BCA - ASHRAE Singapore Chapter Seminar on Sustainable Building Design and Performance

6 March 2009, Singapore

Enhancement of the Envelope Thermal Transfer Value Criterion for Improved Energy Performance of Buildings

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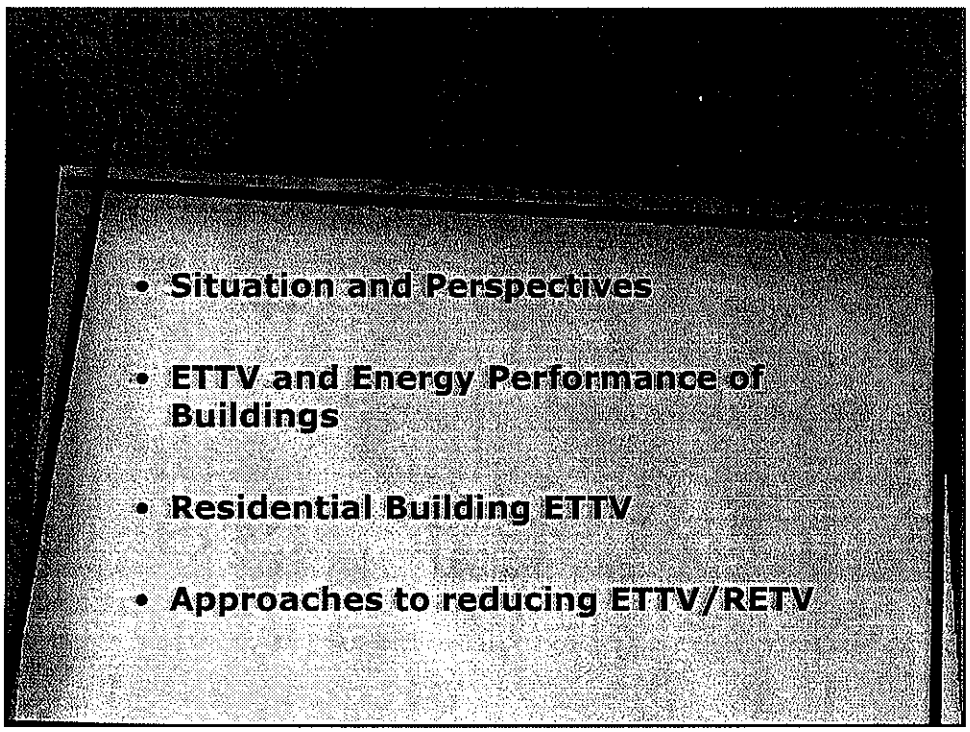


Situation

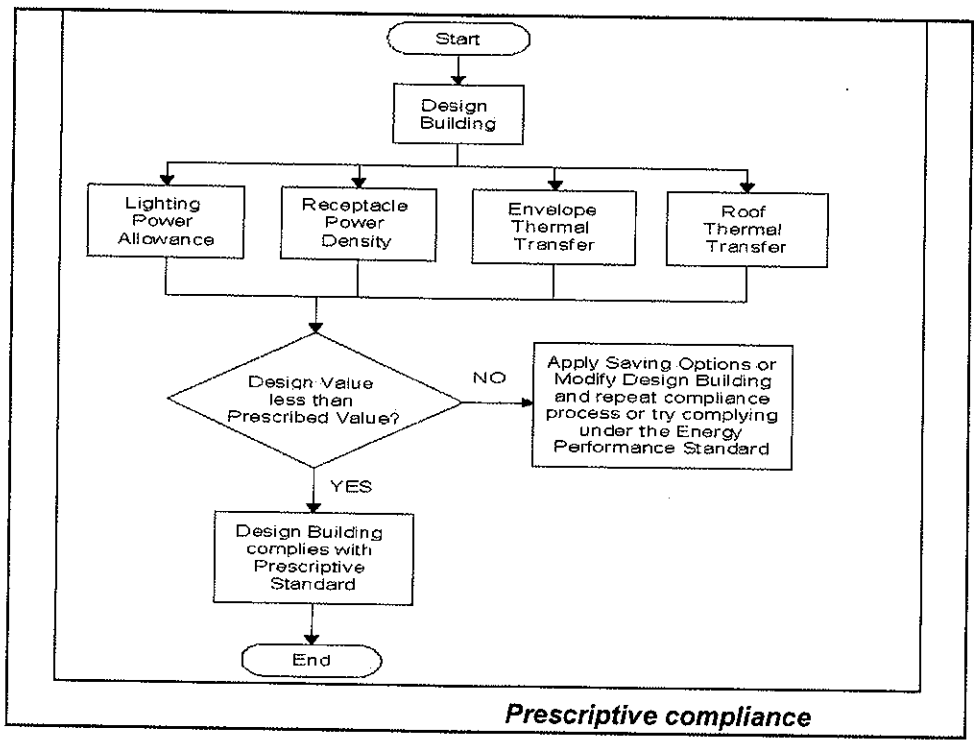
- ***Buildings are energy intensive***
- ***Buildings have large carbon footprints***
- ***Energy performance of buildings presents new opportunities within a total approach in building design***
- ***Energy efficient buildings have significant economic impact***

Building Energy Perspectives

- Building sector accounts for more than 25% of the total electrical consumption in Singapore
- Air conditioning typically contributes at least half of the energy consumption of a commercial building
- Designing for energy efficiency pays
- Tools needed to demonstrate compliance of standards at design and operation
- Training and good practice essential
- Need for smart incentives

Energy Conservation in Buildings - Major Milestones

- 1979: ETTV and prescriptive standards incorporated in the Building Control Regulations
- 1982,1983 (revised 1999): Launch of CP 24 (Energy Efficiency Standard Building Services and Equipment)
- Mid 80s: Revision of OTTV criterion
- 1999: Compliance of CPs 13 (Mechanical Ventilation and Air Conditioning in Buildings) , 24 and 38 (Artificial Lightings in Buildings)
- 2001: Commencement of BCA-funded project on energy efficiency index for non-residential buildings
- 2004: Launch of ETTV and completion of EEI project
- 2006: Commencement of BCA-funded project on ETTV improvement
- 2006: Launch of SS530
- 2007: Launch of Green Mark Incentive Scheme



Prescriptive compliance

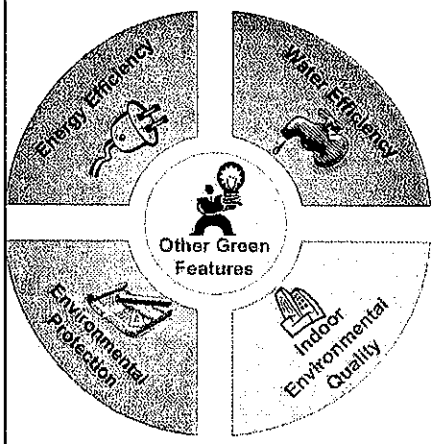
Energy Performance Enhancement

- the BCA Green Mark Scheme

launched in January 2005

BCA Green Mark is a green building rating system to evaluate building for its environmental impact and performance

BCA GREEN MARK



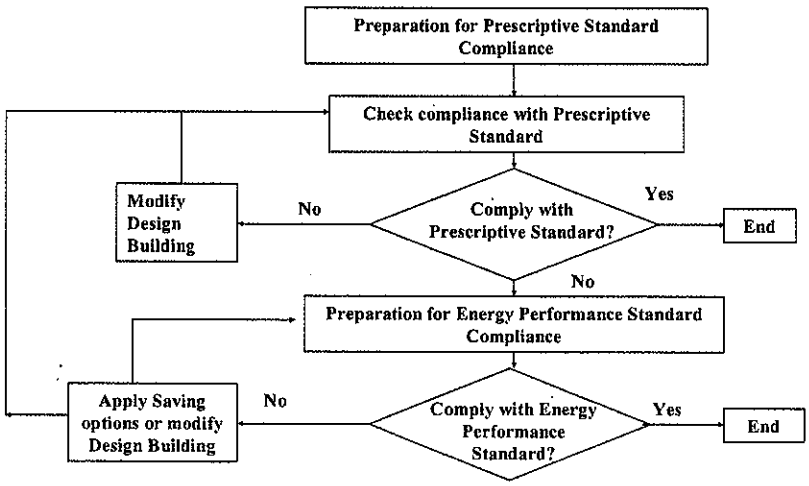
Main objectives:

- To raise awareness
- To recognise 'green' developers
- To identify best practices

With Emphasis on Energy Efficiency

Source: BCA

Designing for Energy Performance



Green Mark Legislation applies to:

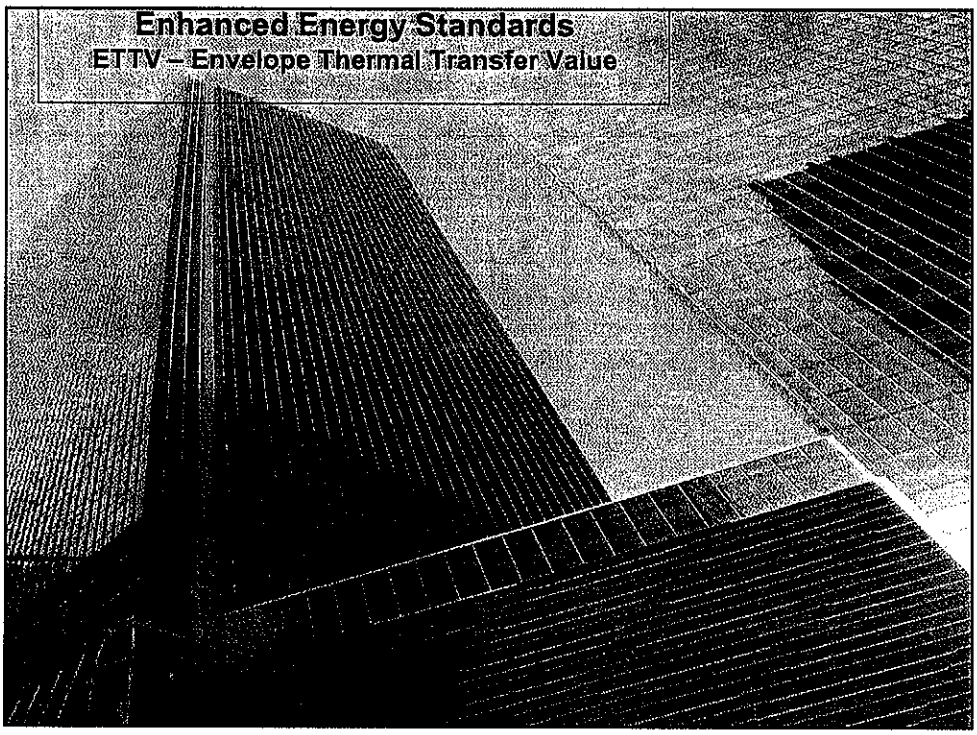
- All new developments and existing buildings undergoing major retrofitting works with GFA of 2000 m^2 or more
- Works involve overhauling of air-conditioning system, modification to building façade, changing of lighting and other building services

Enhancement of the ETTV Criterion – Project Objectives

- determine the contribution of the ETTV on the energy consumption of an air-conditioned non-residential building;
- evaluate the significance of further reductions in the ETTV and the quantitative energy efficiency gains that can be achieved by further tightening the standard;
- evaluate the potential application of the ETTV criterion on residential air-conditioned buildings taking into account the significance of the ETTV criterion and potential energy savings that may be achieved; and
- develop an engineering tool to facilitate calculations and compliance of the ETTV standard criterion.

