TVA Sustainable Architecture Guideline



INTRODUCTION

The Sustainable Architectural Guideline provides design recommendations for reducing the impact of buildings on the environment. Anytime an existing building is renovated or a new building constructed materials and energy are required. The mining, gathering and processing of raw materials into building products used to construct buildings can in many cases deplete material resources and damage the natural environment. The transportation and installation of building materials consumes energy mostly generated by fossil fuels, which is a finite non-renewable energy source. Fossil fuel consumption puts carbon into the air and has been linked to global warming.

The goal of the Sustainable Architectural Guideline is to present building design and renovation standards, which can minimize initial environmental impact from construction and future impact from the operation of a building over its life span.

The standards are arranged in categories and are divided into two groups within each category: "Required Minimum Standards" - which need to be applied to all renovation and construction projects; and "Optional Items" - which should be considered and applied if possible. Within each of these two groups each design standard or concept is marked as to its applicability to renovation or new construction.

Items marked with a "*" indicate a United States Green Building Council (USGBC) "Leadership in Energy & Environmental Design (LEED) energy/environmental strategy (Number of points or "R" –required). To be LEED certified your building must have 26 points. To obtain silver certification you need 33 points, gold-39 and platinum-52.

For further information and/or application beyond want is presented in this guideline consult a member of TVA's Sustainable Architecture Team.

SITE	Required Minimum Standards	Optional Items
BUILDING SHAPE	Required Minimum Standards	Optional Items
BLDG. SPACE LAYOUT	Required Minimum Standards	Optional Items
BUILDING DESIGN	Required Minimum Standards	Optional Items
MATERIALS	Required Minimum Standards	Optional Items
LIGHTING	Required Minimum Standards	
HVAC	Required Minimum Standards	Optional Items

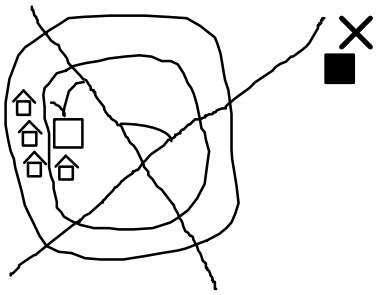
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SITE - Required Minimum Standards

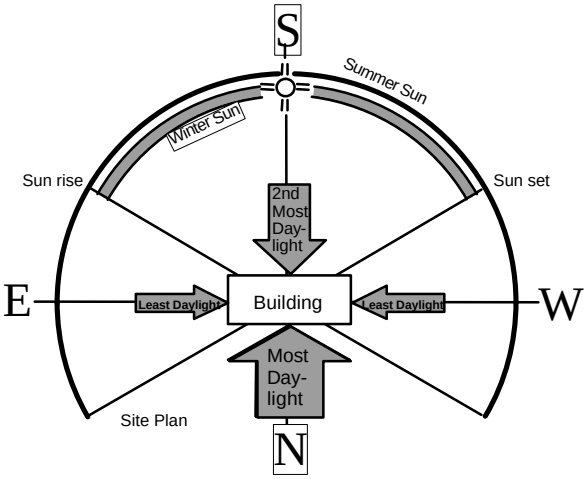
☐ Choose a site that is closest to the users to minimize transportation energy. For people who work in most buildings more energy is used by the people driving to the building then by the building itself. Locating the building in a area where most of the occupants greatly reduces environmental impact.



☐ *Choose a site that is well suited to the building and minimizes disturbance to the environment. If it is necessary to remove fill from the site or import fill to make the site usable then it is probably not a good choice (1).

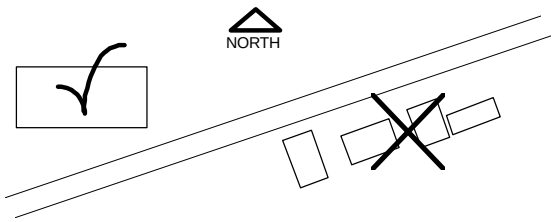
☐ Preserve and make use of existing site features such as trees for shading. Design the building to not only meet functional requirements but make use of existing site features. Bulldozing all the trees, building, then planting new trees and landscaping is not sustainable.

☐ Orient building with the long axis facing north and south for solar heating, daylighting and photovoltaic systems. This is the <u>best</u> orientation. You can deviate up to 15 degrees east or west and still not reduce potential for passive solar heating and daylighting. If site restrictions don't allow optimum orientation minimize east and west facing glass and maximize south facing glass if passive solar heating is needed.



Site Plan

☐ Combine buildings with related functions. Avoid building small multiple buildings. It is less costly, and more material and energy efficient to design one larger building than multiple smaller buildings.



