⁹ Design intent is adequate at schematic design stage.

| | | | |
|--|--------------------------|--------------------------|--------------------------|
| 3. LIGHTING POWER DENSITY (LPD) [1.0 Std/ 0.8 Pref. W/sf] | | | |
| 4. WINDOW TREATMENTS | <i>Provide Statement</i> | <i>Provide Statement</i> | <i>Provide Statement</i> |
| 5. CEILING HEIGHTS [9'-0" min/9'-6" to 10'0" pref.] | | | |
| 6. INTERIOR FINISH REFLECTANCES CEILING [80% Std./ 80-90%+ Pref.] WALL ABOVE PICT. RAIL [50% Std./ 80%+ Pref.] BELOW PICT. RAIL [50% Std./ 50%+ Pref.] | | | |
| 7. LIGHTING CONTROLS | <i>Provide Statement</i> | <i>Provide Statement</i> | <i>Provide Statement</i> |
| 8. EXTERIOR SOLAR SHADING | <i>Provide Statement</i> | <i>Provide Statement</i> | <i>Provide Statement</i> |

THE FOLLOWING ARE NOT DESIGN CRITERIA, BUT ARE USEFUL IN ASSESSING HVAC COOLING LOAD REDUCTIONS:

| | | | |
|--|--|--|--|
| CALCULATED COOLING AIR FLOW TOTAL SUPPLY FAN OUTPUT IN CFM PER NET S.F. OF AIR-CONDITIONED SPACE | | | |
| CALCULATED AIR CONDITIONING LOAD NET S.F. PER INSTALLED TON OF AIR CONDITIONING | | | |

Recommendations and Conclusions

Recommendation One: Revisions for architectural standards

With the requirement of all new projects being considered for LEED certification, additional revisions are needed in the architectural divisions of the building standards. Not only will revisions such as the ones listed below help IU in pursuing LEED certification, but more importantly they will help the university move in a more environmentally sustainable direction.

Division 6 Wood and Plastics

1. Discourage use of non-sustainable wood species.
Encourage use of The Forest Stewardship Council (FSC) certified wood.⁴⁰
2. Encourage use of non-wood products for countertops. i.e., recycled glass, recycled plastic, etc.⁴¹

[Virginia Tech](#)

Division 9 Finishes

1. Painting⁴²
 - a. Clause on importance of choosing 0 or low VOC products
 - b. Use lighter colors to enhance reflectivity and reduce the need for electrical lighting
2. Tile⁴³
 - a. Clause on importance of choosing 0 or low VOC mortar, grout, and sealants
 - b. Encourage use of recycled tile
3. Acoustical Ceilings⁴⁴
 - a. Panels should be highly reflective⁴⁵
 - b. Encourage use of panels and grids with recycled content

[Virginia Tech](#)

[Virginia Tech](#)

[Virginia Tech](#)

⁴⁰ DIVISION 6 WOOD AND PLASTICS- New Section- General Requirements

⁴¹ DIVISION 6 WOOD AND PLASTICS- Can we change plastic laminate countertops to just Countertops?

⁴² DIVISION 9 FINISHES Section 09900-Painting

⁴³ DIVISION 9 FINISHES New section?

⁴⁴ DIVISION 9 FINISHES Section 09510- Acoustical Ceilings

⁴⁵ DIVISION 9 FINISHES Section 09510- Acoustical Ceilings- Part I

4. Flooring⁴⁶
 - a. Clause on importance of choosing 0 or low VOC adhesives, primers, sealants
 - b. Encourage use of flooring with recycled content

[Virginia Tech](#)

5. Carpet⁴⁷
 - a. Clause on importance of choosing 0 to low VOC adhesives and leveling compounds
 - b. Encourage use of carpet with recycled content
 - c. Upgrade air quality section to meet CRI's Green Label Standards (who's doing this??)
 - d. Renovations: recommend recycling carpet through the Carpet America Recovery Effort (CARE) <http://www.carpetrecovery.org/> or other approved program in order to divert from landfill

[Virginia Tech](#)