Usefulness and choice of an indicator on building envelope thermal performance

- *How to tell the difference between buildings in terms of thermal performance efficiency?*
- *What factors influence selection of indicator?*
  - *accuracy, sensitivity, technology, ease of application*
- *What issues need to be considered when applying the desired indicator?*
  - *long term effectiveness, expertise, implementation, policy, cost*
- *How indicator translates to energy efficiency of buildings?*



The Envelope Thermal Transfer Equation - ETTV

$$ETTV = \frac{(Aw \times Uw \times TDeq) + (Af \times Uf \times \Delta T) + (Af \times SC \times SF)}{Ao}$$

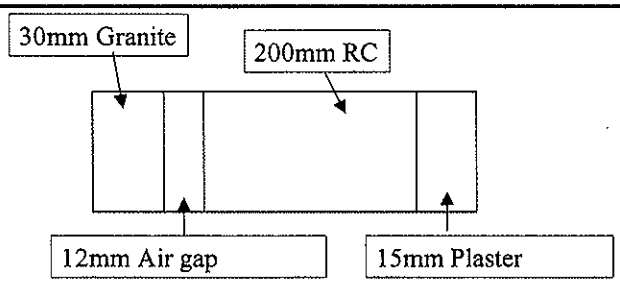
$$ETTV = TDeq(1 - WWR)Uw + \Delta T(WWR)Uf + SF(WWR)(CF)(SC)$$

Energy Modelling - Parameters and Ranges

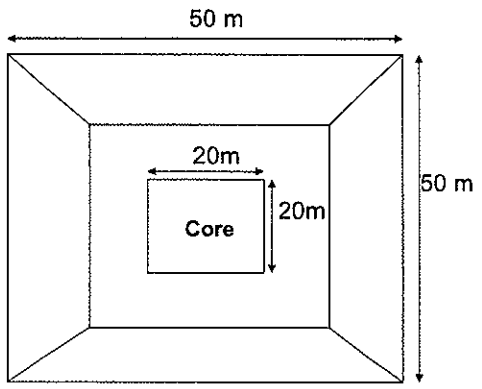
Uwall (W/m²K)	0.5 – 2.5
Uf(W/m²K)	0.2 – 4.21
SC	0.2 – 0.7
WWR	32% – 90%
OA (cmh/m²)	0.85 – 3.0
LIT (W/m²)	10 – 20
LTS	0.5 – 0.8
COP	3.5 – 5.5

Generic Office Building Description

Materials	**External Walls:** 30mm granite, 10mm airspace, 200mm R.C. wall, 15mm plaster (sand/cement) U_w = 2.16 W/m²K ; Solar abs = 0.40 **Interior Walls:** 1.59cm gypsum board, 10cm airspace, 1.59cm gypsum board U = 2.18 W/m²K **Roof:** 1.25cm roof gravel, 0.95 cm built up roofing, R5 polystyrene insulation, 15.2cm concrete, 10.2cm airspace, 1.3cm acoustic tile U = 0.63 W/m²K ; Solar absorptance = 0.3 **Floors:** 15.2cm concrete floors, U = 4.24 W/m²K



Windows	Fenestration (double-glazing): 8mm glass, 12mm airspace, 6mm glass U_f = 1.75 W/m²K Shading Coefficient = 0.40 Window-to-Wall ratio = 0.40
Building info	ETTV = 50 W/m² Total Building Envelope area = 7320 m² Total Building air-conditioned area = 25200 m² (12 Floors x 2100 m²)



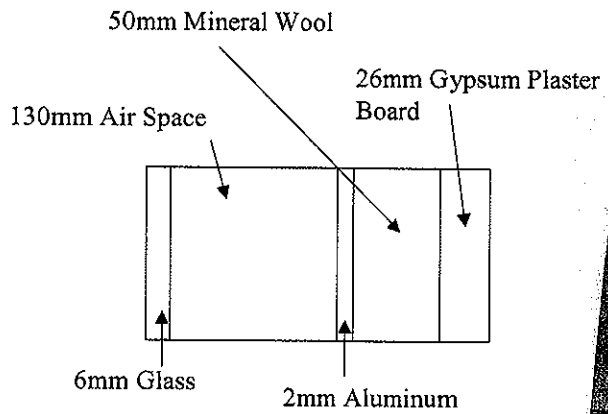
Floor Air-conditioned area
= 50x50 – 20x20(core area)
= 2100 m²

Core area consists of lifts, stairs, etc

Generic Office Building – Operation Characteristics

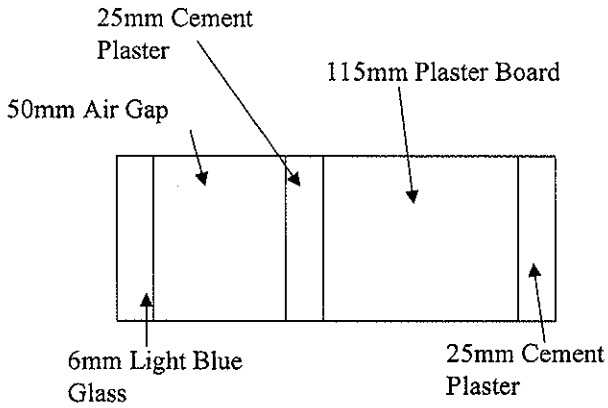
Systems and Plants	Infiltration = 0.6 air changes per hour when fans are off Heat-of-light to space ratio = 0.8 Outside air = 1.25cmh/m^2 Cooling Set point = 25°C Night Setback = 37°C Economizer = None Chiller COP = 4.5 Occupant Load = 117.23 W/person System type: Variable Air Volume (VAVS) Chiller: Hermetic centrifugal compression chiller Total fan capacity = 342998 m^3/h Cooling capacity = 1838.463 kW
Power Density	Lighting Power = 20 W/m^2 in occupied space Receptacle Power Density = 5 W/m^2

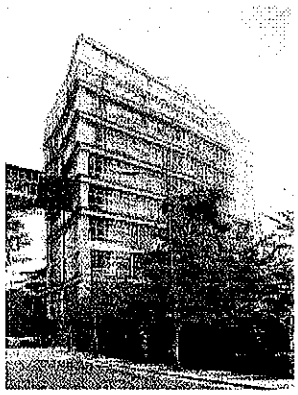
Exterior Wall Type 1



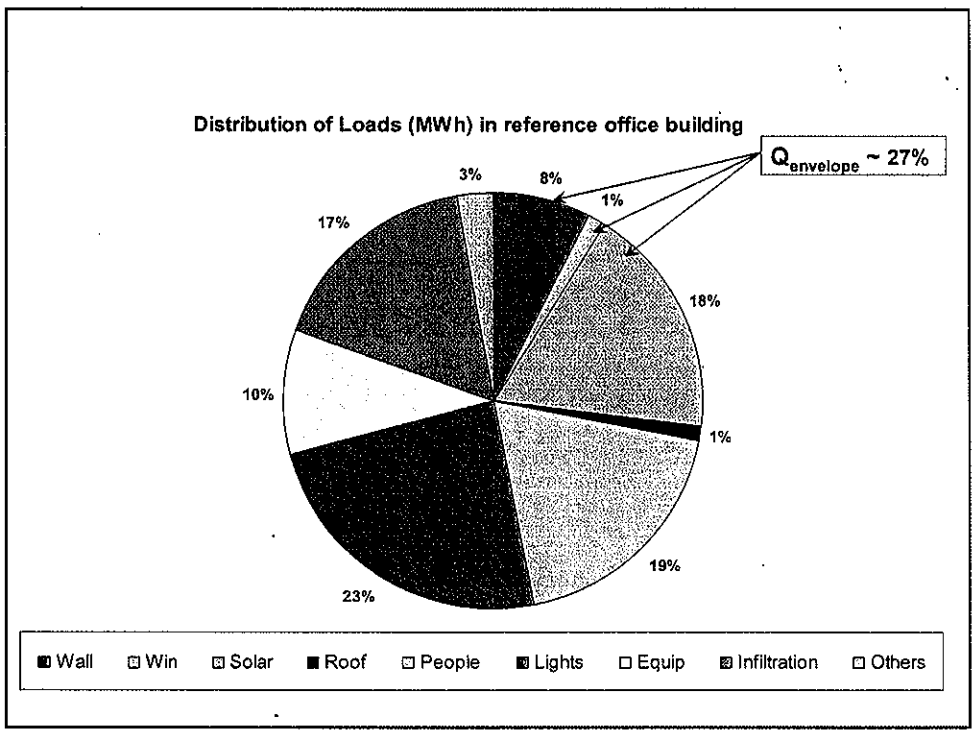
Uwall = 0.52 W/m^2K

Exterior Wall Type 2





U-Value = 1.37 W/m²K



The ETTV formula is given as follows:

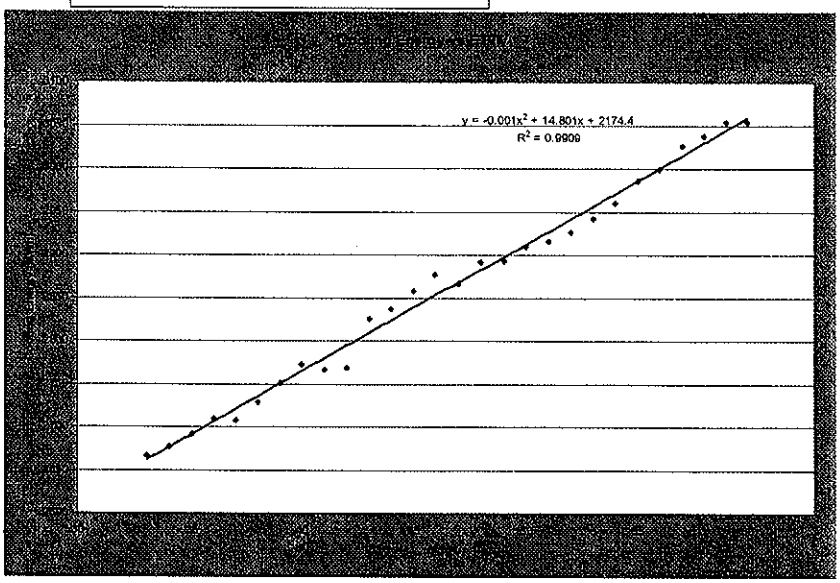
$$ETTV = 12(1 - WWR)U_w + 3.4(WWR)U_f + 211(WWR)(CF)(SC)$$

where

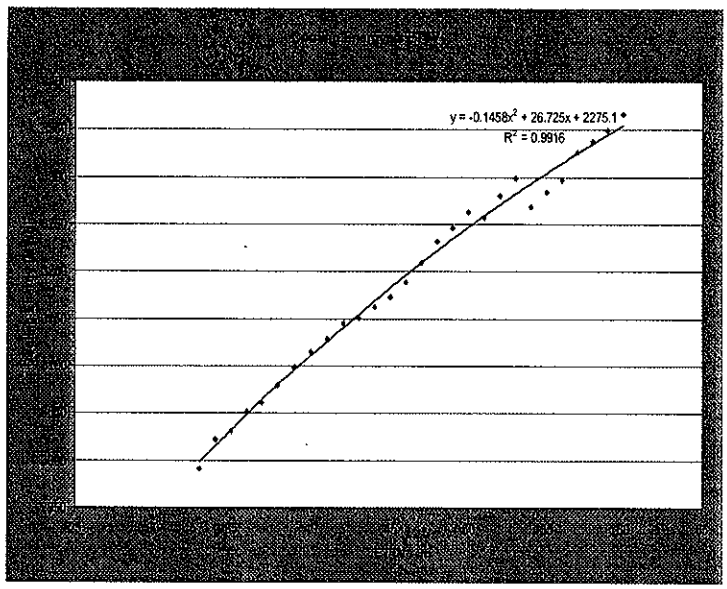
ETTV	=	envelope thermal transfer value (W/m^2)
WWR	=	window-to-wall ratio (fenestration area / gross area of exterior wall)
U_w	=	thermal transmittance of opaque wall ($W/m^2 K$)
U_f	=	thermal transmittance of fenestration ($W/m^2 K$)
CF	=	correction factor for solar heat gain through fenestration
SC	=	shading coefficients of fenestration

