Sustainable HVAC Design for Green Buildings

By

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Course Description

Sustainable HVAC Designs for Green Buildings

Green buildings are more and more popular in the present day for reducing energy of buildings. Green building certification such as LEED of USGBC & ASHRAE Green building standard 189.1 has become prime tools for achieving green building status.

This presentation provides an overview of how to achieve sustainable HVAC designs for Green Buildings by utilising ASHRAE Standards 90.1, 189.1. Also 62.1, & 55 are used.
Learning Objectives

After attending to this lecture, participants will be able to:

1. Explain the importance of Sustainability and energy efficiency in the Green Buildings designs
2. Recognise the importance building certification programmes in designing of green buildings
3. Identify the importance of mandatory requirements of ASHRAE Standard 189.1 and its implementation to green building design
4. Describe the use of ASHRAE green guide and explain implementation of green tips in the green building design.

Content

- What is a Green Design
- ASHRAE Standard 189.1- Green Standard
- ASHARE Standard 90.1
- Selection of building envelope components for green design
- Minimum efficiency requirements for HVAC equipment
- ASHRAE Standard 62.1-2013 & minimum ventilation rates
- Use of energy recovery
What is Green Design?

Concept of “GREEN” with regard to building systems;

• A design that is green is one that is aware of and respects nature and the natural order of things
• It is a design that minimise the negative human impacts on the natural surroundings, materials, resources & processes

Relation Ship to Sustainability

There are so many definitions to sustainability, however ASHRAE defines it as;

Providing for the needs of the present without detracting from the ability to fulfil the needs of the future
Green design & sustainability have no absolutes; They cannot be defined exactly.

It is a goal to be sought.

It is some practical techniques to help practitioners achieve the goal of green design and thus make a significant contribution to earth’s sustainability.

Green Buildings

Green building is one that achieves high performance, over the full life cycle, in the following areas:

- Minimal Consumption
- Minimal atmospheric emission
- Minimal discharge of harmful liquid effluents
- Minimal negative impact on site ecosystems
- Maximum quality of indoor environment
Green Building

Reasons for implementing green buildings are to do the right thing to protect the earth's resources.

“GOOD” Design

Characteristics of good design

1. Meets the purpose and needs of the building’s owners / managers and occupants
2. Meets the requirement of health, safety, and environment impact as prescribed by codes
3. Achieves good indoor environmental quality (IEQ)
4. Compatible with the history & culture of immediate surrounding
5. Creates emotional impact on building’s occupants
Building Certification System for Energy Conservation

Building Certification Systems helps to achieve sustainability. Figure below show world leading certification bodies operating in whole world.

In Sri Lanka, LEED certification system from US green building council is adopted.

LEED ASSESSMENT

LEED Rating Systems
Rating systems are groups of requirements for projects that want to achieve LEED certification.

Each group is geared towards the unique needs of a project or building type. LEED is flexible enough to apply to all project types including healthcare facilities, schools, homes and even entire neighbourhoods.
ASHRAE standards used in LEED program

ASHRAE standards used for LEED certification program;
1. 90.1- Energy standards for buildings
2. 55- Thermal comfort
3. 62.1- Indoor air quality
4. 189.1- High performance green buildings
5. 135- BACnet (Building automation & control)

ASHRAE standards referenced in LEED program

<table>
<thead>
<tr>
<th>ASHARE Standard</th>
<th>Keywords</th>
<th>Related LEED credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.2-2012</td>
<td>Filters, MERV (minimum efficiency reporting value)</td>
<td>EQ 3.1  EQ 5</td>
</tr>
<tr>
<td>55-204</td>
<td>Thermal comfort (temperature, air speed, humidity)</td>
<td>EQ 6.2  EQ 7.1  EQ 7.2</td>
</tr>
<tr>
<td>62.1-2010</td>
<td>Indoor air quality (IAQ)  Natural ventilation</td>
<td>EQ P1  EQ 2  EQ 6.2</td>
</tr>
<tr>
<td>90.1-2013</td>
<td>Energy standards for buildings except low-rise residential buildings</td>
<td>SS 8  EA P2  EA 1  EA 2</td>
</tr>
<tr>
<td>Advanced energy design guides</td>
<td>Perspective compliance path</td>
<td>EA 1 option-2</td>
</tr>
</tbody>
</table>
ASHRAE standard 189.1 Standard for Design of High-Performance Green Buildings

- What is Standard 189.1?
- A standard developed in model code language
- Provides minimum requirements for high-performance, green buildings
- Applies to all buildings except low-rise residential buildings (same as ASHRAE Standard 90.1)
- Optional compliance path to the International Green Construction Code (IgCC)
- Not a design guide, not a rating system

For Green buildings, other ASHRAE Standards to comply with

- Minimum energy requirements (std 90.1-2013)
- Minimum Ventilation Requirements (std 62.1-2010)
- Others:
  - Thermal comfort (std 55),
  - Maintenance (std 180)
Standard for the Design of High-Performance Green Buildings