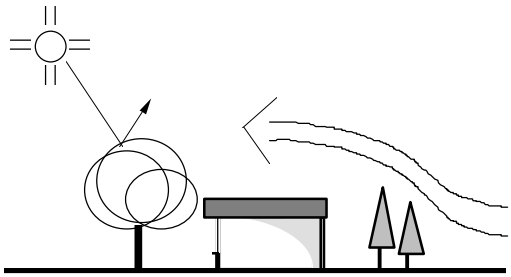
☐ Anticipate future expansion, contraction, or change of function when developing the building design. Design the building to be flexible. It should be easy to add onto the building, move interior partition walls or even reduce the building to meet changes in use. Inflexible buildings end up being torn down and replaced which has a more negative impact on the environment.

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SITE - Required Minimum Standards

☐ ☐ *Minimize the building footprint to preserve as much site as possible for open landscaped space. Part of preserving the natural environment is not covering the land with 100% building and parking (1-2).



☐ ☐ Plant deciduous trees to shade south glass in summer and allow solar heat gain in winter.

☐ ☐ Plant conifer trees and shrubs to block or divert cold winter winds.

☐ ☐ Choose climate appropriate plants for landscaping to minimize watering, pesticide use and maintenance. If it does not grow and thrive well in your climate don't plant it.

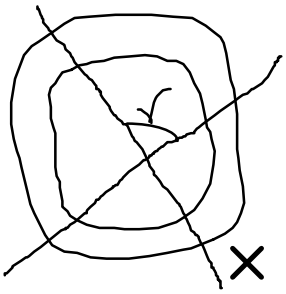
☐ ☐ If additional watering is needed, install drip irrigation systems instead of sprinklers. Such systems put more water into the ground instead of the air.

☐ *Adopt an erosion & sediment control plan for the project site during construction to keep sediment on site (R).

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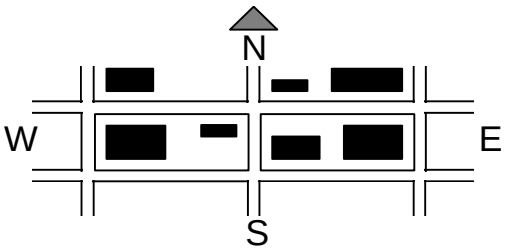
SITE - Optional Items

☐ *Choose a site that is accessible to mass transit and promote its use through employee incentives. Buses and light rail moves far more people using less energy than personal cars (1).



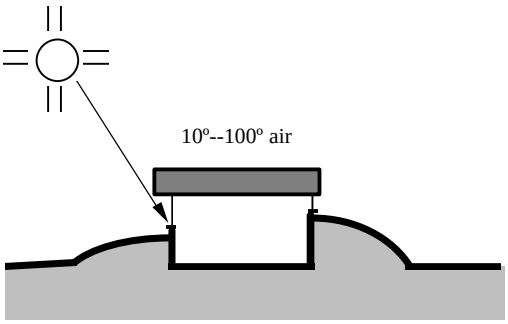
☐ *Choose a site that has been built on before (brown field) and already has utility services in place. Most cities grow like trees with a new layer added to the outside each year leaving dead wood in the interior. Each year a layer is added utilities need to be extended and more forest and crop land is lost. We need to turn inward and reclaim inner city space that already has been built on before and has all the utilities in place (1).

☐ When laying out multiple buildings orient new streets to run east-west so buildings will be oriented correctly. When streets are placed at an angle so will the buildings which reduces passive solar heating, daylighting and shading potential.



☐ *Consider the use of permeable paving to keep storm water on site & and reduce energy use. Permeable paving allows water to penetrate and be absorbed on site instead of running off (1).

☐ ☐ *Use retention ponds or constructed wet lands to treat parking runoff and keep it on site. Channel all run off into a depression filled with native plants that can absorb pollutants and render them harmless (1).



60º earth

☐ Consider the use of earth berms to minimize heat loss and gain. The typical building can lose heat to 20 degree air in winter and absorb heat from 90+ air in summer. Placing earth around the building walls reduces this heat loss/gain because the building is exposed to ~60º earth.

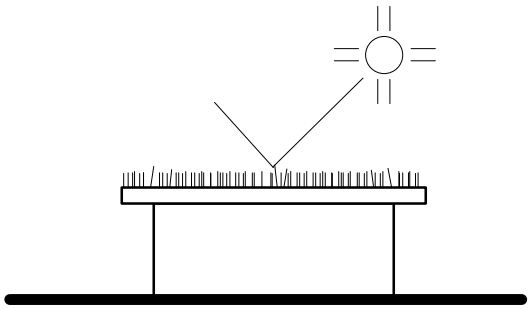
☐ Design the site around public transportation, bicycle use and pedestrian access instead of car access.

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SITE - Optional Items - continued

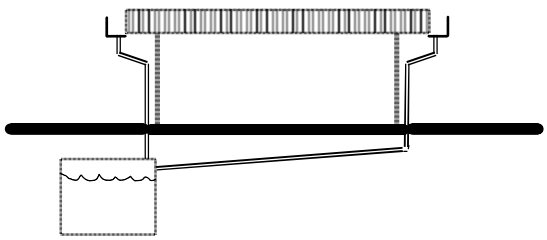
☐ ☐ Consider the use of green roofs (landscaped) to reduce energy consumption and storm water run off. Placing earth and plants on your roof acts as extra insulation reducing heat gain and loss plus water run-off.