ETTV and Energy Consumption

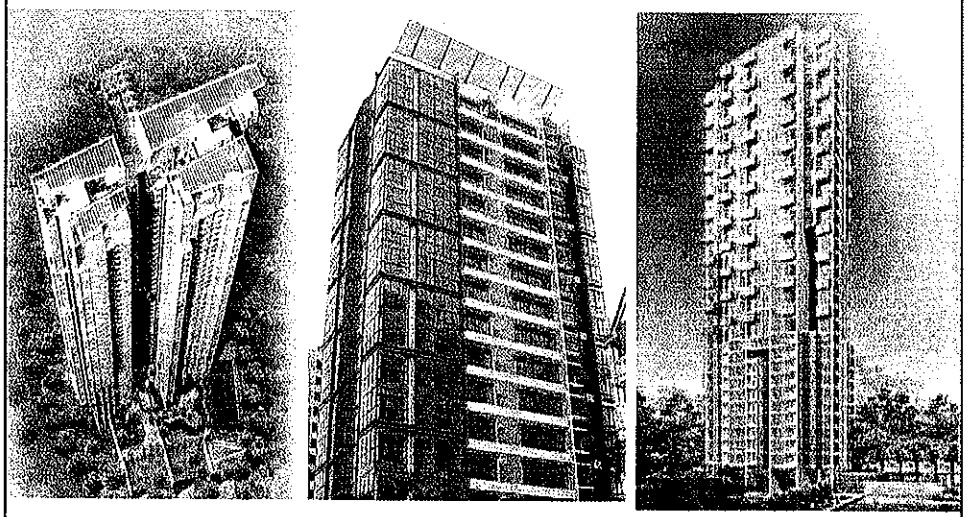
Office ETTV vs Energy



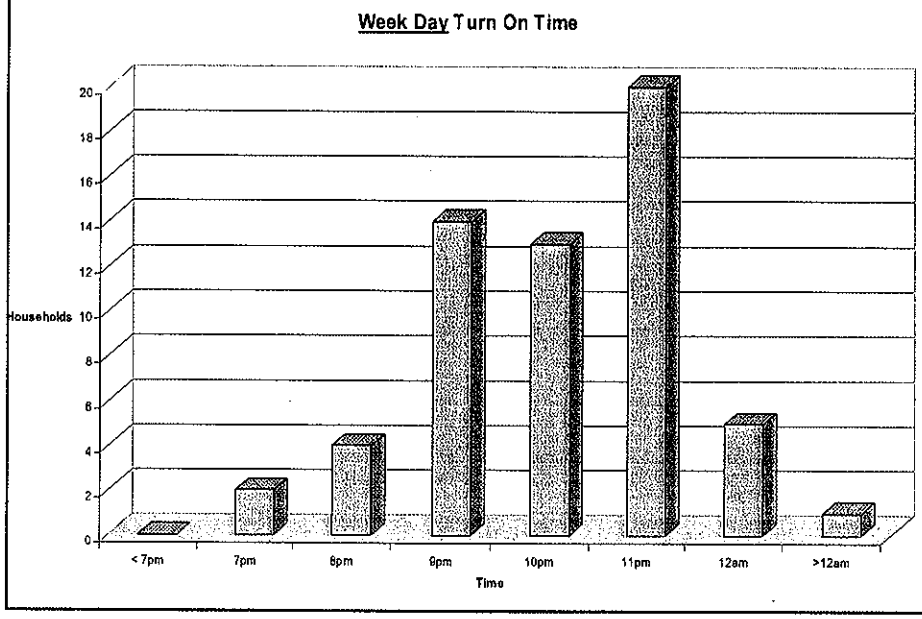
Hotel ETTV vs Energy

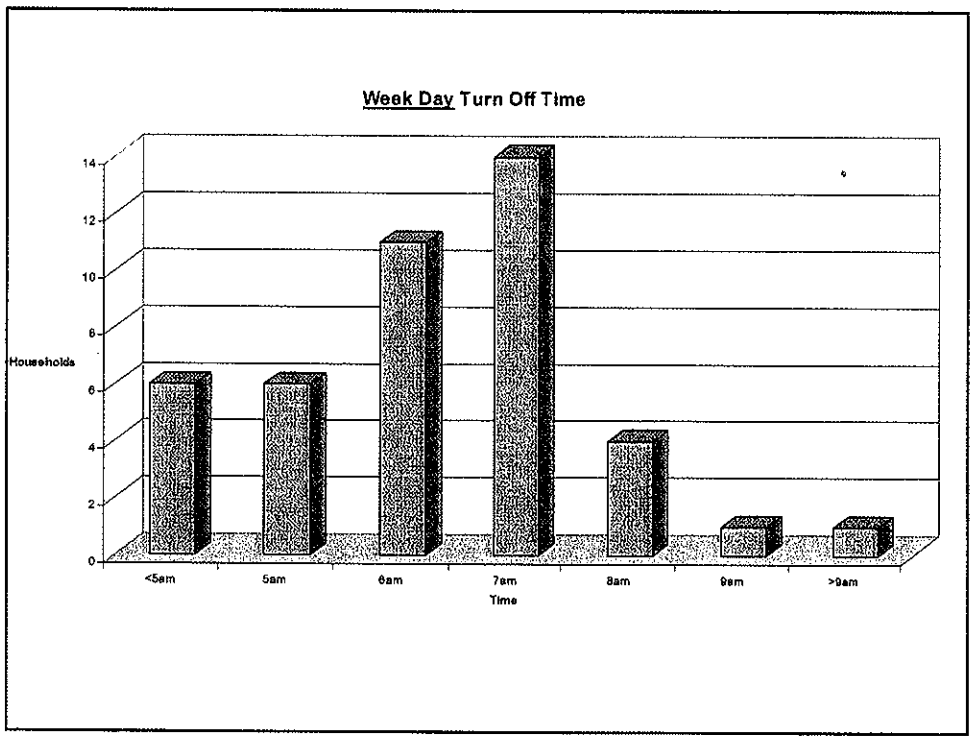


ETTV of Residential Buildings



Air Conditioning Pattern Survey Results




Week Day Turn Off Time
Households
14
12
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8
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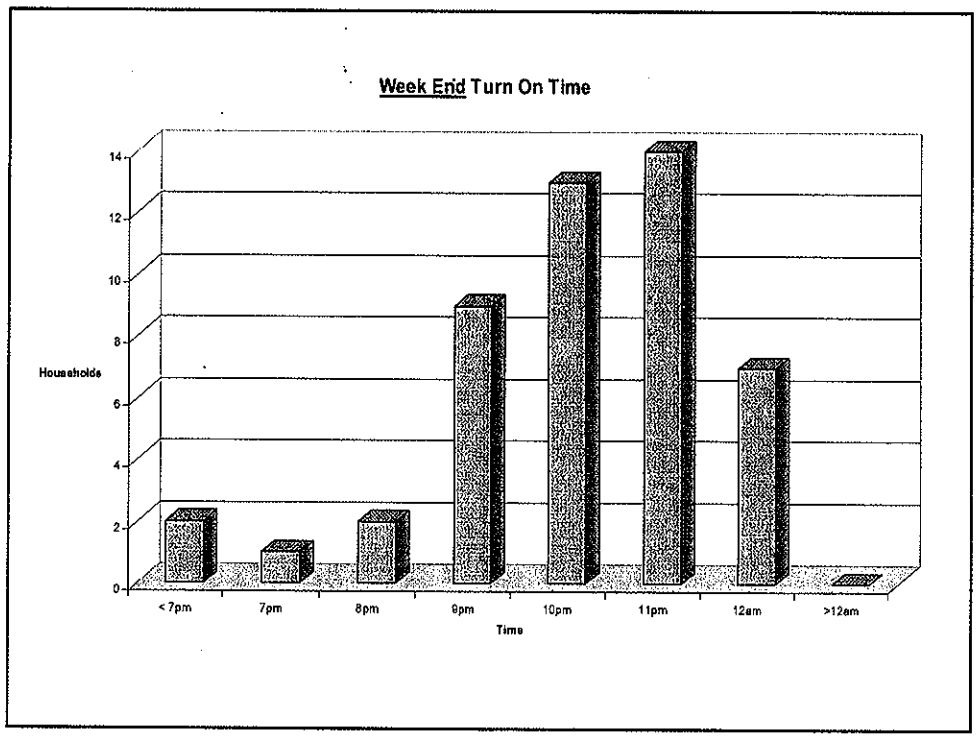
0
<5am
5am
6am
7am
8am
9am
>9am
Time