The purpose of this standard is to provide minimum requirements for the siting, design, construction, and plan for operation of high-performance green buildings to

a. balance environmental responsibility, resource efficiency, occupant comfort and well being, and community sensitivity; and

b. support the goal of development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

About the Standard

- Provides minimum requirements for high-performance, Green buildings
- Applies to all buildings except low-rise residential buildings (same as ASHRAE/IESNA Std 90.1)
- Optional Compliance Path to the International Green Construction Code (IgCC)
- Not a design guide, not a rating system but a standard
- Drives innovation and Market shift towards degree of Green
**ASHRAE standard 189.1 Building Blocks**

Source: Mr. Kent W. Peterson

- ASME - American Society of Mechanical Engineers
- US DOE - US Department of Energy
- USGBC - US Green Building Council
- IESNA - Illuminating Engineering Society of North America
- US EPA - US Environment Protection Agency
- BIFMA - Business & Institutional Furniture Manufacturers Association
- ASTM - American Society for Testing Materials
- Green Seal - Green Seal is a nonprofit organization

**Green Building Codes**

**Primary ASHRAE Standards**
- Std 90.1
- Std 62.1
- Std 55
- Std 180

**Secondary ASHRAE Standards**
- Std 189.1
Compliance Paths

Standard 189.1 used for

- New buildings and their systems
- New portions of buildings and their systems
- New systems and equipment in existing buildings
- Does not apply to:
  - Single-family houses
  - Multi-family structures of 3 stories or less
  - Mobile homes
  - Buildings that use no electricity, fossil fuel or water
Scope

• Sustainable sites
• Water use efficiency
• Energy efficiency
• Indoor environmental quality
• Building’s impact on the atmosphere, materials and resources
• Construction and operation plan

Site Selection

Mandatory Provisions

- Site selection
- Predesign Site Inventory and Assessment
- Plants
- Storm water Management
- Mitigation of Heat Island Effect
- Reduction of Light Pollution
- Mitigation of Transportation Impacts
Water Use Efficiency

Mandatory Provisions
- Site Water Use Reduction
- Building Water Use Reduction
- Water Consumption Measurement

Prescriptive Option
- Site Water Use Reduction
- Building Water Use Reduction
- Special Water Features

Performance Option
- Site Water Use Reduction
- Building Water Use Reduction

Energy Efficiency

Mandatory Provisions
- General
- On-Site Renewable Energy Systems
- Energy Consumption Management

Prescriptive Option
- General Comprehensive Prescriptive Requirements
  - Standard Renewables Approach
  - Building Envelope
  - Heating, Ventilating, and Air Conditioning
  - Service Water Heating
  - Power
  - Lighting
  - Other Equipment

Performance Option
- General Comprehensive Performance Requirements
  - Performance Option A
  - Performance Option B
  - Standard 90.1 Appendix G
  - Standard 189.1 Appendix C
Indoor Environment Quality

Mandatory Provisions
- Indoor Air Quality
- Thermal Environmental Conditions for Human Comfort
- Acoustical Control
- Isolation of the building from pollutants in Soil
- Lighting Quality
- Moisture Control

Prescriptive Option
- Day lighting
  - Materials
  - Lighting for Presentations

OR

Performance Option
- Day lighting Simulation
  - Materials
  - Lighting for Presentations

Building’s Impact on the Atmosphere

Mandatory Provisions
- Construction Waste Management
- Extracting Harvesting, and/or Manufacturing
- Refrigerants
- Areas for Storage and Collection of Recyclables
- Mercury Content Levels of Lamps

Prescriptive Option
- Reduced Impact Materials
  - TWO OF THE FOLLOWING
    - Recycled Content and Salvaged Material Content
    - Regional Materials
    - Bio based Products
    - Multiple Attribute Product Declaration or Certification

OR

Performance Option
- Life Cycle Assessment
Construction and Plans for Operation

Mandatory Provisions

- Construction
- Plans for Operation

ONLY

Prescriptive Option
- No Prescriptive Option

Performance Option
- No Performance Option

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Energy Efficiency

Mandatory provisions

Building Envelope
1. Insulation properties and installation procedure
2. Fenestration & door testing, rating and labelling.
3. Air Barrier design, installation, and products

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Energy Efficiency

Mandatory provisions

HVAC Systems
1. Minimum equipment efficiencies
2. Acceptable methods of calculating heating/cooling loads and pump head.
3. Controls minimum capabilities & required logic
4. HVAC system construction and insulation
5. Walk-in coolers and Freezers construction and control logic.
6. Refrigerates display case construction & control logic

Energy Efficiency

Mandatory provisions

Service Water Heating
1. Load calculation for sizing water heaters.
2. Minimum equipment efficiency
3. Service –hot water piping insulation & locations
4. Service water heating system control of water temperature and circulation pump operation.
5. Storage water heater, heat trap locations
6. Pool heater manual switching, pool heater time clock operation.
Energy Efficiency