☐ ☐ *Minimize parking lot/garage size. Consider sharing parking facilities with adjacent buildings (1)

☐ ☐ *Include bicycle racks and showering/changing facilities in the building design or renovation (1).

☐ ☐ *Install alternative fuel refueling stations and setup carpool/vanpool programs for building occupants (1). This will reduce transportation energy and pollution from multiple cars.

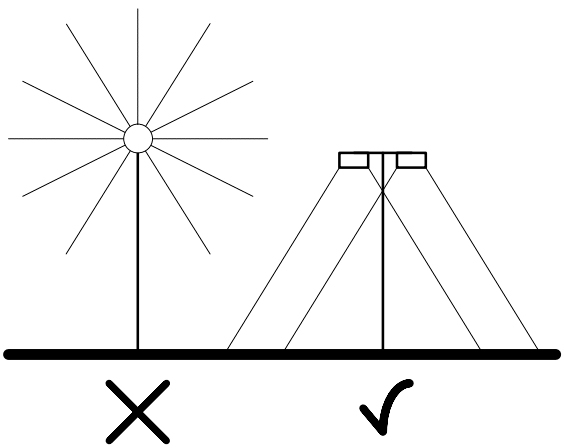


☐ ☐ Install a rainwater collection system to provide irrigation water.

☐ ☐ Use organic or natural gardening and grounds maintenance. Do not use chemicals to keep pests in check.

☐ ☐ *Build in urban areas with existing infrastructure, protect greenfields, preserve habitat & natural resources (1)

☐ ☐ *Shade and/or use light-colored (ref. =< 0.3) materials for 30%+ of the site's non-roof impervious surfaces (1).



☐ ☐ *Cut potable water use for landscaping 50% (1 point) or 100% (2 points).

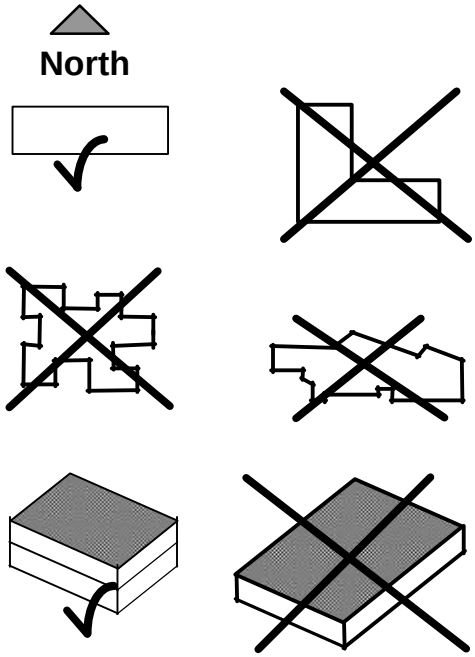
☐ ☐ *Cut light pollution from site. Light pollution from built up areas is becoming an increasing problem especially for astronomers. Miss-directed light also wastes energy (1).

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BUILDING SHAPE - Required Minimum Standards

- ☐ Keep the building shape simple (rectangle) to minimize heat loss, heat gain and material usage. Remember every corner uses additional material and increases cost.
- ☐ Orient rectangular buildings with the long side facing north and south.
- ☐ Avoid designing square buildings which can result in half the glass facing east and west.
- ☐ Avoid designing "L" shaped buildings which can place large areas of glass facing east and west.
- ☐ Do not design buildings with lots of corners and ins and outs, which increases surface area, energy loss/gain and material use.
- ☐ Do not design large one story buildings which minimizes floor area that can be daylit by vertical glass. Large one story building create large amounts of floor area that have no access to outside wall and vertical glass for passive solar heating and daylighting. Bringing natural light into such buildings can only be done with clerestories which is the more costly form of daylighting or horizontal skylights which can introduce unwanted solar heat gain in summer. Keep in mind everyone working all day in a building needs to have connection to the outside (daylight).
- ☐ Do not design large one story buildings which results in large roof areas and increased heating & cooling. The overall goal in building design is to maximize volume and minimize surface area. To this end the best shape is a dome (impractical and not functional in most cases), followed by a cube or square building (not the best for daylighting and passive solar heating). The best shape is a rectangular building oriented with its long side facing north and south.