Week End Turn On Time
Households
14
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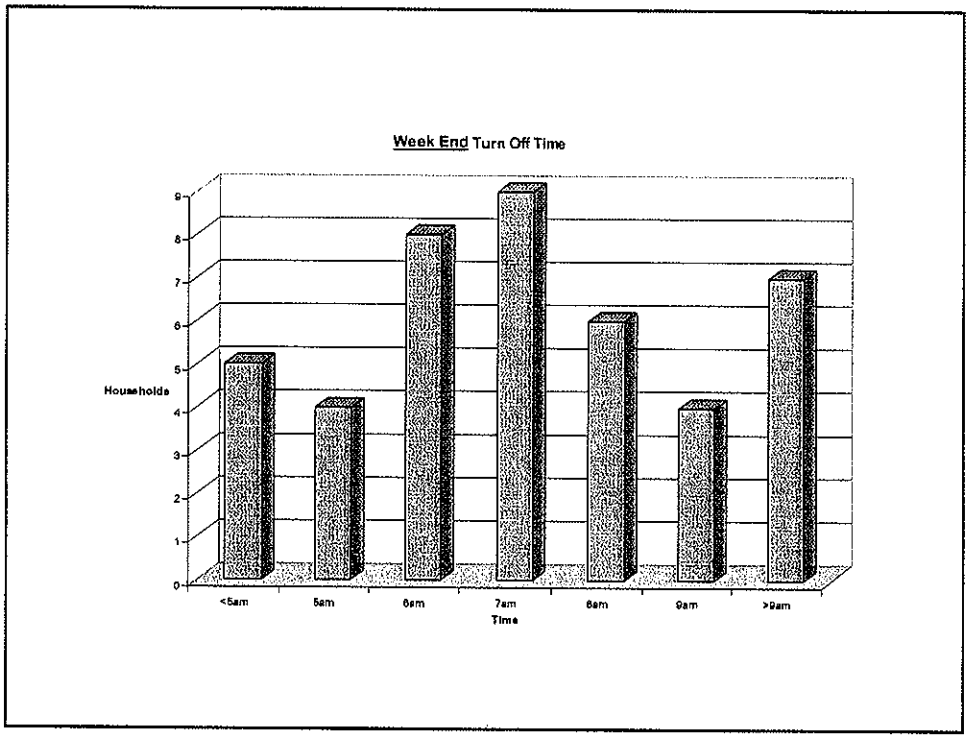
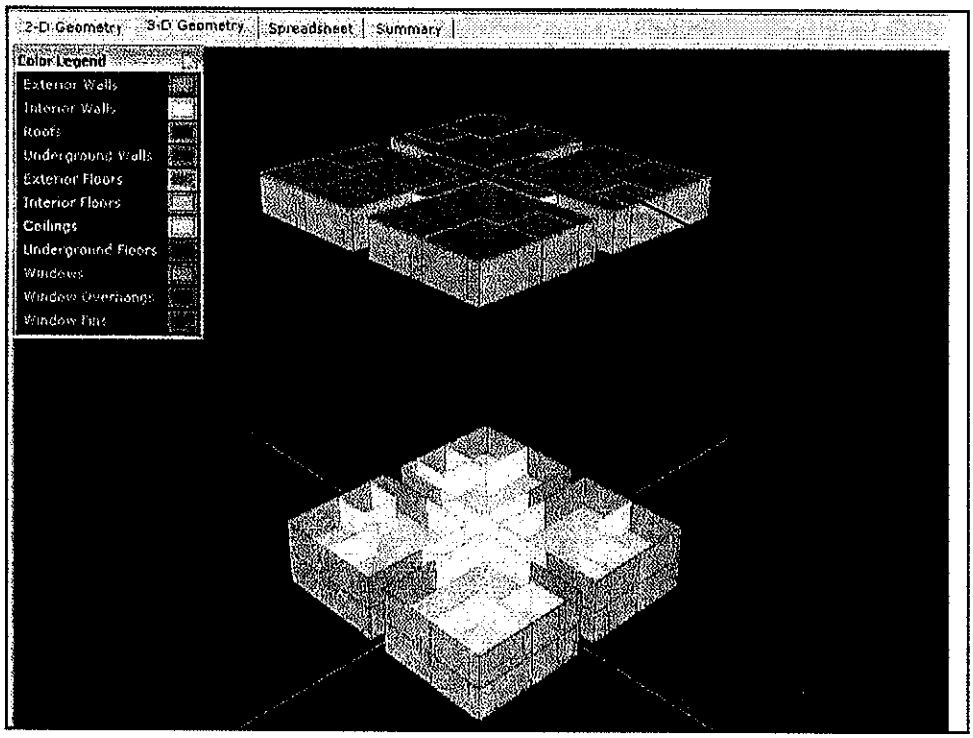
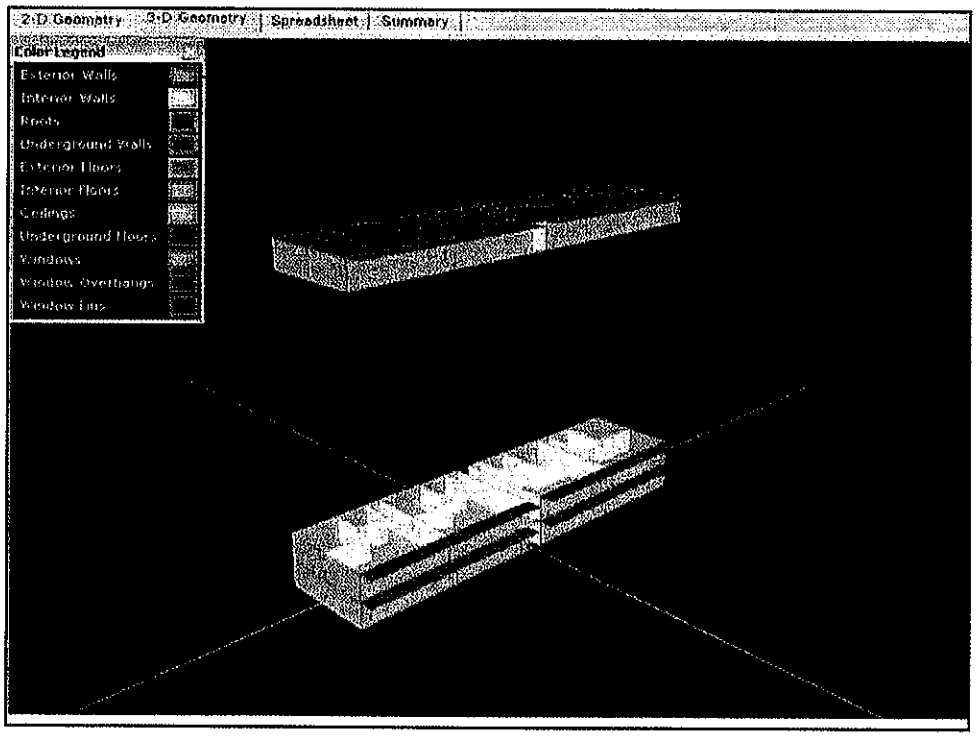
Time



HDB Building Description

System type	Split Unit, rated 7000 Btu/hr to 22,000 Btu/hr per household
Cooling setpoint	24 °C Weekdays (Operation) 22:00-07:00 Weekends (Operation) 22:00-08:00 Rest set point is 37 °C
COP	2.5
Number of occupants in an apartment	A family of 4
Air-conditioned area	Bedrooms, living and dining
Building	12 storeys 4 x 144 m^2
Windows	Opened/Closed when A/C is off Closed when A/C is on


2-D Geometry
3-D Geometry
Spreadsheet
Summary
Color Legend
Exterior Walls
Interior Walls
Roofs
Underground Walls
Exterior Floors
Interior Floors
Ceilings
Underground Floors
Windows
Window Overhangs
Window Fins


2-D Geometry
3-D Geometry
Spreadsheet
Summary
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Exterior Walls
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Underground Walls
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Ceilings
Underground Floors
Windows
Window Overhangs
Window Fins

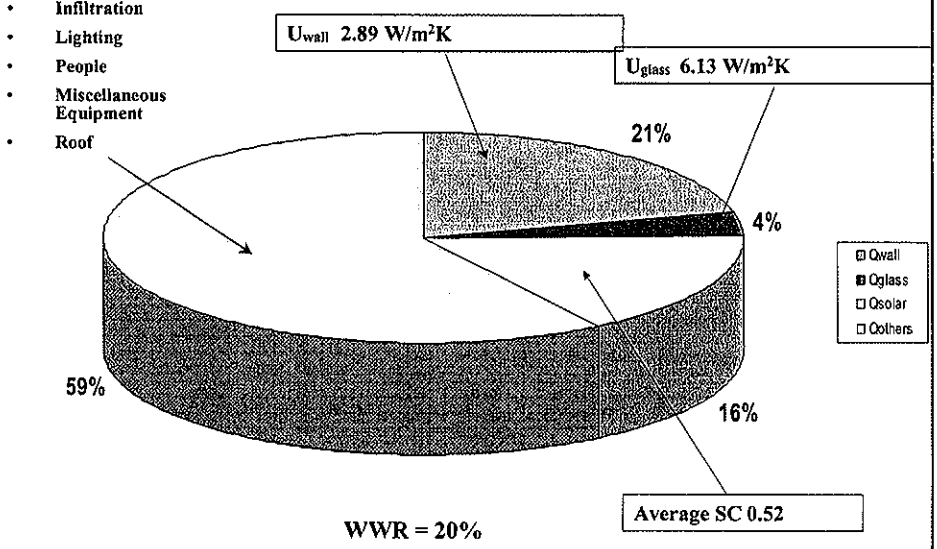
Envelope Parameters and Ranges

Parameters	Ranges
U_w (W/m^2 K)	1.2 – 3.73
U_f (W/m^2 K)	2.2 – 6.17
SC	0.2 – 0.9
WWR	20% to 51%
Wall Absorptance	0.45

HDB Loads Distribution

Includes loads due to:

- Infiltration
- Lighting
- People
- Miscellaneous Equipment
- Roof

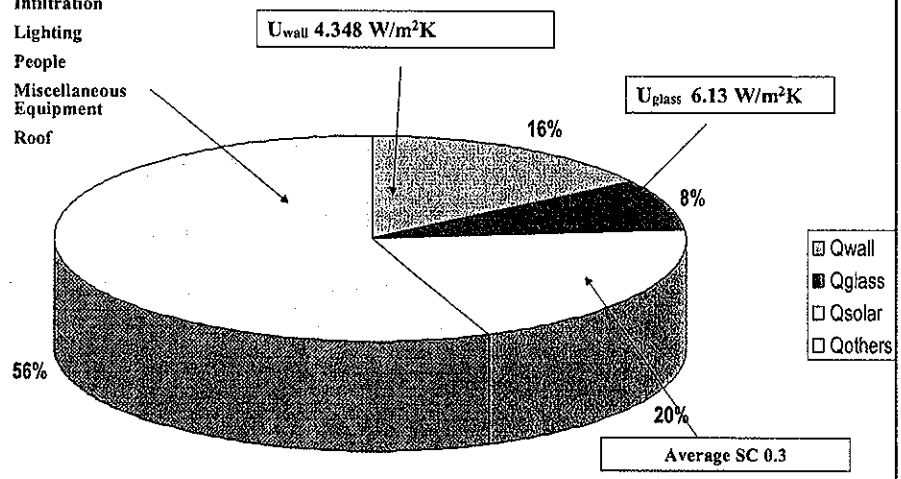


WWR = 20%

Private Residential Building Loads Distribution

Includes loads due to:

- Infiltration
- Lighting
- People
- Miscellaneous Equipment
- Roof



WWR = 51%

The Envelope Thermal Transfer Equation - ETTV

$$ETTV = \frac{(Aw \times Uw \times TDeq) + (Af \times Uf \times \Delta T) + (Af \times SC \times SF)}{Ao}$$

$$ETTV = TDeq(1 - WWR)Uw + \Delta T(WWR)Uf + SF(WWR)(CF)(SC)$$

Residential Envelope Transmittance Value - RETV

The RETV formula is given as follows:

$$RETV = 3.4(1 - WWR)U_w + 1.3(WWR)U_f + 58.6(WWR)(CF)(SC)$$

where

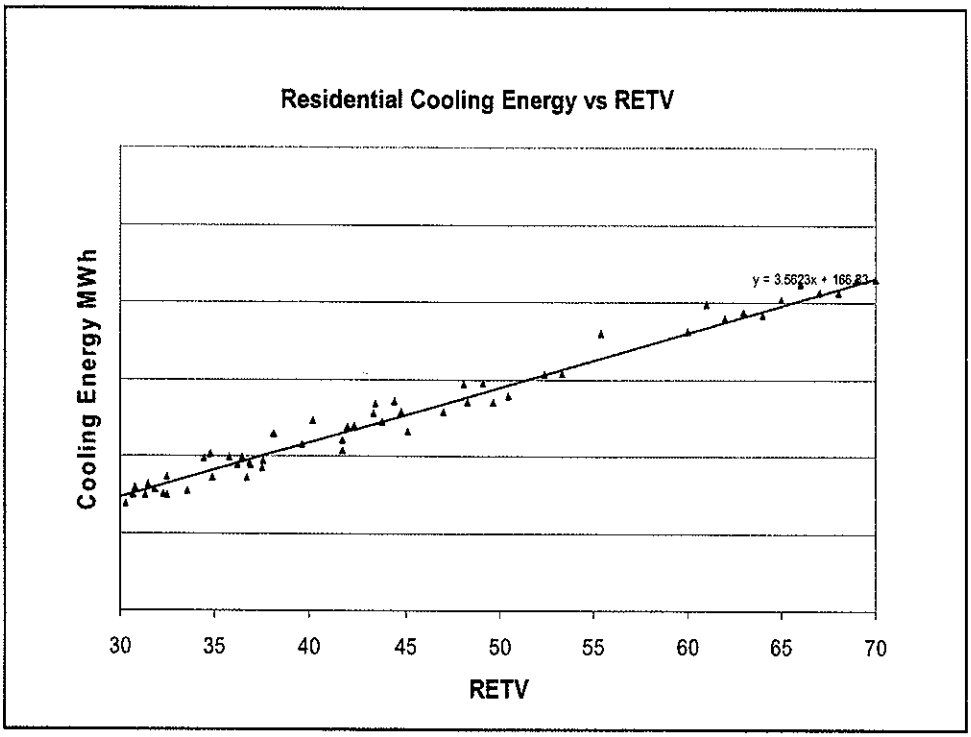
RETV	= residential envelope transmittance value (W/m²)
WWR	= window-to-wall ratio (fenestration area/gross area of exterior wall)
Uw	= thermal transmittance of opaque wall (W/m²K)
Uf	= thermal transmittance of fenestration (W/m²K)
CF	= correction factor for solar heat gain through fenestration
SC	= shading coefficients of fenestration