Division 12 Furnishings and Seatings

1. Window Treatment and Fabrics⁴⁸
 - a.
2. Furniture⁴⁹
 - a. Recommend that furniture be manufactured within a 500 mile radius
 - b. Recommend that A/E give preference to manufacturers with established environmental policies
 - c. "Plan layouts and furniture selections with respect to maximizing daylight and access to views for all building occupants. Consider lower panels and glazed panels for systems workstations. Avoid the use of panels that are 80" or higher that may obstruct adequate air flow and daylight penetration."⁵⁰
 - d. Clause on importance of choosing 0 or low VOC furniture
 - e. "Furniture and upholstery selections shall include the following design strategies wherever possible:

[Virginia Tech](#)

[Virginia Tech](#)

[Virginia Tech](#)

Post-consumer and/or post-industrial recycled content

⁴⁶ DIVISION 9 FINISHES New section?

⁴⁷ DIVISION 9 FINISHES Section 09680- Carpet

⁴⁸ DIVISION 12 FURNITURE AND SEATING Section 12500 Window Treatment and Fabrics

⁴⁹ DIVISION 12 FURNITURE AND SEATING Section 12600 Furniture and Equipment

⁵⁰ DIVISION 12 FURNITURE AND SEATING Section 12600 Furniture and Equipment-Part A

Refurbished furniture, including systems workstations
Products with 10 year warranty, 15 years preferred
Materials that have been extracted locally or regionally
Certified wood products or sustainable species from
abundant, local sources
Rapidly renewable materials (such as straw, wheat,
sunflower board)
Non toxic, low emitting adhesives, sealants, paints and
finishes
Energy efficient task lighting
Products/materials free of formaldehyde, halogen,
heavy metals, polyvinyl chloride, chlorine, plasticizers,
antimony, harmful dyes, topical treatments
Products/materials that are safely disposable,
recyclable, or biodegradable
Fabrics that are durable, minimum 50,000 double rubs,
100,000 preferred
Fabrics that are flame retardant, antibacterial, easy to
clean
If the use of leather is approved, specify only vegetable
tanned leather”

Recommendation Two: Incorporating sustainable design into building program statements

Incorporating sustainable design into program statements will allow for all parties to be aware of IU’s commitment to sustainability from the very beginning of a project’s conception.

For more information, consider what the [University of Cincinnati](#) has done to ensure that all of their program statements include sustainability as a fundamental design principle.

Recommendation Three: Metering standards

The ultimate goal of metering at IU is to be able to provide real-time, web-based, instantaneous energy consumption to building occupants and to facilities management. While this goal is several years away, as it requires the procurement of an intelligent software system and then an overhaul of all existing meters, there is a need to standardize the meters that are being installed at present time. This is especially so, as one of the provisions of this report is that all new buildings be metered.

The metering standardization, or specifications, should include requirements on meter models as well as installation specs, such as location and height. Moreover, there needs to be a consensus amongst the parties involved in metering that all newly installed meters will have the potential to communicate with a new energy management software system, whether this is by retrofitting meters at some point down the road or by purchasing these smart meters at present time.

Recommendation Four: Landscaping standards

Several of the universities reviewed while creating this report had strong sustainable landscaping standards. Notable universities include the [University of North Carolina- Chapel Hill](#), [Virginia Tech](#), and [Stanford](#).

There are several ways in which sustainable landscaping can help the university achieve environmentally sustainable goals such as water conservation, reducing heat island effects, and helping with storm water issues.

Moreover, according to Virginia Tech's energy conservation standards, a sustainable landscaping design can help reduce energy in a building by the use of wind breaks and tree placements.⁵¹

At a minimum, the existing IU landscaping standards should be revised to include sustainable language and to encourage things such as rainwater harvesting projects, rain gardens, shading for non-roof impervious surfaces and the use of native plant species.

Recommendation Five: Campus energy policy

The creation of an Indiana University Energy Policy would greatly assist the effort towards a sustainable campus. Such a policy, supported by students, faculty and staff, would help establish quantifiable goals for the university to work towards together.

One campus energy policy worth noting is that created by [Virginia Tech](#).