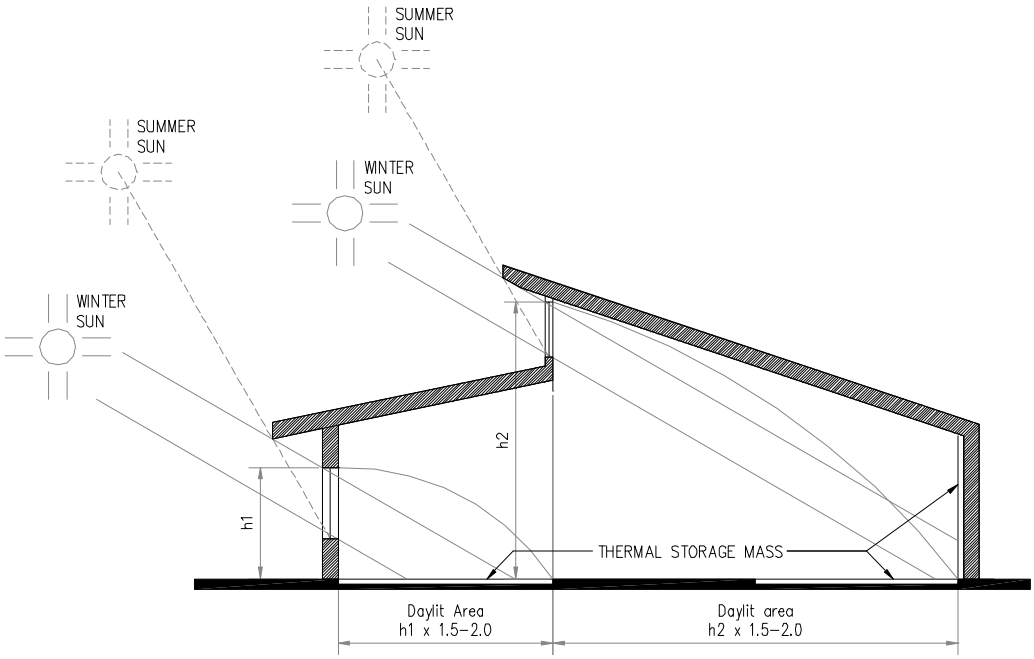
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BUILDING SHAPE - Optional Items

☐ Shape buildings to collect sunlight for passive solar heating (if needed) and daylighting. All small to medium size buildings should be designed to be heated and lit by the sun.

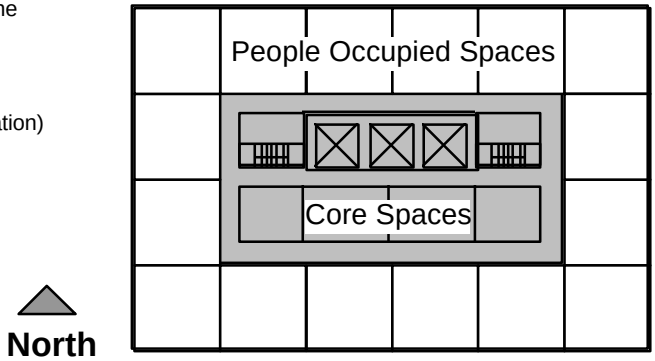


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BUILDING SPACE LAYOUT - Required Minimum Standards

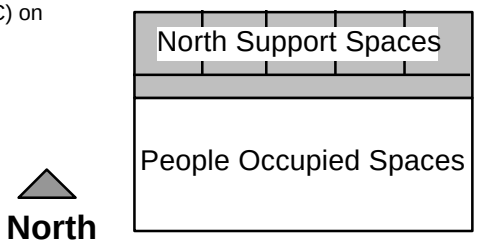
☐ ☐ Place people occupied space on exterior walls to provide them connection to the outdoors and daylight.

☐ ☐ Place high wall spaces (restrooms, conference, storage, HVAC. & circulation) in the interior of the bldg.



Typical Multistory Office Building Floor Plan

☐ ☐ Place buffer spaces (storage & HVAC) on the north side of heating dominated buildings.



Typical Heating Dominated Building Floor Plan

BUILDING SPACE LAYOUT - Optional Items

☐ ☐ *Layout space for daylight & views – 75% daylit occupied areas (1 point), 90% occupied areas with direct view to outside (1 point). Most people need a connection to the outdoors to maintain a sense of well being and productivity.

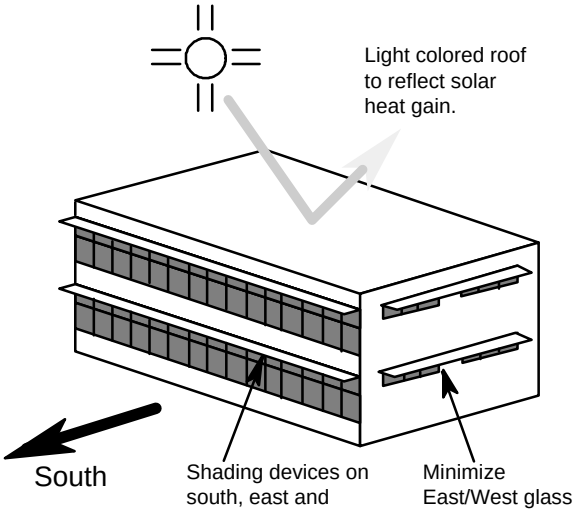
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BUILDING DESIGN - Required Minimum Standards

