

DESIGN AND ANALYSIS OF NET ZERO ENERGY BUILDINGS IN WARM AND HUMID CLIMATE



Presented By,

ANTONY JOSEPH

CONTENTS

- ✓ Framework for net-zero energy concept
- ✓ What is a Net Zero Energy Building?
- ✓ Standard form vs Stacked planes
- ✓ LEED Guidelines for Building materials
- ✓ Renewable Energy
- ✓ Light
- ✓ Thermal Comfort
- ✓ ZNE is driven by good design, High Performance Systems and Shading
- ✓ Challenge the client brief, address contradictions
- ✓ Implement adaptive comfort approach
- ✓ Thermal zoning of Design building, overview
- ✓ What is building energy modeling?
- ✓ Comfort
 - Thermal comfort comparison with online tool
 - Boundary conditions for performance evaluation with thermal simulation
 - Building performance verification of comfort and energy with dynamical simulation
- ✓ Facade Day light and glare
- ✓ Net Energy story

CONTENTS(cont.)

- Net Zero Energy story
- ASHRAE versus Indian Model for Adaptive Comfort
- ✓ Daylighting Analysis Areas
- ✓ BIM Model for QUantity Estimates
- ✓ BIM System Integration
- ✓ Building Energy Monitoring System
- ✓ What energy modeling can do?
- Code compliance analysis
- Whole building design
- The energy modeling process
- Modeling data requirements
- ✓ eQUEST overview
- ✓ eQUEST capabilities
- Internal load tab
- Water side HVAC tab
- Air Side HVAC tab
- ✓ References

What is a Net Zero Energy Building?

"A building that produces and exports
at least as much renewable energy on site as it
imports and uses from emission-producing energy sources
annually."

Source: U.S. Department of Energy

Consumption

Building Size
Energy Efficiency

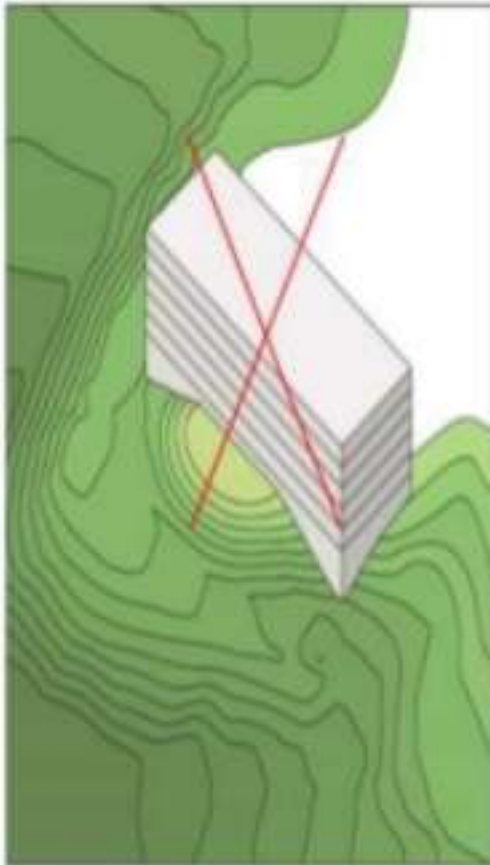
Generation

On Site Renewable Energy
Renewable Energy Credits



The traditional sealed envelope
is not appropriate

REJECTION OF STANDARD FORM

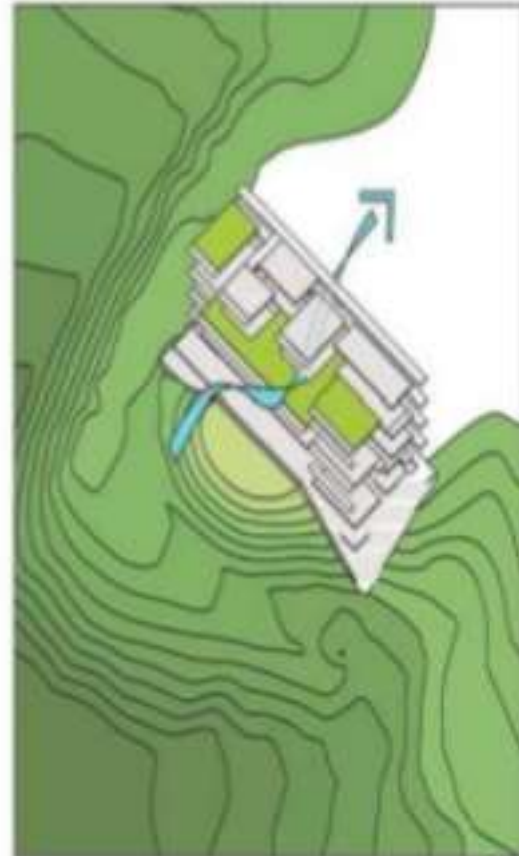


The standard architectural form with emphasis on
enclosure and architecture as object

Therefore our proposal is based on
the idea of stacked planes

Key Design Concepts

I. STACKED PLANES



The proposal starts not with the definition of enclosed spaces but with a series
of raised horizontal planes. These planes are loosely stacked and configured to
facilitate a range of different activities. Each plane is extended horizontally to
provide shade for the space below.