The whole building weighted average RETV is given as

$$RETV = \frac{3.4(A_{w1} \times U_{w1} + A_{w2} \times U_{w2} + \ldots + A_{wn} \times U_{wn})}{A_o} +$$

$$\frac{1.3(A_{f1} \times U_{f1} + A_{f2} \times U_{f2} + \ldots + A_{fn} \times U_{fn})}{A_o} +$$

$$\frac{58.6(A_{f1} \times SC_{f1} + A_{f2} \times SC_{f2} + \ldots + A_{fn} \times SC_{fn})(CF)}{A_o}$$



Deemed to have satisfied the RETV criterion

Should the building's WWR and SC fall within any one of the following cases, the building is deemed to have complied with the RETV criterion and, hence, is exempted from computing RETV

$$WWR_{bldg} < 0.3 \text{ and } SC_{facade} < 0.7$$
or
$$WWR_{bldg} < 0.4 \text{ and } SC_{facade} < 0.5$$
or
$$WWR_{bldg} < 0.5 \text{ and } SC_{facade} < 0.43$$

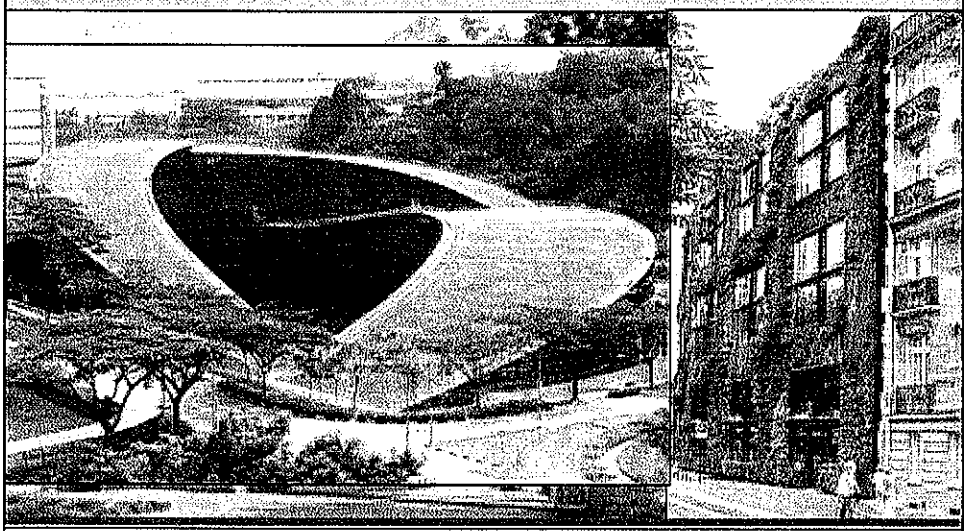
where

WWR = Window to wall ratio
SC = Shading coefficient of fenestration
= SC glass x SC shading device

On-going work on ETTV/RETV - considerations

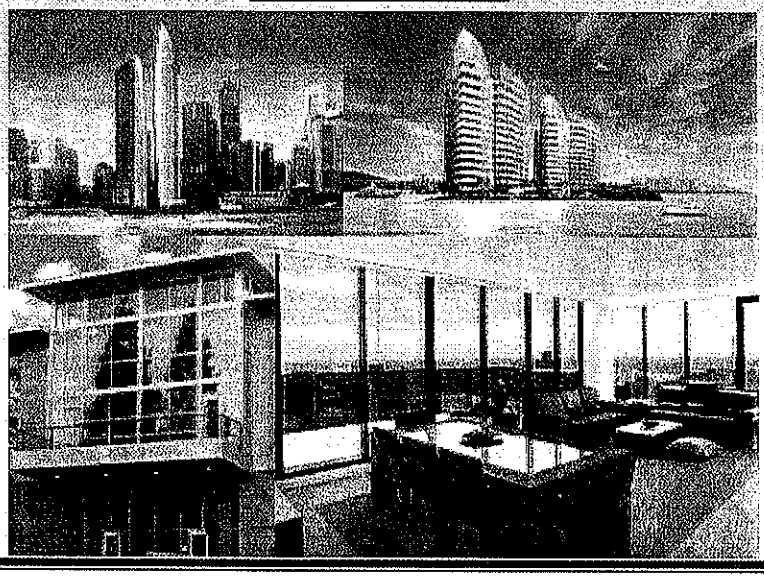
- Sensitivity and range
- Effect of building shape, aspect ratio and orientation
- Effect of wall U value and construction weight
- ETTV equation should relate to accurate estimation of cooling energy consumption
- Impact of solar component over the air-conditioning operating hours
- Effect of household a/c usage patterns
- Influence of a/c efficiency rating
- Facilitating household energy estimation

Green Roof / Wall

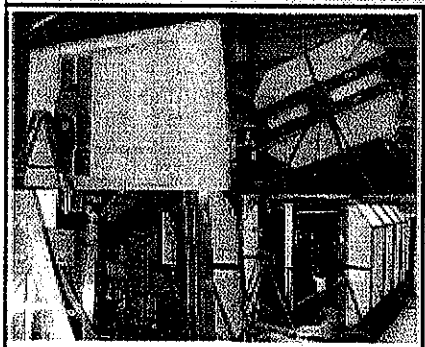


NUS

Windows



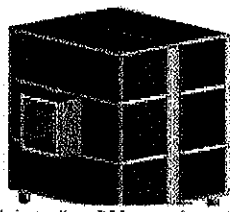
The Guarded Hot Box



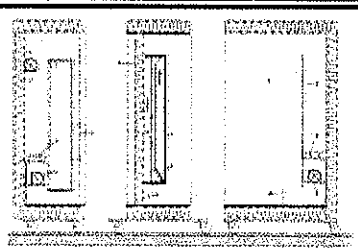
Oak Ridge National Laboratory



University of Otago

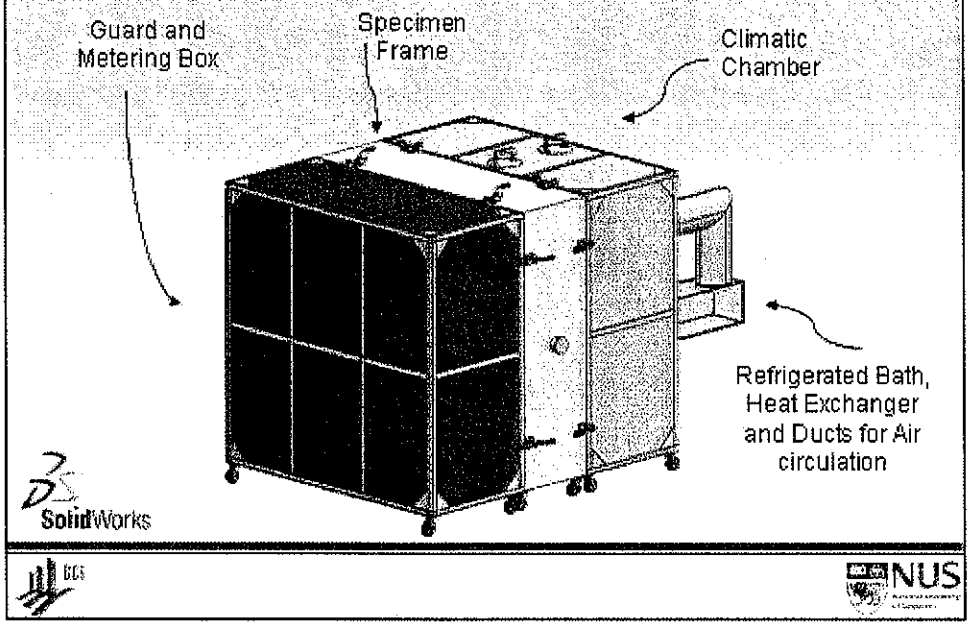


University of Massachusetts



Technical University of Denmark

NUS Guarded Hot Box



Approaches to reducing ETTV/RETV

- ***Glass shading coefficient***
- ***Window-to-Wall ratio***
- ***Wall absorptance***
- ***Wall resistance***
- ***U fenestration***
- ***Wall cladding***
- ***External shading devices***
- ***Solar film***

THANK YOU

for your attention

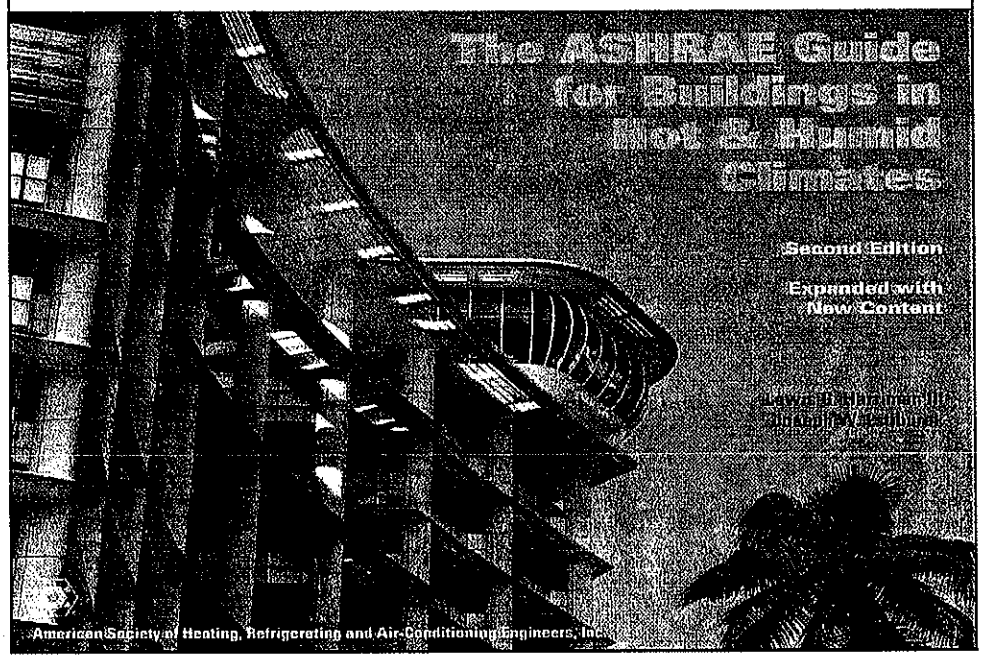
Design Guidance for New & Existing Buildings in Hot and *Humid* Climates

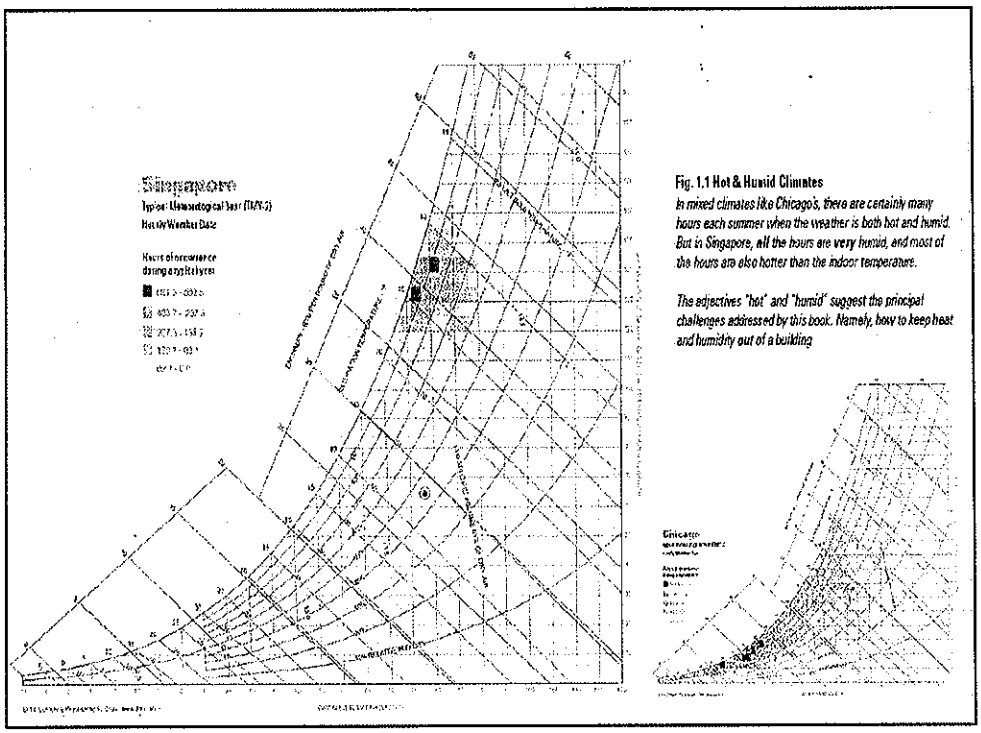
Terry E. Townsend, P.E., FASHRAE
March 6, 2009

Questions to Answer Today

1. What should owners, Architects, HVAC designers, contractors and building operators think about when wanting a "sustainable building in a hot and humid climate?
2. What are the *critical issues* for being able to achieve excellence and long-term sustainability in facilities in a hot and humid climate?
3. What suggestions and guidance can ASHRAE provide to assist professionals to make better decisions about buildings?