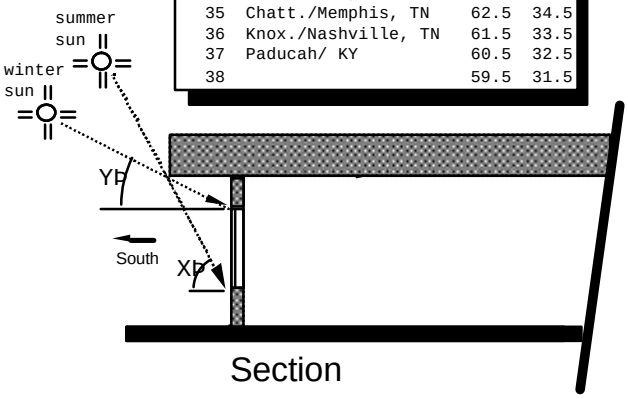
- ☐ ☐ *Set energy performance goals for each project. 30-50% energy cost reductions are economically realistic (R).
- ☐ ☐ Maximize glass facing south and north for solar heat gain (if needed) and daylighting.
- ☐ ☐ Recess east & west glass or provide overhangs and fins to minimize heat gain and cooling loads.
- ☐ ☐ *Install light colored roofs to minimize solar heat gain, air-conditioning loads and urban heat island effect (1).



- ☐ ☐ Design recycling centers into the building. Provide vertical chutes if possible in multistory buildings to support operation and maintenance (O&M) ability to collect and process recycled materials
- ☐ ☐ Design <u>all</u> bldgs. with future uses in mind. All bldgs. should be capable of being converted to housing. Buildings that can easily be modified for other uses minimize energy and materials use from avoiding demolition and replacement.
- ☐ ☐ Provide optimum insulation for all building surfaces up to and including super insulation where applicable.
- ☐ ☐ Provide operable windows as a minimum and arrange spaces to allow cross ventilation.
- ☐ ☐ Provide fixed overhangs for south glass. Size overhangs for solar heat gain for heating dominated bldgs.

Angles to correctly size overhangs for shading

LAT.	CITY	X°	Y°
32	Jackson, MS	65.5	37.5
33		64.5	36.5
34	Huntsville, AL	63.5	35.5
35	Chatt./Memphis, TN	62.5	34.5
36	Knox./Nashville, TN	61.5	33.5
37	Paducah/ KY	60.5	32.5
38		59.5	31.5



Section

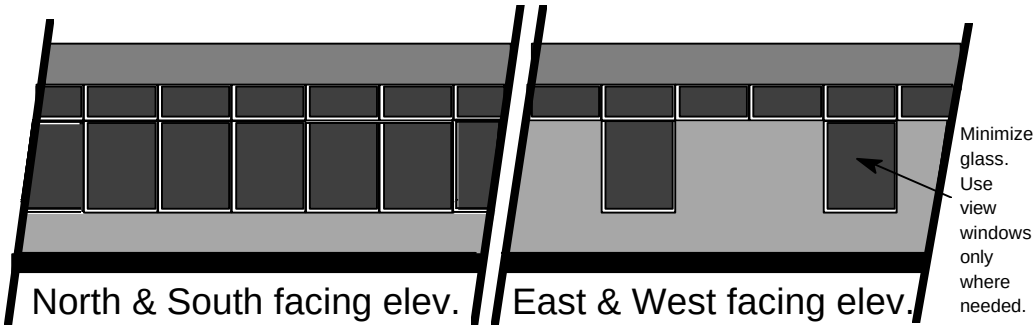
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BUILDING DESIGN - Required Minimum Standards

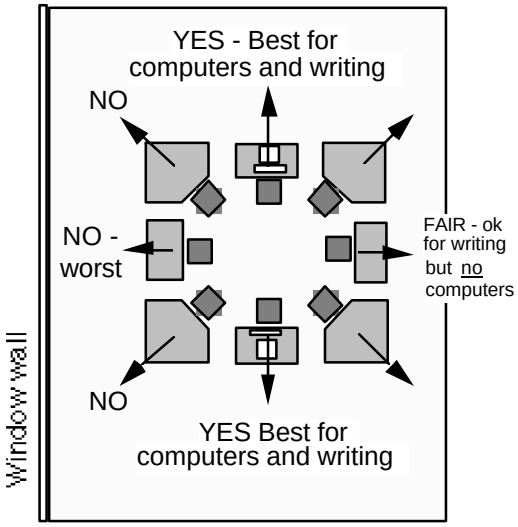
☐ Minimize east & west glass to reduce solar heat gain & cooling . Provide minimum for views & daylighting.



Glass area for daylight = minimum 46% of wall area.

Glass area for daylight = maximum 24% of wall area.

☐ ☐ Place people in the space perpendicular to the window wall to minimize glare when using computers.