Mandatory provisions

Power
1. Maximum allowable voltage drop through feeder and branch circuits.
2. Automatic receptacle control location and requirements
3. Electrical energy monitoring
4. Low voltage dry-type distribution transformer efficiency

Lighting
1. Interior & exterior lighting control
2. Maximum exterior building lighting power allowance
3. Functional testing of lighting control system
**Energy Efficiency**

Mandatory provisions

**Other Equipment**

1. Minimum electric motor efficiency
2. Service water pressure booster system design requirements
3. Allowable elevator cab lighting power & minimum elevator control system
4. Minimum escalator and moving walk control systems.
5. Whole building energy monitoring of energy utilities such as fuels, steam and heating & cooling water

**ASHRAE Green Tips**

ASHRAE provides **Green Tips** which are practical suggestions for possible incorporation in a green design.

Total of 29 **Green Tips** are available, out of which 11 tips relating to HVAC is discussed in this seminar.
**ASHRAE Green Tip #1**  
**Night Pre-Cooling**

Night pre-cooling is Circulation of cool air within a building during the night time.

Hot dry environment is ideal for this technique, however it should not be used in humid environment.

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**ASHRAE Green Tip #2**  
**Air-to-Air Heat Recovery**  
**Enthalpy Wheels**

A heat exchange enthalpy wheel, has a revolving cylinder filled with an air-permeable medium with a large internal surface area.

Heat transfer media may be selected to recover both sensible & latent heat.

Because cross contamination can be detrimental, purge section can be installed to reduce carryover.
**Function of an Enthalpy Wheel**

- Heating/Cooling Energy (e.g., 80%) is always returned to where it came from.
- Moisture and Dry Air (e.g., 80%) is always returned to where it came from.

**ASHRAE Green Tip #3**

**Air-to-Air Heat Recovery Heat Pipe System**

A heat pipe heat exchanger is a completely passive energy recovery device. The tubes are divided into evaporator & condenser sections by an internal plate. Tubes are filled with a refrigerant.
ASHRAE Green Tip #4
Air-to-Air Heat Recovery Run-around Coil

Typical coil energy recovery loop, places finned tube coils in the supply and exhaust systems. In re-heating of a Total Fresh air system, two coils are placed in the fresh air intake and after the cooling coil for re-heating supply air.

ASHRAE Green Tip #6
Dedicated Outdoor air systems

A DOAS ensures Compliance with ASHRAE 62.1 for proper multiple space ventilation and adequate IAQ

Separate AHU to condition the outdoor air before delivering it direct to the occupied space. This is most beneficial in a facility with multiple spaces with differing ventilation needs. This is not Treated fresh Air system which directly connects to the return air mixing box.
ASHRAE Green Tip #7
Demand Control Ventilation using CO₂

Outdoor air flow rate for ventilation is controlled via CO₂ sensor and damper with a modulating actuator. Applicable to spaces that have wide variances of occupancy such as gymnasiums, auditoriums etc.

Demand control ventilation (DCV) is required for spaces larger than 500ft² and with a design occupancy for ventilation of greater than 25 people per 1000ft² of floor area and served by systems with one or more of the following;
- Air-side Economizer
- Automatic modulating control of OA damper
- Design outdoor air flow greater than 3000 CFM

CO₂ sensor coupled to a controller operates the Volume control damper of fresh air duct
OR
Operates the VFD of the fresh air fan

ASHRAE Green Tip #9
Variable Flow / Variable Speed Pumping Systems

Variable flow is produced in chilled water systems by using automatic two position valves (2-way valves)

Variable speed pumping is achieved by using variable speed drives on the CHW pump motor

- Primary-only variable flow system with chiller bypass line and a valve for minimum flow
- primary –secondary system, where secondary system with variable speed pumps.
Variable flow/ Variable speed pumping
Primary Variable with chiller by-pass

Variable flow/ Variable speed pumping
Primary-Secondary de-coupled system
Thermal storage system (TES) utilise a building’s cooling equipment to remove heat, usually at night, from and energy storage medium (ice/chilled water) for later use as a source of cooling.

Basic principle of TES is to reduce peak building cooling loads by shifting a portion of peak cooling production to times when the building cooling load is lower.
ASHRAE Green Tip #15
Thermal Energy Storage for Cooling

**Freeze Mode**

**Melt Mode**

**Full Storage**

ASHRAE Green Tip #19
Desiccant Cooling and De-humidification

Rotary desiccant dehumidifiers use solid desiccants such as silica gel to attract water vapour from the moist air.

Use in applications that require dew point at or below 4°C (40°F), such as film drying, manufacture of drugs, chemicals etc.
ASHRAE Green Tip #20
Indirect Evaporative Cooling

Evaporative cooling of supply air can be used to reduce the amount of energy consumed by mechanical cooling equipment.

Direct evaporative cooling introduces water directly into supply air stream, usually with a spray or wetted media.

Indirect evaporative cooling uses an additional water side coil to lower supply air temperature and is piped to a cooling tower where the evaporative process occur.

Q & A