New ASHRAE Publication





Format of Information

- **Common Issues in Hot & Humid Climates**

1. Introduction
2. Improving Thermal Comfort
3. Managing Ventilation
4. Reducing Energy Consumption
5. Avoiding Bugs, Mold & Rot
6. Improving Sustainability

Format of Information

- **The Building Enclosure**

7. Elements of a Perfect Wall
8. Keeping Water Out
9. Keeping Heat Out
10. Lessons from Storms

- **HVAC Design**

11. Dehumidification Loads
12. Cooling Loads
13. Dehumidification Systems
14. Cooling Systems
15. Ventilation Air System
16. Airtight HVAC System

Format of Information

- **Construction**

17. Construction

Appendix

* Dehumidification Design Factors
* Dew Point and Humidity Ratio Tables
* Psychrometric Charts

Lstiburek's Guide to Solving IAQ Problems

1. If it smells – it probably is bad
2. Not everything that is bad smells
3. Vent combustion sources
4. Construct a tight enclosure
5. Keep things from getting wet, hot or exposed to UV – isolate those that do from occupants
6. Control indoor humidity
7. Maintain "stinky places/things" (e.g. bathrooms, kitchens, elevator shafts & trash chutes) under a negative pressure

Lstiburek's Guide to Solving IAQ Problems

Continued

8. Keep things & spaces clean
9. Filter for people not just equipment
10. Ventilate for people, not just the building→(source control ventilation will handle the building)
11. Don't do stupid things in your building!

Improving Thermal Comfort

- **KEY SUGGESTIONS**

1. Design and construct the enclosure to be well insulated; keep solar heat and glare out through exterior shading of windows; reduce the size of all windows to a minimum (especially west facing).
2. Keep indoor temperature above 23.3 Deg.C and below 26.1 Deg.C while keeping the indoor dew point below 12.8 Deg.C.
3. Use ***more*** rather than fewer air handling systems (to closer match different/dynamic changing internal heat loads) →makes systems simpler, less costly to operate and more reliable.

By Lew Harriman



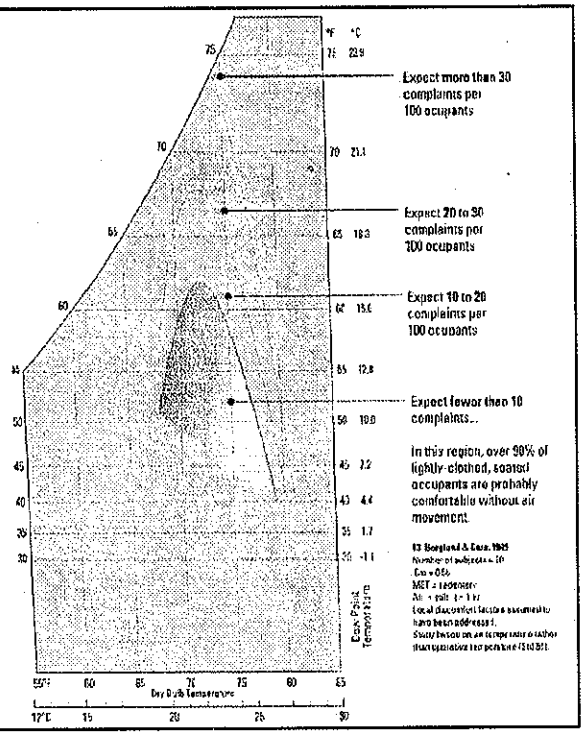


Figure 2.1 Reducing thermal comfort complaints

Unlike structural and electrical engineering in which codes demand that design capacity be over 100% of expected loads, standard HVAC design practice assumes that only 80% of occupants will be thermally satisfied.

Improving beyond 80% probable satisfaction requires a better-than-minimum building enclosure and a more-than-usually-effective HVAC system. Interestingly, these improvements also reduce operating costs and help owners meet energy reduction targets.

Improving Thermal Comfort

- **Foundation of Comfort**

1. Shaded Windows = Improved Comfort & Reduced Glare
   * Less radiant heat passed through
   * Less glare = reduced eyestrain & facial muscle tension (improved perception of comfort)
   * Reduced peak cooling loads
2. Less East & West Glass = Better Comfort
   * Direct solar loads accumulate
   * Reduction of size, complexity and cost of operating the cooling system

Improving Thermal Comfort

- **Foundation of Comfort**

3. Comfort is Unlikely in 'Glass Boxes'
   * Glass conducts 5X more solar heat than a well-insulated solid wall
   * Higher probability of comfort complaints
   * Higher costs for mechanical system construction, operation and maintenance
4. Tight, Well-constructed Exterior Walls Avoid Sharp Changes in Interior Conditions
   * Greater internal temperature stability and uniformity
   * Reduces air infiltration & mold potential

Improving Thermal Comfort

- **Foundation of Comfort**

5. High Ceilings and Personal Fans Allow Low-cost Comfort
   * Achieve temperature stratification
   * Ideal ceiling height = 3.65 m
   * Ideal fan blade height = 3.0 m
6. One Fan per Floor = Better Comfort + Simpler Systems
   * Similar occupancy schedules & heat loads
   * Reduced energy cost compared to moving large amounts of air to provide comfort to multiple areas of building.

Improving Thermal Comfort

- **HVAC Systems**

1. Design HVAC Systems for Real-Clothing Preferences
   * Indoor design conditions = 26 Deg.C (versus 24 Deg.C) and dew point below 12.8 Deg.C
   * Have several stages of cooling capacity or modulation capability
   * Consider noise and chilling effect of supply air stream
2. Dry Ventilation Air Helps Avoid Temperature Swings
   * Dedicated Outside Air System (DOAS)
   * Cooling equipment → Sensible Loads

Improving Thermal Comfort

- **HVAC Systems**

3. Constantly-cold Coils Can Also Dry Air Effectively
   * Cooling coil or desiccant dehumidifier controlled with a humidistat vs thermostat
   * For a VAV system w/constantly-cold coil
     + Supply air dew point is low enough
     + Coil stays cold while dew point is above the specified indoor dew point
     + Re-heat comes from waste heat (refrig. Condensers or heat recovery wheel)
4. Drier Air Expands the Comfort Range in Mixed Uses

"It's not the heat...it's the humidity"

Improving Thermal Comfort

- **HVAC Systems**

5. Capacity Modulation Avoids Sharp Changes – Stop Overshooting Desired Conditions
   * Stop oversizing cooling equipment – size at or just under "peak load"
   * Specify variable-speed motors or multiple stages of equipment capacity
   * Split cooling load between several pieces of equipment (vs) one large piece/component
   * Ensure that a component in system responds to a humidistat control of dew point conditions

Improving Thermal Comfort

- **HVAC Systems**

6. Higher Velocity VAV Diffusers Avoid "Cold Air-Dumping" (use in non-sleeping areas)
   * Low velocities cause 'cold air columns'
   * Benefit to having "white noise" generation

Other Resources

- ASHRAE Standard 55-2007
- 2005 ASHRAE Fundamentals Chapter 8
- ASHRAE Humidity Control Design Guide

Managing Ventilation Air

- **Appropriate Amounts of O/A Must Reach the Breathing Zone**
- **Ventilation Air Must be Clean, Dry & Free from Pollutants**
- **KEY SUGGESTIONS**

1. Size Ventilation System with ASHRAE 62.1-2007 and Assistance of 62.1 User's Manual
2. Dry All Ventilation Air to 12.8 Deg.C (when O/A is above that level)
3. Install a Minimum MERV-8 Filter on O/A Stream
4. Modulate Amounts of O/A with Controls
5. Recover Waste Energy

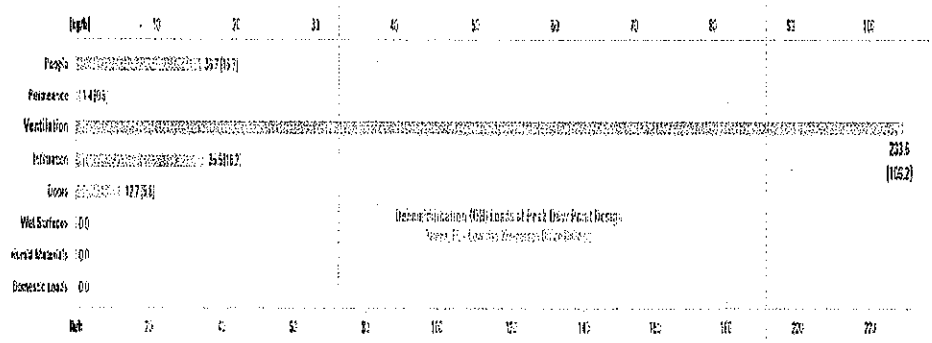
Most Buildings are Over-ventilated

Measured Ventilation Air Flow - 510 Office Buildings

ASHRAE Standard Requirement (At the time of measurement)
Excess ventilation

	Per Person cfm/person [l/s/person]	Per Unit Floor Area cfm/ft2 [l/s.m2]	Air Changes Per Hour
Mean (Average)	**117** [55]	0.4 [2.04]	2.00
Median (Most Common)	**63** [30]	0.2 [1.03]	0.98
Standard Deviation	**158** [74]	0.5 [2.54]	2.45
Std 62.1-1989	**20 [9]**	**0.07 [0.36]**	**0.34**

Ventilation is Mostly Dehumidification



Managing Ventilation Air

- **Dehumidification and Air Cleaning**

1. DOAS – Load is Both High & Continuous All Year Long
2. W/O DOAS – Need to Install Dehumidification Equipment in System Controlled by a Humidistat
3. Particle Filtration
   * MERV = Minimum Efficiency Reporting Values
     MERV-4 <20% (3 – 10 microns)
     MERV-8 >70%
     MERV-11 >85%
     MERV-17 >99%

Managing Ventilation Air

- **Dehumidification and Air Cleaning**

4. Filtering Ozone
   * Ozone – Principle ingredient of smog
   * Use of Air Cleaners or Carbon Filters (outdoor concentration ≥0.107 ppm)

- **How Much Air & Where?**

1. Ventilation Rates = Occupancy + Area Factors
   * Air dilution of occupants' contaminants (e.g. 10 CFM per person)
   * Flush of buildings' generated contaminants (e.g. 0.12 CFM per sq. meter of area)

Managing Ventilation Air

- **How Much Air & Where?**

2. Recommended Rates are Minimums, NOT Maximums
3. Rates Assume Odors will be Perceived by Newcomers (6 minutes ~ 80% are 'adapted')
4. Building Must Exclude Water or Tolerate It
5. Access for HVAC Maintenance is now Required!
6. 12.8 Deg.C Dew Point Better than 65% RH as an Upper Limit
7. Commissioning, Documentation & Maintenance are Required!