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BUILDING DESIGN - Optional Items

☐ *Reduce new building energy use by 29% (2), 30% (4), 40% (6), 50% (8) or 60% (10 points) as compared to a building design that meets ASHRAE 90.1-1999 energy code. Use a computer based building simulation program to model the design that meets the energy code to compare to a model of the proposed design that shows 30-60% less energy.

☐ *Reduce existing building energy use by 10% (2), 20% (4), 30% (6), 40% (8) or 50% (10 points) as compared to a building design that meets ASHRAE 90.1-1999 energy code. Use process described above.

☐ Use whole building energy analysis: base case, individual strategy performance and group performance.

☐ For heat dominated bldgs. consider passive solar heating (direct gain, trombe walls, greenhouses & hot air collectors).

☐ ☐ Add thermal mass (concrete/water) to the bldg. to minimize temperature fluctuations in solar heated spaces.

☐ ☐ Consider the use of shade screens or tinted glazing for cooling dominated spaces. Note such systems can diminish daylighting and should be carefully designed.

☐ ☐ When designing and renovating consider using wood structures first, steel second and concrete last. Wood is a renewable resource and has the least impact on the environment.

☐ Consider installing a photovoltaic system to provide some or all of the buildings power needs.

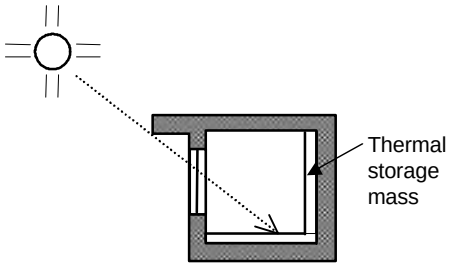
☐ ☐ Design the roof for the potential future retrofit with a photovoltaic system once prices decrease.

☐ Consider installing a wind generator to provide some or all of the buildings power needs.

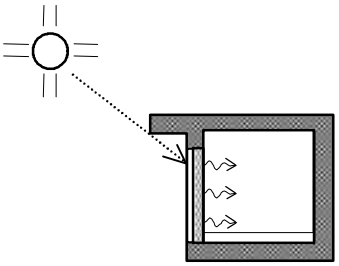
☐ Consider installing radiant barriers in the roof and walls to reduce cooling loads.

☐ ☐ Consider installing vented roof and/or thermal chimneys to provide natural ventilation cooling.

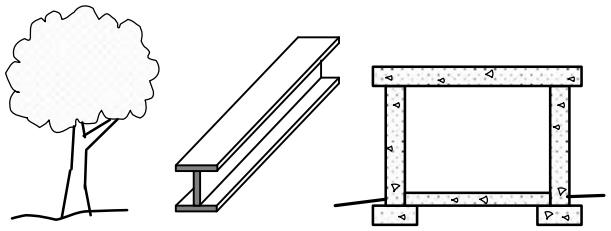
☐ Consider installing movable insulation (hand operated or automated) to close off glass areas during the night.

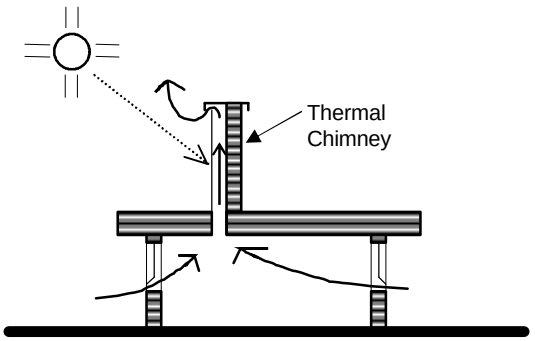


Direct gain passive solar heating



Trombe wall passive solar heating





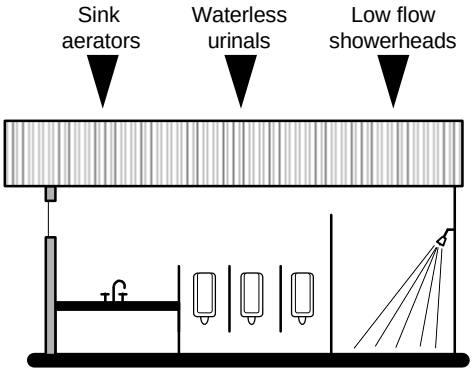
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BUILDING DESIGN - Optional Items continued