Recommendation Six: Semi-annual review of building standards

New and cutting-edge green building designs are being created every day due to increases in energy costs and environmental concerns. Because of this, IU's building standards should be reviewed on a semi-annual basis, time and staff

⁵¹ Virginia Polytechnic Institute and State University. (2006). *Design and Construction Standards*. Retrieved on August 28, 2007 from http://www.cdc.vt.edu/Standards_Codes/VT_Stds/Design_Guidelines.pdf . p 19.

permitting, and revised as necessary to reflect new energy conservation measures.

Recommendation Seven: Awareness program: Maintaining a sustainable building

As IU moves into this direction of building sustainable buildings, purchasing efficient equipment, and using new technology for the purpose of energy conservation, then there is a need to ensure that building occupants and maintenance personnel are aware of what they can do to help ensure their success.

According to the U.S. Department of Energy's Energy Efficiency and Renewable Energy site, "a well-crafted O&M program and increased awareness of maintenance and instructional staff can save 5% to 20% on energy bills without a significant capital investment."⁵²

⁵² U.S. Department of Energy. (2006). *Energy- Efficient Operation and Maintenance for University Buildings*. Retrieved on August 29, 2007 from <http://www.eere.energy.gov/buildings/info/university/maintain.html>

Sources

Big Ten & Friends

UNIVERSITY OF IOWA

University of Iowa <http://www.uiowa.edu/>

Campus and Facilities Planning
<http://www.facilities.uiowa.edu/cfp/cfpindex.htm>

Design Reference Manual <http://www.uiowa.edu/%7EEdesign/index.htm>

Energy Conservation <http://energy.uiowa.edu/>

NORTHWESTERN UNIVERSITY

Northwestern University <http://www.northwestern.edu/>

Facilities Management <http://www.northwestern.edu/fm/index.html>

Guidelines??

Environmental Sustainability Site
http://www.northwestern.edu/fm/environmental_sustainability.htm

UNIVERSITY OF MICHIGAN

University of Michigan <http://www.umich.edu/>

Facilities Management <http://www.plantops.umich.edu/maintenance/>

Design Guidelines <http://www.plantext.bf.umich.edu/desguide/index.html>

Energy Management
http://www.plantops.umich.edu/utilities/energy_management/

THE OHIO STATE UNIVERSITY

The Ohio State University <http://www.osu.edu/>

Facilities Operations and Development <http://fod.osu.edu/index.htm>

Building Design Standards <http://www.fpd.ohio-state.edu/assets/Main/dbcontent2/?section=PDCstandards>

Energy Services and Sustainability
http://fod.osu.edu/energy_sustainability/index.htm

UNIVERSITY OF MINNESOTA

University of Minnesota <http://www1.umn.edu/twincities/index.php>

Facilities Management <http://www.facm.umn.edu/>

Standards and Procedures for Construction
<http://www.cppm.umn.edu/standards.html>

Center for Sustainable Building Research <http://www.csbr.umn.edu/>

MICHIGAN STATE UNIVERSITY

Michigan State University <http://www.msu.edu/>

Engineering and Architectural Services <http://www.eas.msu.edu/home.cfm>

Construction Standards (left sidebar)

Office of Campus Sustainability <http://www.ecofoot.msu.edu/>

PENNSYLVANIA STATE UNIVERSITY



Penn State <http://www.psu.edu/>

Office of Physical Plant <http://www.opp.psu.edu/>

Construction Standards
<http://www.opp.psu.edu/construction/standards/index.cfm>

Green Penn <http://dolphin.upenn.edu/~pennenv/audit/>

Energy Information <http://energy.opp.psu.edu/>

Green Density Council <http://ecenter.colorado.edu/index.html>

Penn State Green Roof Story <http://energy.opp.psu.edu/green-roofs-show-university-s-ecological-commitment>