LEED Guidelines for Building materials

Architectural Applications	VOC Limit(g/L less water)	Special Application	VOC Limit(g/L less water)
Indoor Carpet adhesives	50	PVC welding	510
Carpet pad Adhesives	50	CPVC welding	490
Wood flooring adhesives	100	ABS welding	325
Rubber floor adhesives	60	Plastic cement welding	250
Subfloor adhesives	50	Adhesive primer for plastic	550
Ceramic tile adhesives	65	Contact adhesive	80
VCT and asphalt adhesives	50	Special purpose contact adhesive	250
Drywall and panel adhesives	50	Structural wood member adhesive	140
Cove base adhesives	50	Sheet applied rubber lining adhesive	850
Multipurpose construction adhesives	70	Top and trim adhesives	250
Structural glazing adhesives	100		

SEALANT PRIMERS	VOC Limit(g/L less water)
Architectural, non-porous	250
Architectural, porous	775
Other	750

SUBSTRATE Applications	VOC Limit(g/L less water)	Sealants	VOC Limit(g/L less water)
Metal to metal	30	Architectural	250
Plastic foams	50	Non-membrane roof	300
Porous material(excep wood)	50	Roadway	250
Wood	30	Single Ply roof membrane	450
Fibre glass	80	Other	420

Extensive roof-top PV cells provide electricity for the building

Zero Energy Strategy

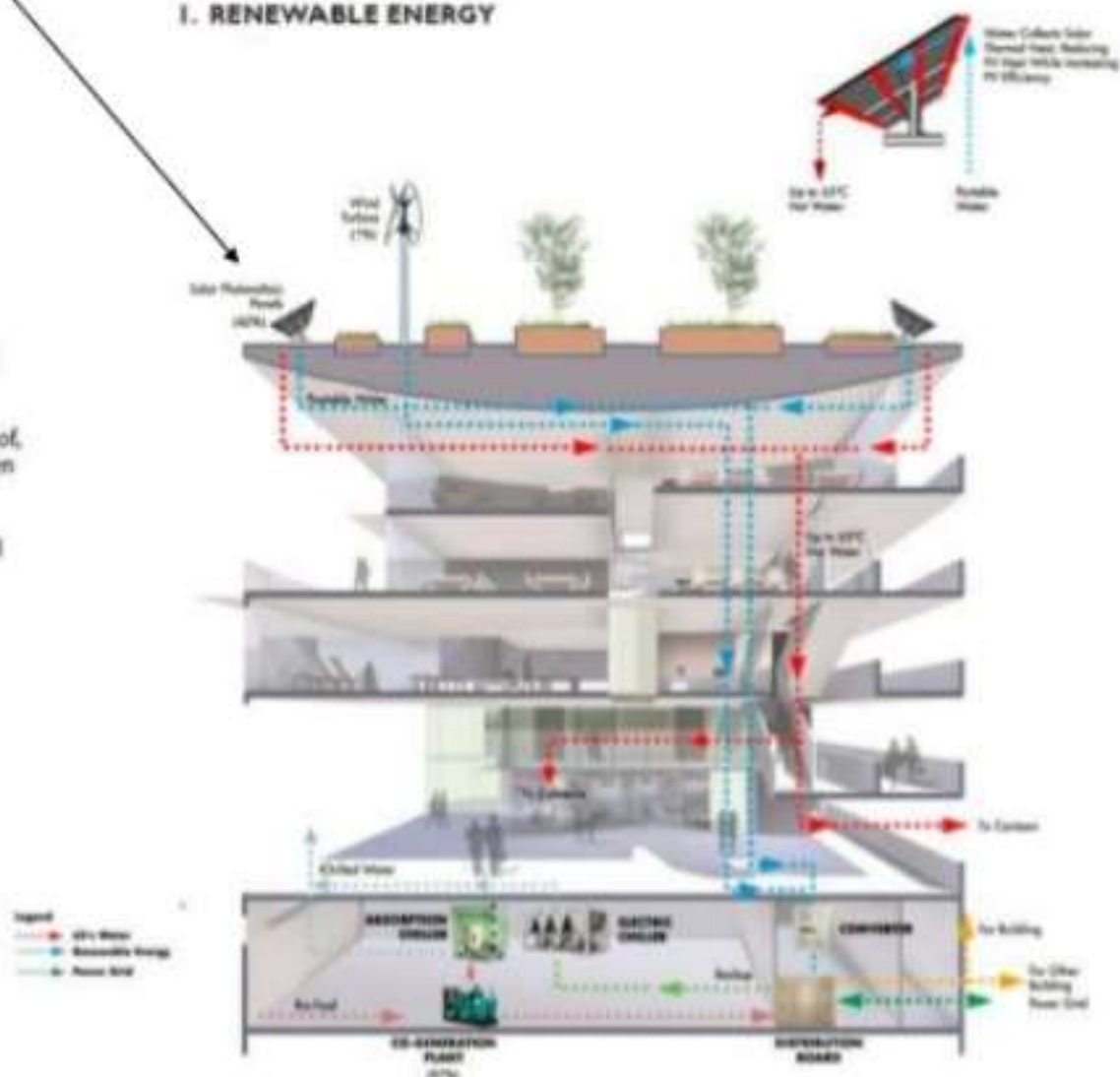
I. RENEWABLE ENERGY

As a tropical building, two passive 'rules' were set for the envelope building :

- Allow good quality light into the interior while controlling heat and glare.
- Allow good natural ventilation while keeping the rain and pests out

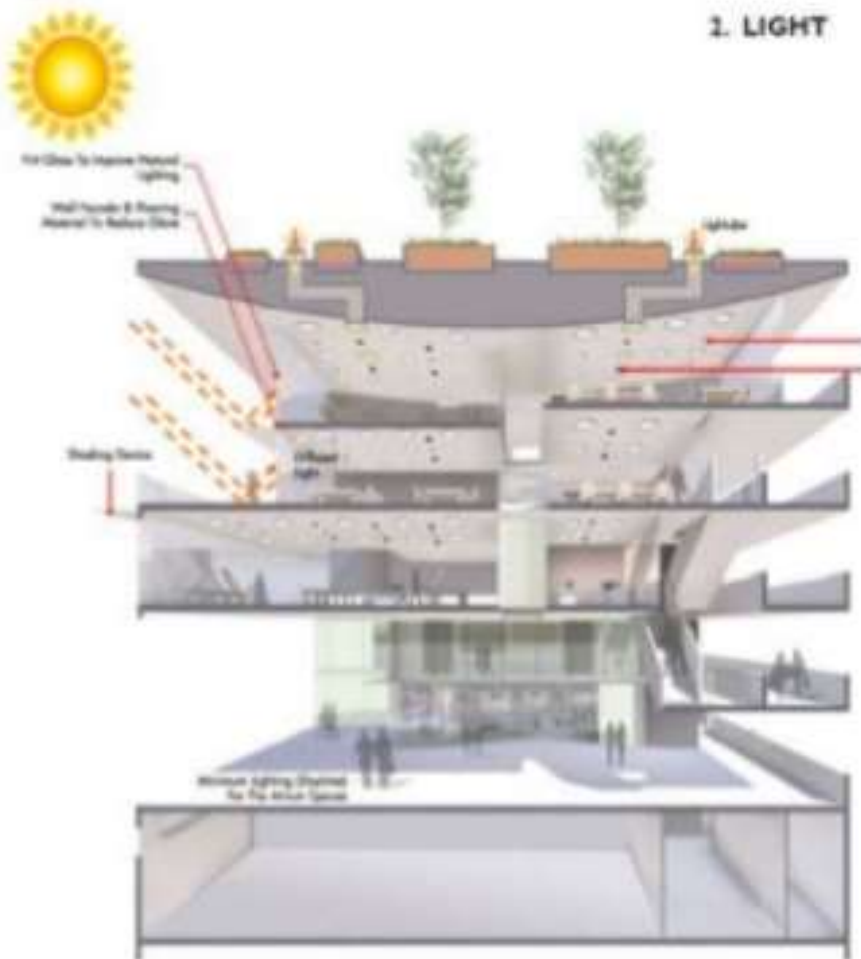
This is achieved by using the over-sailing roof, light shelves, and the east/west vertical green wall as key shading devices.

The loosely stacked planes, when combined with occupant-control glazing, allows the building to further make use of natural ventilation.