Managing Ventilation Air

- **Ventilation Maintenance Aspects**

1. Replace Outdoor Air Filters Every Month
2. Observe Position & Operation of O/A Dampers Every Three Months
3. Recalibrate O/A Sensors Every Six Months
   * Humidity sensors can drift ± 5% RH to ± 15% RH in a manner of weeks
4. Clean Coils, Drain Pans and Damp Duct Interiors Once a Year

Don't ventilate unoccupied buildings – ventilation air is for people and it should be cleaned and dried by systems that are properly operating & maintained.

Energy Consumption Reduction

- **KEY POINTS**

1. Minimize exterior glazing, install low-e glass and shade it
2. Avoid west facing glazing
3. Design glazing to allow daylighting of perimeter
4. Exterior enclosure must be air tight
5. Commission building and systems
6. Seal all ducts and plenums
7. Match ventilation to building's occupancy
8. Capture & re-use heat from clg. eqmt. & exh. air
9. Control indoor dew point temperature
10. Provide ongoing-commissioning of systems

Energy Consumption Reduction

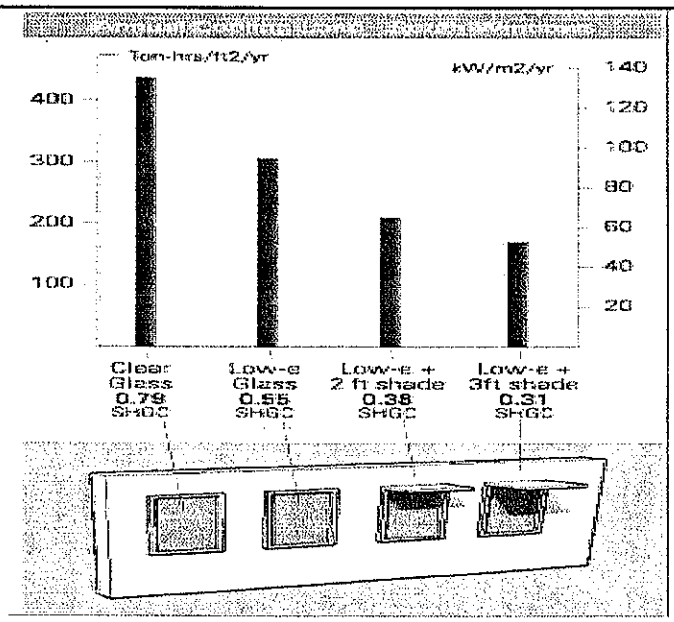
- **Suggestions for Reducing Energy Use**

1. Reduce Cooling Load from Windows
   * 72% of load from heat through windows + interior heat generated
   * Keep WWR between 20% and 40%
2. Avoid West Facing Glass
   * Allows 2 – 2.7 X more heat than South Glass
3. Use Daylighting
   * Every lighting watt saved = 1.2 watt reduction in power consumption
   * Place wide daylighting windows high on walls
     + Light penetrates 1.5 X window height

Energy Consumption Reduction

- **Suggestions for Reducing Energy Use**

3. Use Daylighting continued
   * Use light shelves underneath windows
     + Increase penetration 30% (2X height)
     + Act as shades for view windows
     + Help divert rainwater/reduce intrusion
   * Add exterior sun shades above windows
     + Provides SHGC = 0.31
   * Windows should pass > 60% of visible light w/o passing sun's radiant heat
     + Visible Light Trans (T_{vis}) = 0.60
     + Clear glass T_{vis} = 0.80; Low-e T_{vis} = 0.71



More specifically, to achieve the most significant reduction in lighting power and cooling load, the building will need:

1. Wide daylighting windows placed high on the walls, near the ceiling of each floor.
2. Light shelves projecting outwards from the exterior wall underneath those windows.
3. Exterior sun shades above those windows.
4. Glazing in those windows which passes a significant portion of visible light - ideally more than 60%, while still keeping out most of the sun's radiant heat.

Fig. 4.9 Windows for daylighting

Conventional windows set at eye level do not transmit enough daylighting to allow a reduction in lighting power. The key exterior architectural elements for success are shown in this photo.[6] Also, interior surfaces need to reflect rather than to absorb the incoming light.



Energy Consumption Reduction

- **Suggestions for Reducing Energy Use**

3. Use Daylighting continued
   * Light-colored ceiling and wall finishes
     + Finishes – reflective and diffusive
     + Avoid glare generating finishes (mirrors)
   * Automatic lighting controls – dim or modulate lights
4. Build an Air-tight Exterior Enclosure
5. Commission New Building Systems
   * ASHRAE Guideline 0 – The Commissioning Process
   * ASHRAE Guideline 1 – The HVAC Commissioning

Energy Consumption Reduction

- **Suggestions for Reducing Energy Use**

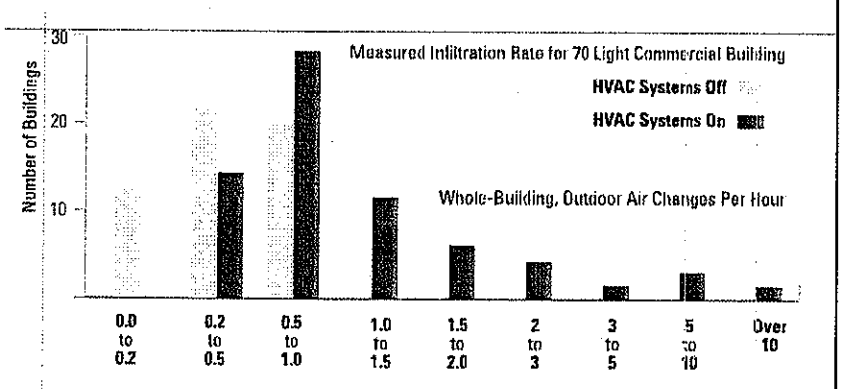
5. Commission New Building Systems continued
   * ASHRAE Guideline 1 – The HVAC Commissioning Process
     + Commissioning Authority
     + Commissioning Plan
     + Functional Testing
     + Documentation
     + Training Requirements of O&M Staff
   * More than "factory startup" and TAB

Energy Consumption Reduction

- **Suggestions for Reducing Energy Use**

6. Seal All Duct Connections, Air Handlers and Plenums
   * Leakage = 25 – 30% of annual operating cost
7. Reduce Ventilation Air when Occupants Leave
   * DOAS - 2-position or modulating dampers
     - BAS time-of-day schedules
     - CO_2 Sensors
   * Single-zone – 2-position or motorized O/A damper
     - BAS or CO_2 Control of damper
   * Multiple-zone – Motorized damper/zone
     - BAS or CO_2 Control of damper

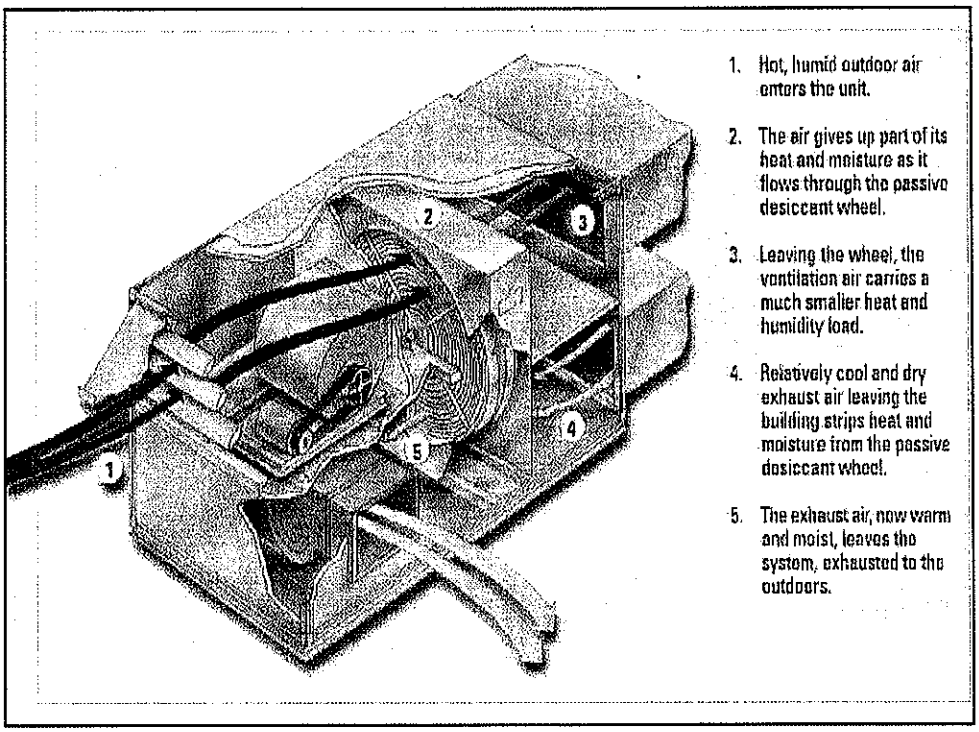
Importance of Air-tight Air Systems



Energy Consumption Reduction

- **Suggestions for Reducing Energy Use**

8. Recover Waste Energy (Eqmt. or Exhaust Air)
   * Energy Recovery Ventilators (ERVs)
   * Condenser heat →regenerate desiccant dehumidification system or reheat air
     →preheat domestic hot water
9. Lower Dew Point & Raise Thermostat Setting
   * 24 →25.6 Deg.C = 20% Savings
   * Maximum Dew Point Temp = 12.8 Deg.C
   * Maintain proper air velocity
   * Use independent dehumidification equipment controlled by a humidistat



Energy Consumption Reduction

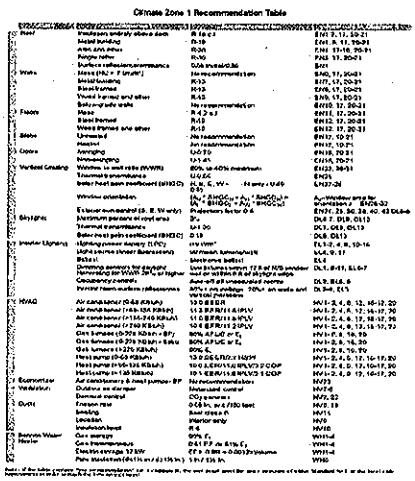
- **Suggestions for Reducing Energy Use**

10. Implement "Ongoing Commissioning"
11. ASHRAE Advanced Energy Design Guides
    * Prescriptive guidance for achieving 30% & 50% beyond ASHRAE Standard 90.1 towards Net-Zero
    * Small Offices
    * Small Retail
    * Warehouses
    * K-12 Schools
    * Currently under development –
      + Highway Lodging
      + Healthcare Facilities