PURDUE UNIVERSITY

Purdue University <http://www.purdue.edu/>

Physical Facilities <http://www.purdue.edu/physicalfacilities/>

Consultant's Handbook

<http://www.purdue.edu/physicalfacilities/architect/handbook/index.html>

UNIVERSITY OF ILLINOIS – URBANA

University of Illinois- Urbana <http://www.uiuc.edu/>

Facilities and Services <http://www.fs.uiuc.edu/>

Building Standards http://www.fs.uiuc.edu/ae_contractors.cfm

Energy Conservation

http://www.energymanagement.uiuc.edu/bif_sustainableenergyproject.htm

UNIVERSITY OF WISCONSIN-MADISON

University of Wisconsin at Madison <http://www.wisc.edu/>

Facilities Planning and Management <http://www2.fpm.wisc.edu/fpm/>

Design Guidelines <https://fpm->

www3.fpm.wisc.edu/MajorProjects/ConstructionDesignGuidelines/DesignGuidelines/tabid/80/Default.aspx

IOWA STATE UNIVERSITY



Iowa State University <http://www.iastate.edu/>

Facilities Planning and Management <http://www.fpm.iastate.edu/>

(For design guidelines, click on Facilities Design Manual, log in with these credentials: username: Guest / password: guest / These are case-sensitive. Make sure you are the administrator of the computer so that you can get through the ActiveX controls. Contact John Hoffman (jhoffman@iastate.edu) with problems/questions on accessing material.

Energy Information <http://www.fpm.iastate.edu/utilities/energyefficiency/>

UNIVERSITY OF CINCINNATI

University of Cincinnati <http://www.uc.edu/>

Facilities Management <http://www.uc.edu/facmgmt/fachome.asp>

Guidelines and Standards <http://www.uc.edu/architect/tblcontsdes.asp>

MISSOURI UNIVERSITY

University of Missouri at Columbia <http://www.missouri.edu/>

Planning Design and Construction <http://www.cf.missouri.edu/pdc/>

Design Guidelines

<http://www.umsystem.edu/ums/departments/fa/management/facilities/guidelines/>

UNIVERSITY OF COLORADO – BOULDER

University of Colorado at Boulder <http://www.colorado.edu/>

Facilities Management <http://fm.colorado.edu/>

Building and Construction Standards

<http://fm.colorado.edu/construction/standards/Categories.html>

Environmental Center <http://ecenter.colorado.edu/index.html>

UNIVERSITY OF NORTH CAROLINA - CHAPEL HILL



University of North Carolina at Chapel Hill <http://www.unc.edu/>

Facilities Planning and Construction <http://www.fpc.unc.edu/>

Design and Construction Guidelines

<http://www.fpc.unc.edu/DesignGuidelines.asp>

Sustainability at UNC <http://sustainability.unc.edu/>

OHIO UNIVERSITY

Ohio University <http://www.ohio.edu/>

University Planning and Implementation <http://www.upi.ohio.edu/>

Construction Standards <http://www.upi.ohio.edu/menu/sss/const-standards.htm>

Planet Ohio <http://www.facilities.ohiou.edu/planetohio/index.html>

UNIVERSITY OF TEXAS- AUSTIN

University of Texas at Austin <http://www.utexas.edu/>

Project Management and Construction Services
<http://www.utexas.edu/physicalplant/pmcs/>

Design and Construction Standards
<http://www.utexas.edu/campusplanning/dc/index.html>

Sustainability <http://www.esi.utexas.edu/research/sustainability.html>

UNIVERSITY OF FLORIDA

University of Florida <http://www.ufl.edu/>

Facilities Planning and Construction <http://www.facilities.ufl.edu/>

Design and Construction Standards
<http://www.facilities.ufl.edu/dcs/index.htm>

LEED Site <http://www.facilities.ufl.edu/sustain/>

UNIVERSITY OF ARIZONA *

University of Arizona- Tucson <http://www.arizona.edu/>

Facilities Design and Construction
<http://www.fdc.arizona.edu/Procedures/contractorhowto.cfm>

Design and Specification Standards
http://www.fdc.arizona.edu/dss/dss_list.cfm

BROWN

Brown University <http://www.brown.edu/>

Department of Facilities Management
http://www.brown.edu/Facilities/Facilities_Management/construction_standards.html

Facilities Design Guidelines <http://facilities-web.plantops.brown.edu/fdg/pages/FDG.htm>

Brown is Green

http://www.brown.edu/Departments/Brown_Is_Green/index.html

UNIVERSITY OF VIRGINIA

University of Virginia <http://www.virginia.edu/>

Facilities Management <http://www.fm.virginia.edu/>

Facilities Design Guidelines

<http://www.fm.virginia.edu/fpc/DesignGuidelines.htm>

Energy Management Program <http://utilities.fm.virginia.edu/energy/index.asp>

OSHER

Osher <http://www.osher.edu/>

Osher's Sustainability

http://www.osher.edu/sustainability/portfolio/alumni_initiatives.html

No online facilities management page or design standards—the university does require that all new construction is LEED certified.