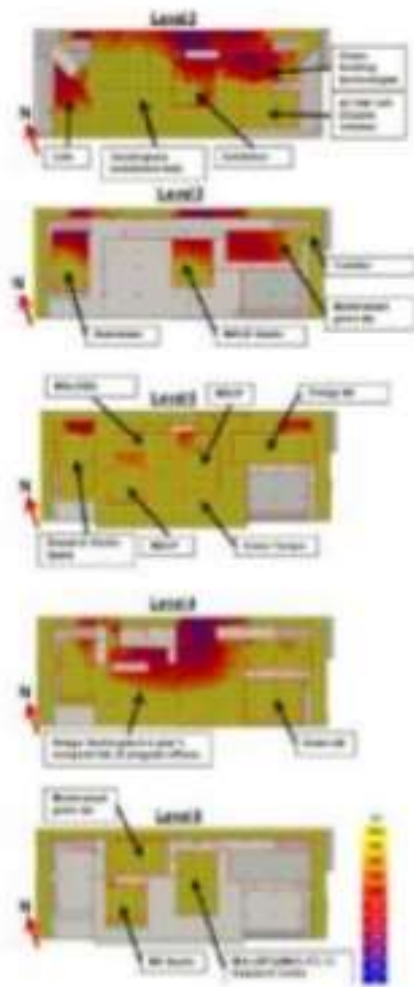


There are good levels of natural light throughout the building

1. LIGHT



Natural light is critical in a learning environment. As such, the building proposes to have as much day lighting as possible. Loosely stacked rooms allow diffused light to filter into different portions of the building. Light shelves and shading devices located at the south side of the building together with fritted glazing permit most of the rooms to be lit sufficiently without artificial light on sunny days.



The building aims to make maximum use of natural ventilation

Zero Energy Strategy

3. THERMAL COMFORT

Thermal comfort is primarily achieved by increasing ventilation and lowering of ambient temperature (surrounding and roof top greenery).

All corridors and services areas will be naturally ventilated; these spaces will be well-shaded and adequately ventilated by the 'positive and negative' spaces created within the building by the "loosely stacked rooms".

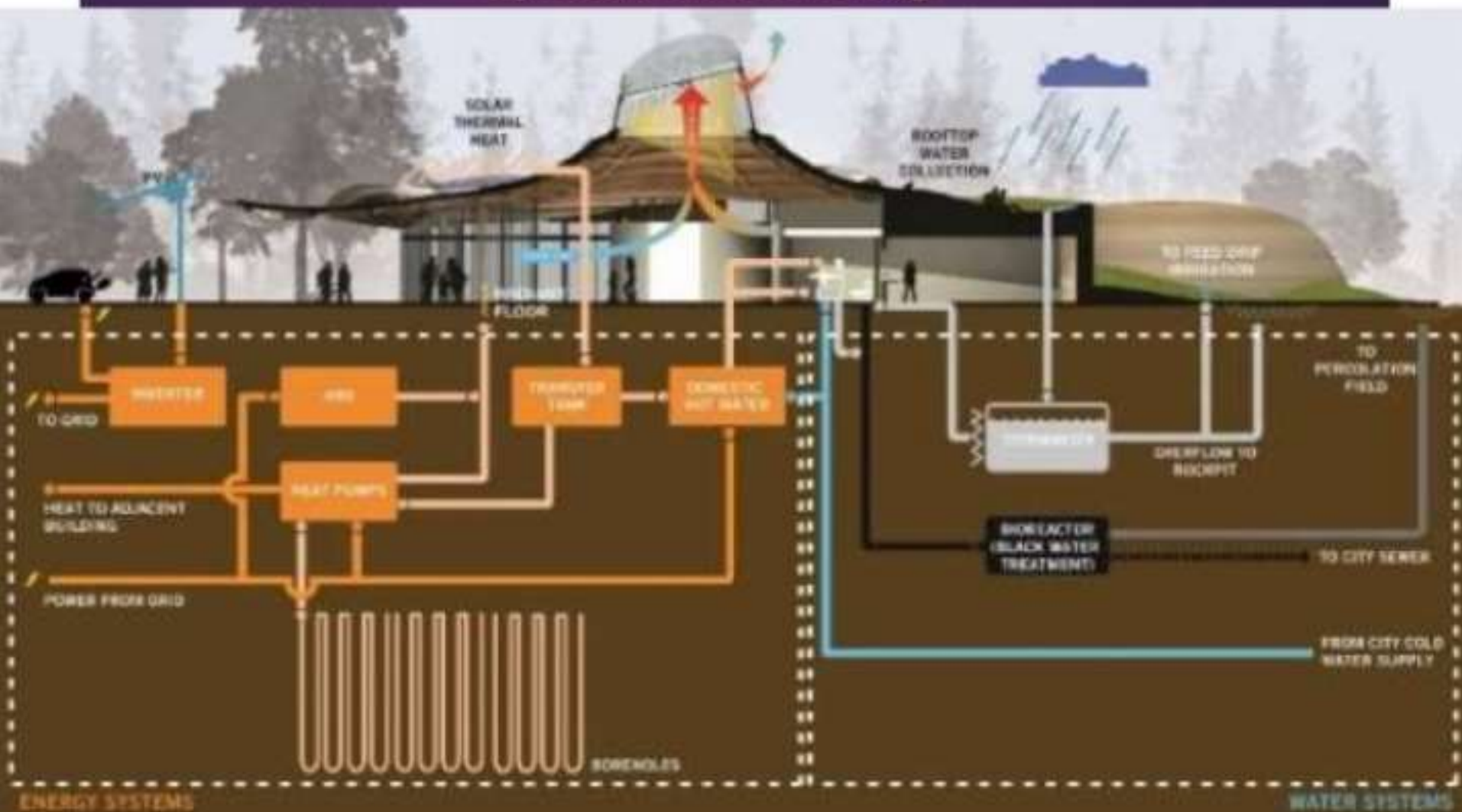
Two wind towers at the roof seek to "catch" wind during the period where prevailing wind is from the north.