- ☐ ☐ Design the roof to collect rainwater & provide storage tanks to use the water for landscaping & toilets.
- ☐ ☐ Control noise pollution, provide maximum separation between sources of noise and the spaces that are quiet..
- ☐ ☐ Ensure Operations and Maintenance are active participants & use environmentally responsible procedures.
- ☐ ☐ *Reduce the use of potable water for sewage by 50% or treat 100% of sewage on site (1). This can be done by collecting gray water for use in flushing toilets, using composting toilets or building constructed wetlands to treat polluted water.
- ☐ ☐ *Reduce building potable water use 20% (1 point) or 30% (2 points).
- ☐ ☐ *Use renewable energy for a portion of the bldgs. energy use - 5%-(1 point), 10%-(2 points) & 20%-(3 points). Renewable energy sources such as solar, wind, geothermal, biomass, hydro and bio-gas can be used.
- ☐ ☐ *Reuse an existing bldg. or large portions - 75%-(1 point), 100%-(2 points) 100%+50% interior-(3 points). It takes far less material and energy resources to use existing building structures then to build new from the ground up.
- ☐ *Provide occupant control of windows, lights & airflow for each 200sf perimeter zone & 50% interior area (1). A minimum of one operable window an one light control are to be provided for every 200 sf of occupied space 15 feet off the perimeter walls
- ☐ *Go above or beyond existing individual LEED requirements or come up with new and innovative design (1-4).



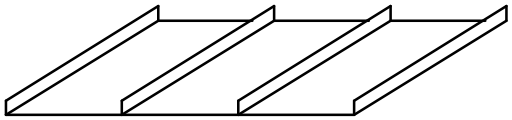
Water-saving technologies that have a less than 1 year payback.

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MATERIALS - Required Minimum Standards

☐ ☐ Consider the use of standing seam metal roofs first which have a long life span & can be easily recycled.



☐ ☐ Use locally available materials for construction to minimize transportation.

☐ ☐ Use durable, easily maintained materials inside and out to minimize future replacement.

☐ ☐ Use non-toxic low or no VOC interior finishes (paint, flooring, carpet, adhesives and wall coverings).

☐ Use double glazed glass with thermal break frames. Use heat mirror high R-value glass in colder climates.

☐ Choose materials with recycled content first over conventional materials. Look for recycle content labels. Give preference to material that contain post consumer recycled content.

☐ Choose materials which can easily be separated into there base components for easy recycling.

☐ ☐ Consider the use of cellouse insulation first. Instead of fiberglass. Encapsulate all fiberglass insulation.

Encapsulated fiberglass batts



☐ Use autoclaved concrete block which contains flyash & has a high R-value instead of standard block.

☐ ☐ Salvage and reuse building materials for the current project, or sell or donate materials for reuse by others.

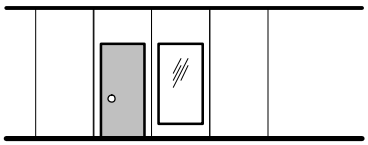
☐ ☐ *Divert construction waste and other construction debris from landfills - 50%-(1 point), 75%-(2 points). Develop and implement a waste management plan. Recycle cardboard, metals, brick, concrete, plastic, wood, glass wallboard, carpet & insulation.

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MATERIALS - Optional Items



☐ ☐ Consider interior movable walls first. Movable walls provide for easily modifications with minimum waste. Movable walls eliminate painting and disposal of used drywall.

☐ Use natural cedar in place of pressure treated wood.

☐ ☐ Consider solid wood & water base finishes first. Avoid the use of particle board and vinyl finishes.

☐ ☐ *Use salvaged or refurbished materials for 5% of construction (1 point) or 10%-(2 points). Previously used materials such as structural pieces, flooring, paneling, doors & frames, cabinets, furniture and brick should be considered for use in new and renovated designs.

☐ ☐ *Use recycled content materials for 25% of construction (1 point) or 50%-(2 points). Determine materials to use, establish goals & identify suppliers.

☐ ☐ *Use locally available (within 500 miles) materials for 20% of construction (1 point) or 50%-(2 points). It takes far less energy to transport materials from local sources.

☐ ☐ *Use rapidly renewable materials (bamboo flooring, wool carpet, strawboard, etc.) for 5% of construction (1). Other materials to consider are cotton insulation, linoleum, OSB made of popular & wheatgrass board.

☐ ☐ *Use certified (Forest Stewardship Council guidelines) wood from a renewable forest for a minimum of 50% of wood used in construction (1).

☐ ☐ *Use non-toxic materials: Adhesives (1 point), Paints (1), Carpet (1) & Composite wood w/ no formaldehyde (1) as defined by Green seal & Carpet Rug Institute.

☐ ☐ *Design building to prevent occupants from being exposed to chemical pollutants from both inside & outside (1). Use entryway grates to trap dirt & filter all incoming air.