EMORY UNIVERSITY

Emory University <http://www.emory.edu/>

Design and Construction Standards <http://www.fm.emory.edu/emory-std/2006%20Emory%20Design%20&%20Construction%20Standards.pdf>

Sustainability and LEED Guidelines for New Construction

<http://www.fm.emory.edu/emory-std/frontend/finalsustainabilitydesignguide.pdf>

CORNELL

Cornell University <http://www.cornell.edu/>

Facilities Management <http://www.fm.cornell.edu/>

Design and Construction Standards <http://cds.pdc.cornell.edu/default.cfm>

Cornell Sustainable Campus <http://www.sustainablecampus.cornell.edu/>

Ecotecture <http://ergo.human.cornell.edu/ecotecture/INDEX.HTM>

Utilities and Energy Management

<http://www.utilities.cornell.edu/index.html?CFID=131639&CFTOKEN=97212653&jsessionid=b230f606c04f1d586261>

UNIVERSITY OF BUFFALO

University at Buffalo <http://www.buffalo.edu/>

University Facilities <http://wings.buffalo.edu/services/fac/>

UB High Performance Building Guidelines

<http://wings.buffalo.edu/ubgreen/leos/ubhpguidelines.pdf>

UB Green <http://wings.buffalo.edu/ubgreen/>

UNIVERSITY OF CALIFORNIA- BERKELEY

University of California at Berkeley- <http://www.berkeley.edu/>

Facilities Services <http://www-pdc.berkeley.edu/>

Construction Design Standards [http://www-](http://www-pdc.berkeley.edu/CDS_ucb/CDS_Page.html)

[pdc.berkeley.edu/CDS_ucb/CDS_Page.html](http://www-pdc.berkeley.edu/CDS_ucb/CDS_Page.html)

Green Building Research Center <http://greenbuildings.berkeley.edu/index.htm>

Center for the Built Environment <http://www.cbe.berkeley.edu/>

STANFORD UNIVERSITY

Stanford University <http://www.stanford.edu/>

Facilities Operations <http://facilities.stanford.edu/sections/zones.html>

Facilities Design Guidelines <http://facilities.stanford.edu/fdcs/>

Sustainable Stanford <http://sustainablebuildings.stanford.edu/>

VIRGINIA TECH

Virginia Tech

Facilities at Virginia Tech <http://www.facilities.vt.edu/>

Design and Construction Standards

http://www.cdcd.vt.edu/Standards_Codes/VT_Std/Design_Guidelines.pdf

Sustainability site <http://www.facilities.vt.edu/sustainability/>

Sustainability Initiatives

<http://www.facilities.vt.edu/sustainability/facilities.asp?value=credc#proactive>