The rooms are proposed to have open-able windows for occupant control. Air-conditioning is provided by absorption chillers which operate using heat from the cogen plant to give out cooling.

Although these absorption chillers use electricity to pump refrigerant, the power consumed will be negligible compared to a conventional compressor system.



ZNE is driven by good design, High Performance Systems and Shading



Idea of the new building

Model of low consumption and reduced emissions

The new building shall be a **low-carbon and net zero energy building**. (The Net Zero Energy consumption is computed on an annualized basis, with permanent automated verification and reporting system with high visibility to all users.) To this end, there must be a protocol set in place for carbon accounting at the drawing board/stage. There must be sufficient thought given to the selection and integration of renewable technologies. Excellent achievements in energy efficiency and renewable energy systems should be achieved in highly optimised conditions, demonstrating technologies' performance, integration and predictive capacity. The new building must also set benchmarks for use of water and materials.

Benchmarks and Targets

- a. Energy efficiency index of building-in-use: **not more than 75 kWh/m²/year**
- b. **Daylight access: at least 75% of gross floor area**
- c. **Cross ventilation and/or mechanical ventilation with due provisions to avert potential humidity related problems: at least 50% of the gross floor area**
- d. Cross natural ventilation as a viable option: another 25% of gross floor area (in rooms that have air conditioning provisions)
- e. 100% of regularly occupied rooms to have access to view
- f. On-site water sourcing that equals 100% of non-potable demand
- g. Green plot ratio: not less than 4
- h. **Optimize adoption of renewable energy potential**
- i. **High energy efficient air-conditioning equipment with innovative air distribution that meets requirements across the wide range of load and occupancy diversity expected in educational facilities.**
- j. Interactive smart monitoring and control system to facilitate facilities management of resources and optimize performance and indoor environmental quality

Thermal zoning of Design building, overview

- Photovoltaic**
renewable energy
- Hybrid Tempered, 26%**
library, design studios
Theatrette, offices
- Full AC, 17%**
green building technology lab
energy lab, computer lab
- Natural Cross Ventilated, 46%**
with elevated air speed
social Plaza and social
interaction spaces
modeling areas, work shops
smart green home
- Circulation**
micro climate, wind
vegetation, green and blue
- mech and aux rooms 10%**





What is building energy modeling?