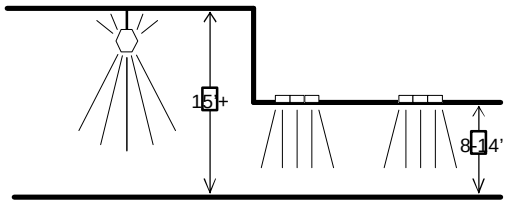
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LIGHTING - Required Minimum Standards

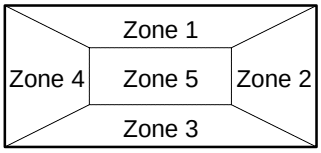
- ☐ Design all new buildings to utilize daylighting.
- ☐ Retrofit existing buildings with daylighting where possible using existing windows.
- ☐ ☐ Install switched control sys. in transition spaces & dimmable sys. in occupied spaces to respond to daylight.
- ☐ ☐ Use light colored finishes to maximize light distribution.
- ☐ ☐ Install energy efficient lighting systems (HID in high bay spaces & efficient fluorescent in low bay spaces). Consider the use of T5 fluorescent lights in both high and low bay spaces.
- ☐ ☐ Consider an indirect lighting system first with supplemental task lighting as needed. Best for computer use.
- ☐ ☐ Install occupancy sensors in all spaces (restrooms, offices, conference & storage). Open office spaces should be zoned into areas that correspond to sensor coverage.
- ☐ ☐ Install parabolic lighting fixtures in open office areas and prismatic fixtures in small enclosed spaces.
- ☐ ☐ *With exterior lighting, avoid light pollution and use compact fluorescent or metal halide lamps (1).



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HVAC - Required Minimum Standards



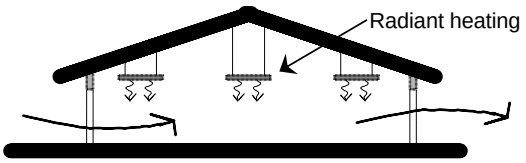
- ☐ Divide the building into multiple thermal zones so unused areas can be switched off or allowed to float.
- ☐ Consider ground source heat pump HVAC system first, then high efficiency air-to-air heat pumps. Ground source heat pump systems obtain heat and cooling from the ground and minimize electricity and fuel use.
- ☐ Install variable air volume systems instead of constant volume systems.
- ☐ ☐ Consider placing insulation on the outside of ducts first, instead of the inside to reduce potential mold growth.
- ☐ ☐ Install programmable thermostats for unoccupied setbacks/ups in small buildings.
- ☐ ☐ Install direct digital controls with energy management control systems (EMCS) in large buildings.
- ☐ ☐ Select energy efficient motors for HVAC equipment and other applications. All fans and pumps should be powered by premium motors.
- ☐ ☐ Install variable frequency drives on any appropriate motor or pump.
- ☐ ☐ Install water saving plumbing fixtures.
- ☐ ☐ *Design the HVAC system to ASHRAE 62-1999 to provide minimum indoor air quality (R).
- ☐ ☐ *Provide zero exposure of nonsmokers to environmental tobacco smoke (R).

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HVAC - Optional Items



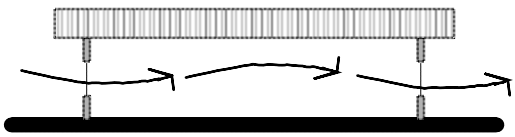
- ☐ Consider radiant heating systems in high traffic areas exposed to large amounts of air infiltration.
- ☐ Consider installing a separate ventilation system which delivers fresh air directly to the occupants.
- ☐ Consider installing under floor HVAC distribution systems for efficiency and individual user control.
- ☐ Consider multiple boiler systems that are solar assisted or biomass fired, also consider cogeneration.
- ☐ Use an air distribution system that distributes a large mass of air at a low velocity.
- ☐ ☐ Consider adding solar collectors to provide domestic hot water.
- ☐ ☐ Consider the use of air to water heat pumps to provide domestic hot water.
- ☐ ☐ Select high-efficiency and high-performance office, food service, and other equipment (Energy Star labeled).
- ☐ ☐ Install electronic controls with new plumbing fixtures or retrofit existing fixtures.
- ☐ ☐ Consider installing photovoltaic panels to supplement building electric use.
- ☐ *Commission building - check and verify that all new systems are installed and working correctly (R).
- ☐ *Do additional building commissioning before and after construction (1).
- ☐ ☐ *Eliminate the use of CFC refrigerants when installing new HVAC equipment (R).

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HVAC - Optional Items - continued

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☐	☐	*Install or replace all HVAC equipment that has HCFC's or Halon (1).
	☐	*Model the building to predict savings & monitor it after construction to verify performance (1).
☐	☐	*Enter a two year contract to buy green power for a portion of the building's energy use (1).
☐	☐	*Design the HVAC system to ASHRAE 62-1999 to provide minimum indoor air quality (R).
☐	☐	*Install a carbon dioxide (CO2) monitoring system to adjust ventilation (1).
☐	☐	*Install a ventilation system that provides a minimum of .9 air changes per hour during occupied hours (1).
☐	☐	*Exceed ventilation requirements (SMACNA IAQ Guidelines) during const. & Install new filters after const. (1).
	☐	*Flush building with 100% outside air for a minimum of 2 weeks after construction & replace filters (1).
	☐	*Provide very tight thermal comfort (ASHRAE 55-1992) (1point), install temp. & humidity monit. & controls (1).
☐	☐	*Have at least one member of the design team complete the LEED Accredited Professional exam (1).



Building flush after construction