YALE UNIVERSITY

Yale University <http://www.yale.edu/>

Office of Facilities <http://www.facilities.yale.edu/Home/Home.asp>

Design Standards <http://www.facilities.yale.edu/Work/Standards.asp>

Utilities and Energy Conservation

<http://www.facilities.yale.edu/Campus/Utilities.asp>

Office of Sustainability <http://www.yale.edu/sustainability/>

UNIVERSITY OF OREGON

University of Oregon <http://www.uoregon.edu/>

Facilities Services <http://facilities.uoregon.edu/>

Sustainable Development Plan

<http://www.uoregon.edu/~recycle/PDFdocuments/SDPFull.pdf>

University of Oregon Sustainability <http://sustainability.uoregon.edu/>

WASHINGTON STATE UNIVERSITY

Washington State University <http://www.wsu.edu/>

Facilities Operations <http://facops.wsu.edu/default.htm>

Uniform Design and Construction Standards <http://www.cpd.wsu.edu/UDCS/>

Energy Program <http://www.energy.wsu.edu/>

International Universities

UNIVERSITY OF BRITISH COLUMBIA

University of British Columbia <http://www.ubc.ca/>

Land and Building Services <http://www.lbs.ubc.ca/>

UBC Technical Guidelines <http://www.cpd.ubc.ca/guidelines/>

Ecotrek <http://www.ecotrek.ubc.ca/>

Sustainability Office <http://www.sustain.ubc.ca/>

AUSTRALIAN NATIONAL UNIVERSITY

Australian National University

Facilities and Services <http://www.anu.edu.au/facilities/index.html>

ANUgreen <http://www.anu.edu.au/facilities/anugreen/index.html>

Specifications and policies
<http://www.anu.edu.au/facilities/policies/index.html>

Ecologically Sustainable Design- Planning and Construction Standards
http://www.anu.edu.au/facilities/policies/esd_standards.html

ETH ZURICH

ETH Zurich http://www.ethz.ch/index_EN (can select English text)

Center for Sustainability at ETH Zurich
<http://www.sustainability.ethz.ch/en/aboutus/aboutus.cfm>

NATIONAL UNIVERSITY OF SINGAPORE

National University of Singapore <http://www.nus.edu.sg/>

PEKING UNIVERSITY

Peking University <http://www.pku.edu.cn/eindex.html>

UNIVERSITY OF CAMBRIDGE

University of Cambridge <http://www.cam.ac.uk/>

Design and Construction of Environmentally Sustainable New Buildings
<http://www.admin.cam.ac.uk/offices/environment/guidance/building.html#heading2.1>

Centre for Sustainable Development <http://www-g.eng.cam.ac.uk/sustdev/>

Cambridge Environmental Initiative <http://www.cei.group.cam.ac.uk/>

DUBLIN CITY UNIVERSITY

Dublin City University <http://www.dcu.ie/index.shtml>

Estates Office <http://www.dcu.ie/buildings/index.shtml>

E3 website <http://www.e3.ie/>

TRINITY COLLEGE, DUBLIN

The University of Dublin- Trinity <http://www.tcd.ie/>

Estates Management <http://www.tcd.ie/Buildings/>

Green Pages <http://www.tcd.ie/GreenPages/>

UNIVERSITY OF LIMERICK

University of Limerick <http://www.ul.ie/>

Buildings and Estates <http://www.ul.ie/buildings/>

UNIVERSITY OF SUSSEX, BRIGHTON

University of Sussex <http://www.sussex.ac.uk/>

Estates and Facilities Management <http://www.sussex.ac.uk/efm/>

Energy Savings <http://www.sussex.ac.uk/efm/1-2-20.html>

THE UNIVERSITY OF EDINBURGH

University of Edinburgh

Estates and Buildings <http://www.estates.ed.ac.uk/>

Design Guidelines <http://www.estates.ed.ac.uk/Design/index.html>

Energy and Sustainability <http://www.eso.ed.ac.uk/Energy/>

Other

The American Institute of Architects- Green Projects
<http://www.aiatopten.org/hpb/overview.cfm?ProjectID=286>

Association of University Leaders for a Sustainable Future
<http://www.ulsf.org/>

The Construction Specifications Institute
http://www.csinet.org/s_csi/index.asp

Energy Design Resources <http://www.energydesignresources.com/>

Green Roofs <http://www.greenroofs.com/index.html>

Indiana Office of Energy and Defense Development
<http://www.in.gov/energy/grants/current.html>

Indiana University Design Standards
http://www.indiana.edu/~uao/html/contracts_standards.html

Labs for the 21st Century <http://www.labs21century.gov/>

Lighthouse Sustainable Building Centre
<http://www.sustainablebuildingcentre.com/>

The State of Minnesota Sustainable Building Guidelines
<http://www.msbg.umn.edu/index.html>

US EPA Green Buildings <http://www.epa.gov/greenbuilding/>

US Green Building Council <http://www.usgbc.org/>

Whole Building Design Guide <http://www.wbdg.org/index.php>