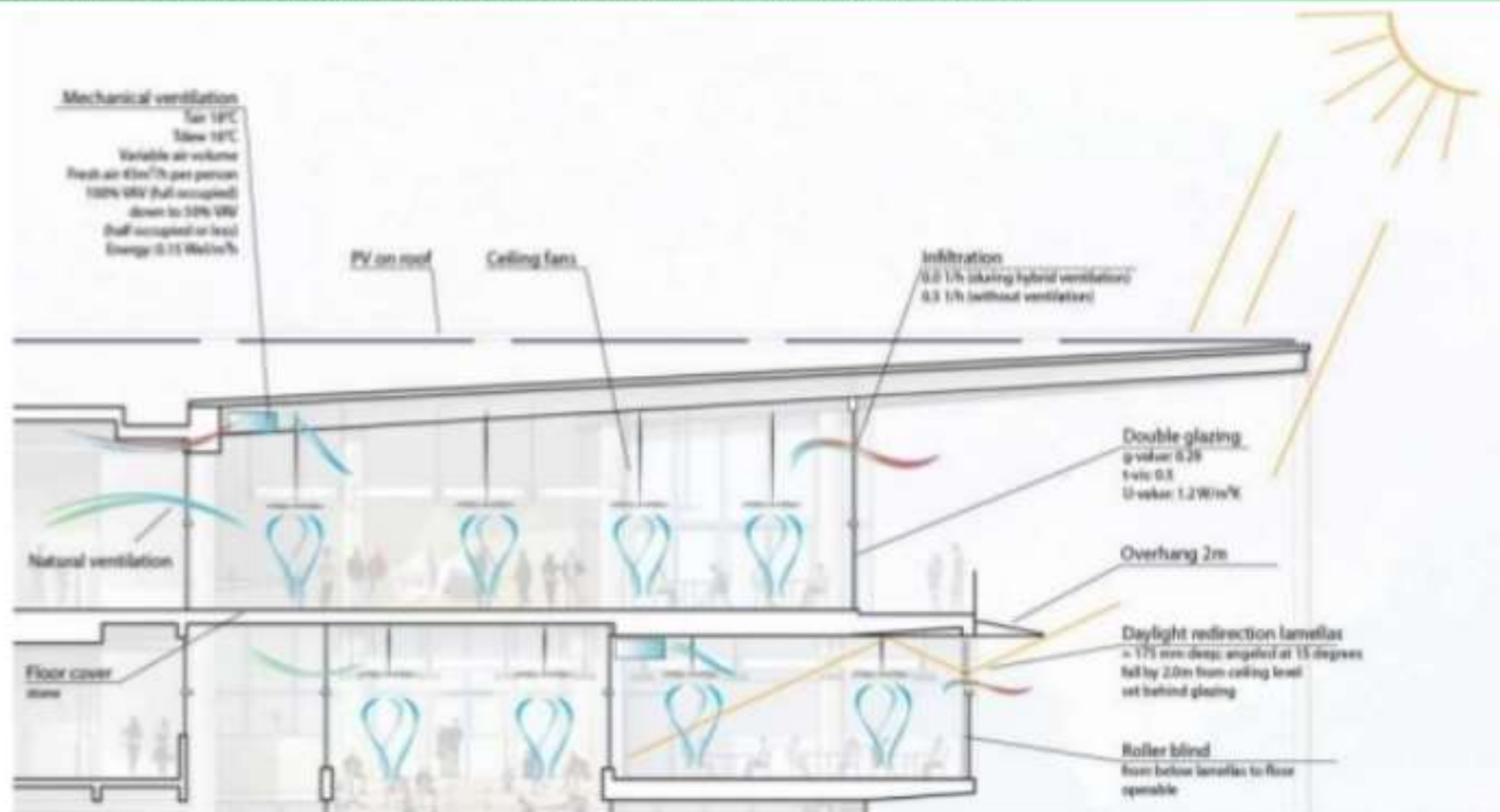
- Various interpretations

For our purposes:

The use of building energy analysis software designed to predict hourly energy use and energy cost for a building, using hourly weather data and a description of the building including its HVAC equipment and controls, its operating schedules, and its utility rate structure

- Energy modeling vs. building simulation

Boundary conditions for performance evaluation with thermal simulation



4 m² per person
 MET 1.2
 Summer CLO 0.6



max: 0.7 m/s
 14 m² per fan



60 W per person
 15 W/m²

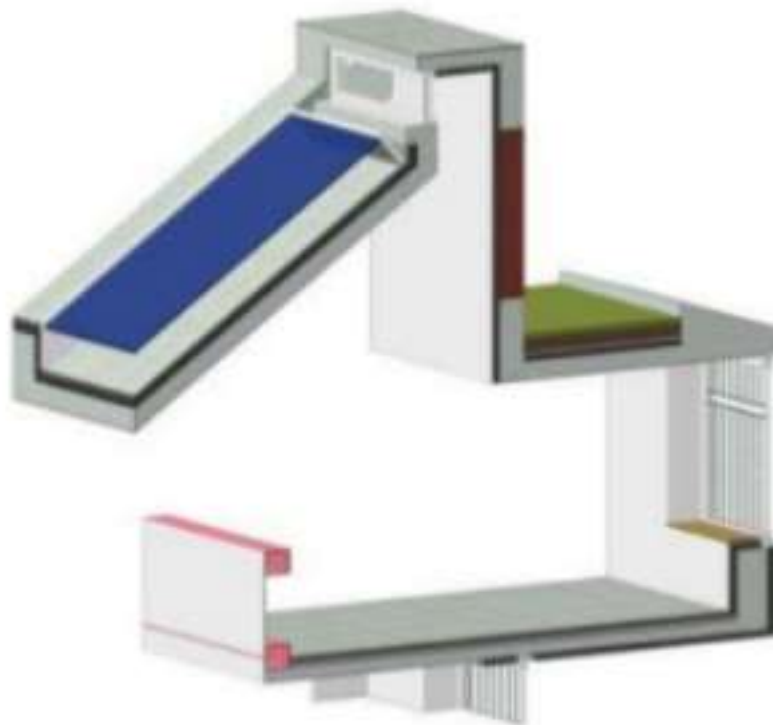


min 300 Lux
 6 W/m²



schedule occupancy and internal gains
 operation time: 5 working days

BIM Model for Quantity Estimates



INT. FLOOR FINISH			
Type	Area	Cost	Comments

BASEMENT FLOOR			
Worn Ceramic Tile	212,419 sq'		Floor Finish
	212,419 sq'		

GROUND FLOOR			
Worn Ceramic Tile	97,400 sq'		Floor Finish
	97,400 sq'		

FIRST FLOOR			
Worn Ceramic Tile	120,311 sq'		Floor Finish
	120,311 sq'		

SECOND FLOOR			
Worn Ceramic Tile	47,204 sq'		Floor Finish
	47,204 sq'		