Energy Consumption Reduction

- **ASHRAE Advanced Energy Design Guides** continued

Small Office

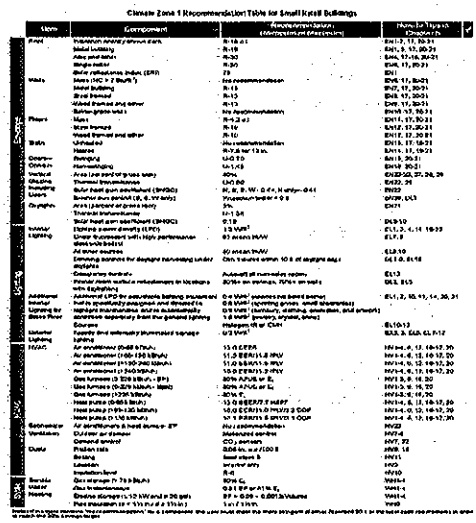


Climate Zone 1 Recommendation Table

Energy Consumption Reduction

- **ASHRAE Advanced Energy Design Guides** continued

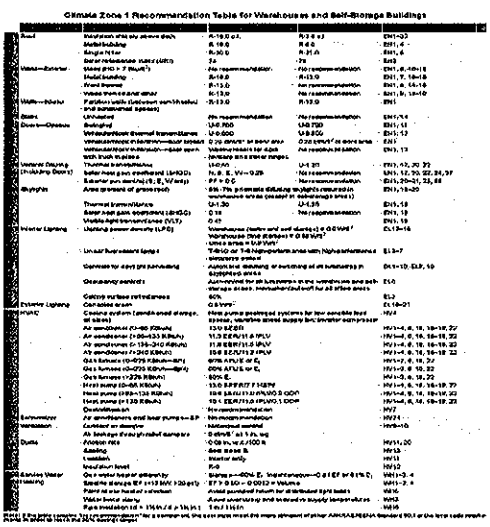
Small Retail



Energy Consumption Reduction

- **ASHRAE Advanced Energy Design Guides** continued

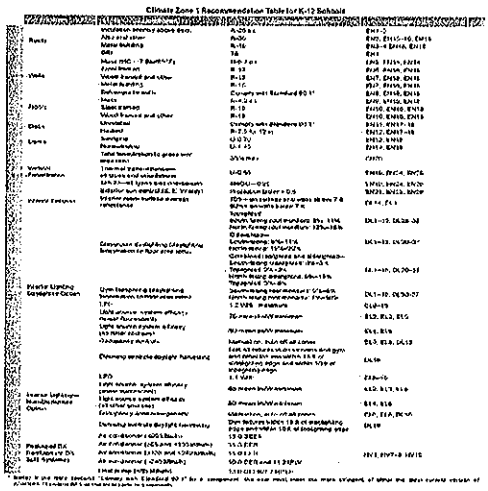
Warehouses



Energy Consumption Reduction

- **ASHRAE Advanced Energy Design Guides** continued

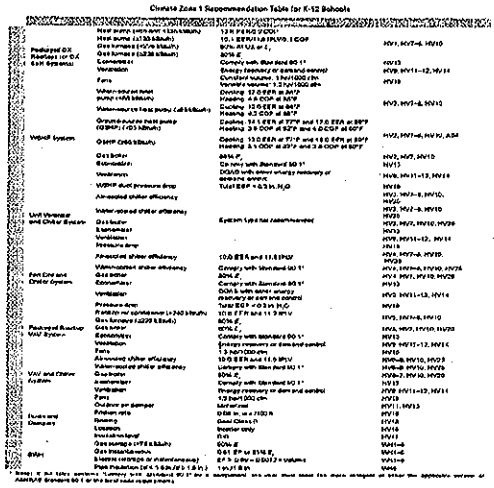
K-12 Schools



Energy Consumption Reduction

- **ASHRAE Advanced Energy Design Guides** continued

K-12 Schools



Energy Consumption Reduction

- **ASHRAE Advanced Energy Efficiency Guides for Existing Buildings**

  Publ. # Target Audience

  * 1st - Business owners and decision-makers
  * 2nd - Operation and maintenance personnel
  * 3rd - Technicians/designers

  (4 - Prescriptive Options)
- Achieve EUI of comparable facilities (~30% reduction)
- Achieve minimum 15% increase over comparable facilities' EUIs
- Achieve 90.1-level EUI for type of facility
- Achieve 30% increase in energy efficiency over 90.1 requirements

Energy Consumption Reduction

- **ASHRAE Advanced Energy Efficiency Guides for Existing Buildings** Continued
- Energy Conservation Measures/Opportunities
  * LED Exist Sign Lighting (25 yr life)
  * Occupancy Sensors (Passive + Ultrasonic)
    + Offices = 25 – 50% Ltg. Savings
    + Rest Rooms = 30 – 75% Ltg. Savings
    + Storage Areas = 45 – 65% Ltg. Savings
  * High-Bay Lighting – T-5 H/O
    + 50% Savings over Metal Halide
  * T-12 → T-8 w/Electronic Ballasts
    + 30 – 40% Energy Savings

Energy Consumption Reduction

- **ASHRAE Advanced Energy Efficiency Guides for Existing Buildings** Continued
- Energy Conservation Measures/Opportunities
  - * Incandescent →CFL
    - + 75 – 80% Energy Savings & 5 – 15 X Life
  - * Daylighting (w/continuous dimming ballasts)
    - + >50% Energy Savings
  - * Energy Management System
    - + Automatic Temperature Adjustments
    - + Control of HVAC, Lighting & DWH Systems
  - * Drinking Fountain Timer
    - + Operating Cost/yr ~ Small Refrigerator

Energy Consumption Reduction

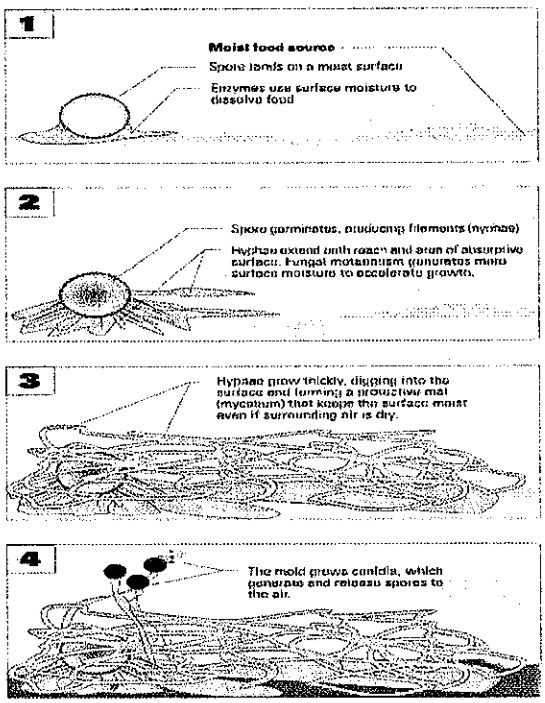
- **ASHRAE Advanced Energy Efficiency Guides for Existing Buildings** Continued
- Energy Conservation Measures/Opportunities
  - * Upgrade Cold Drink Machines
    - + Power Controller Activated by Occupancy Sensor
    - + Payback = 1 – 2 years
  - * Low Flush Toilets & Low Flow Faucets
    - + 50 – 75% reduction in water consumptions
  - * Weather Stripping, Caulking & Sealing of Building Envelope
  - * Cogged V-Belts – HVAC Motors Incr. Eff. = 8%

Avoid Mold & Water Intrusion

- **KEY SUGGESTIONS**

1. Keep rain off exterior walls and away from foundations
2. Keep rain from leaking through joints in exterior cladding and around windows & doors
3. Keep rain from wetting sheathing inside exterior wall
4. Ensure exterior walls "dry to the interior"
5. Keep indoor air dry at all times
6. Seal all ducts, air plenums and connections to air handlers
7. Measure the moisture content of building's materials

Fig. 5.3 Mold growth cycle
Mold cannot grow until the moisture content of the food source is high enough for the mold's surface enzymes to dissolve its food. Keeping materials dry makes sure that the growth cycle can never begin.



Avoid Mold & Water Intrusion

- **Suggestions for the HVAC Designer**
  - * Keep indoor dew point low enough to limit condensation and absorption (maximum = 12.8 Deg.C; Target = 11 Deg.C)
  - * Control and monitor humidity based on dew point, not RH
  - * Require air-tight duct connections (25 – 35% savings in operating cost)
  - * Specify economizers which do not flood the building with humid air (outdoor air dew point **must be** below the indoor dew point)

Avoid Mold & Water Intrusion

- **Operations & Maintenance Suggestions**
  - * Replace outdoor air filters to avoid humid air infiltration (clogged filters → negative press. bldg.)
  - * Replace filters that protect cooling coils & ductwork
  - * Run the building "dry" when unoccupied (ventilation air can produce moisture 'build up')
  - * Clean out condensate drain lines to avoid overflows and bacteria in drain pans
  - * Locate any standing water → drain it or dry it
  - * Keep moisture content below 14% WME (Wood Moisture Equivalent)

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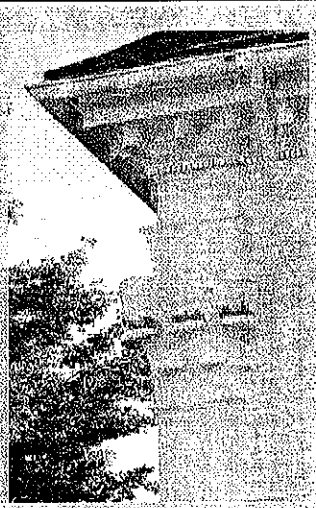
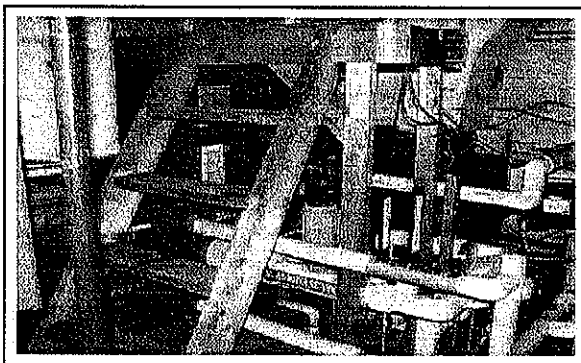
Sustained for more than 2,000 years
Roof overhangs have protected the structure and the sculptural detail on this Roman institutional building for 2,000 years—and counting. Overhangs keep rain from hitting and flowing down the walls. They greatly improve the durability—and therefore the sustainability—of any building.



Sustained for more than 200 years
Roof overhangs have protected the cladding and the sculptural detail on this North American Colonial building for 200 years—and counting. The material is wood, not stone. Still, the overhangs have protected the exterior walls for more than 200 years. The photo provides compelling evidence of the durability (sustainability) improvement made possible by roof overhangs.



Rebuilt after fewer than 20 years
No roof overhangs on this missing home. The architect's fashion preferences did not favor roof overhangs and gutters. Roof overhangs would have reduced the wall's rain contact volume by more than 50%. Less water *contact* would have reduced the leakage *volume*, improving the sustainability of its thermally excellent (but moisture-fragile) exterior insulation and finish system.



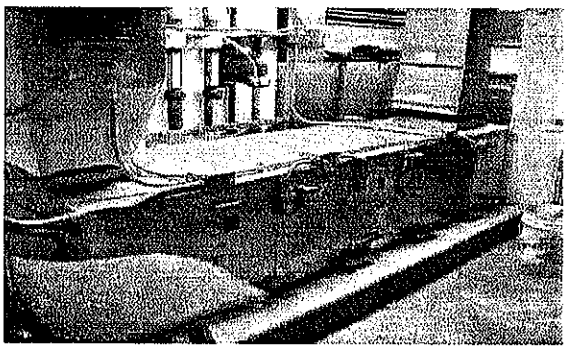


Fig. 6.5 Maintenance access

If maintenance and system adjustments require heroics from the operations staff, they won't happen often. Absurdly obstructed access in grossly-undersized mechanical rooms, like the system in the upper photo, pretty much guarantees the system will go out of adjustment, leading to constant discomfort and needless energy waste.

The lower photo shows a mechanical room large enough to fit the equipment, its duct work and utility connections—and also the service technicians, their tools and supplies. No ladder is required for either inspection or adjustments. Given this adequate space, the HVAC designer was able to locate the gauges and controls at eye level, in plain view. No comfort complaints and no energy waste from this system.

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- Cases studies featured provide performance data, verifying actual sustainability performance
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