CONCRETE SLAB/WALL/COLUMN			
Material	Material Volume	Cost	Comments

Exposed Concrete	293.22 m³		
------------------	-----------	--	--

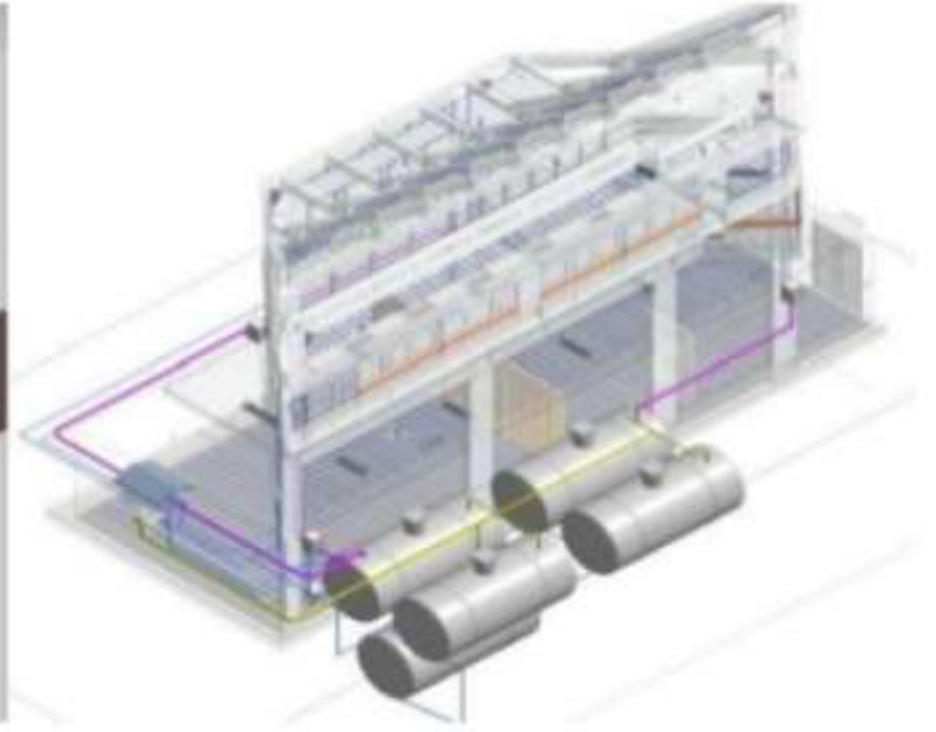
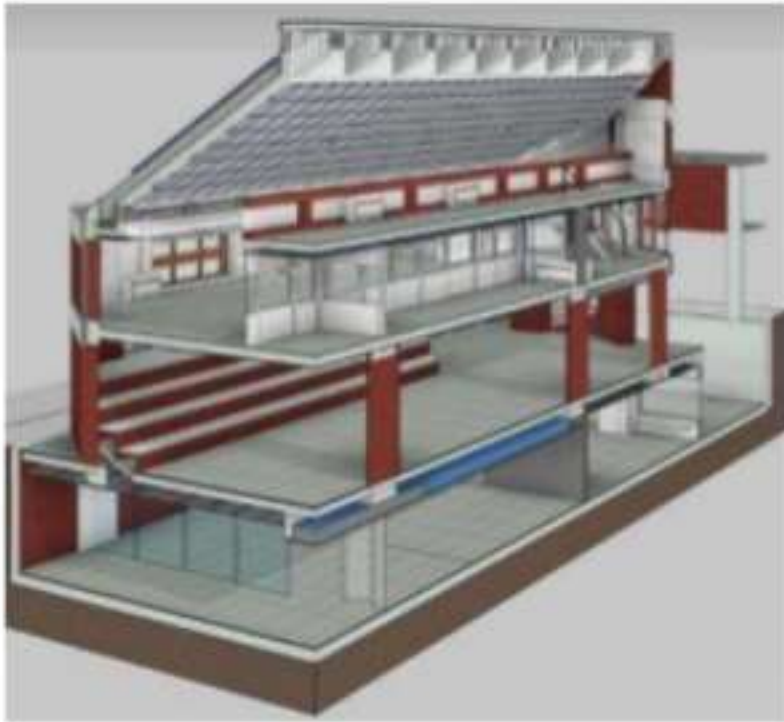
EPS POLY STYRENE FOAM INSULATION			
Material	Material Area	Cost	Comments

EPS Poly Styrene Foam Insulation	767,170 sq'		
----------------------------------	-------------	--	--

ROOF GARDEN			
Type	Area	Cost	Comments

Worn Vegetation	47,340 sq'		Vegetation
-----------------	------------	--	------------

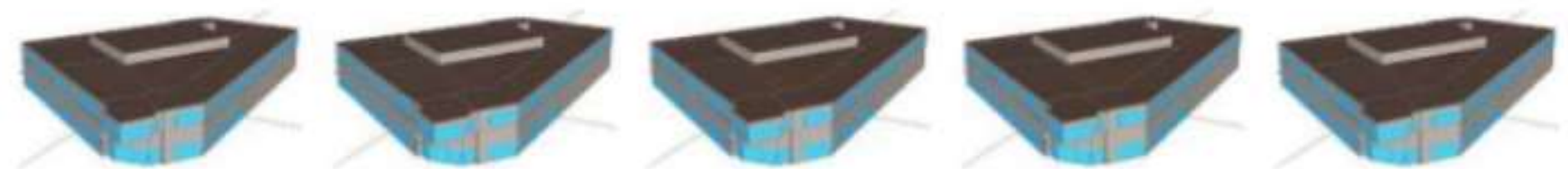
BIM System Integration



100

What energy modeling can do?

- 1) Quantify energy savings (new and existing buildings)
- 2) Code compliance analysis
- 3) Whole building design optimization
- 4) Help with commissioning and M&V
- 5) Predict operating costs



The energy modeling process

- Define scope and set priorities
 - Purpose of model (e.g. utility ECMs, LEED, overall EUI)
 - Confirm objectives with designer/owner
- Gather data
 - From design team, owner, facilities staff
- Create model
 - Existing building or
 - Baseline building (code minimum or ASHRAE App G base)
- Calibrate model (existing buildings)
- Model alternatives
- Repeat steps as required



Modeling data requirements

- Architectural
 - Plans, wall sections, building elevations, window specs
- Mechanical
 - HVAC plans, schedules, specifications, control sequences
- Electrical
 - Lighting plans, lighting take-off, occupancy sensors, daylighting
- Internal Loads
 - Peak occupancy, lighting, equipment loads
- Operations
 - Schedules of operation (occupancy, lighting, equipment, thermostats, fans, ventilation)
- Economics
 - Utility rates
- Level of detail depends on stage of modeling and purpose of model



eQUEST capabilities

- Complex geometries
- Sunspaces
- Custom glazing
- Daylighting with optional sun control
- Various methods for air infiltration
- 50+ HVAC system configurations available in wizards; more in detailed mode
- Flexible HVAC equipment control strategies
- Ground-source heat pumps
- Dual-fuel cooling plants
- Thermal energy storage
- Photovoltaics
- Cogeneration
- Custom performance curves

“ Internal loads tab

- View and edit occupancy lighting, daylighting, equipment loads

Internal Loads Spreadsheet | Summary |

Display Mode: General

	Space Name	Display Mode	Occupancy	Lighting	Daylighting	Equipment	Internal Energy Sources	Infiltration	Internal Mass	Surf
1	L1 S office/corr	General	No							No
2	L1 clean rooms	General	No							No
3	L1 N elec/stairs	General	No							No
4	L1 core dispensing	Floor 1	Conditioned							No
5	L1 N solvents	Floor 1	Conditioned							No

”

Water-side HVAC tab

The screenshot displays the 'Water-Side HVAC' tab in a software application. The interface includes a menu bar (File, Edit, View, Model, Tools, Help), a toolbar, and a ribbon with tabs for Project & Site, Building Shell, Internal Loads, Water-Side HVAC (active), Air-Side HVAC, and Utility & Economics. A 'Component Tree' on the left lists various system components, including 'HW Loop' and 'HW Pumps'. The main area shows a 'Graphical view' of a 'Chiller 1' connected to a 'HW Loop' which then feeds into 'Multiple Coils'. A callout box highlights 'Performance Curves (custom and default)' for the HW Pumps, listing various performance metrics like 'MS ER(CHWT, DAT) - take 427' and 'MS ER(PUR)'.

File Edit View Model Tools Help

Project & Site Building Shell Internal Loads **Water-Side HVAC** Air-Side HVAC Utility & Economics

Component Tree

- Project: 'Example project'
- Global Parameters
 - LPD
 - etc
- CHW Loop
 - Chiller 1
- Air-Side System(s)
- Thermal Zone(s)
- HW Loop
 - HW Pumps
 - S-1
 - S-2
- Air-Side System(s)
- Thermal Zone(s)
- Performance Curves
 - MS ER(CHWT, DAT) - take 427
 - MS ER(PUR)
 - MS Cap(CHWT, DAT) - take 427
 - Pump-Head-Flow

Plant Equipment | Spreadsheet | Summary

Chiller 1

Multiple Coils

CHW Loop

Graphical view

Performance Curves (custom and default)

- MS ER(CHWT, DAT) - take 427
- MS ER(PUR)
- MS Cap(CHWT, DAT) - take 427
- Pump-Head-Flow

MS ER(CHWT, DAT) - take 427

MS ER(PUR)

MS Cap(CHWT, DAT) - take 427

Pump-Head-Flow

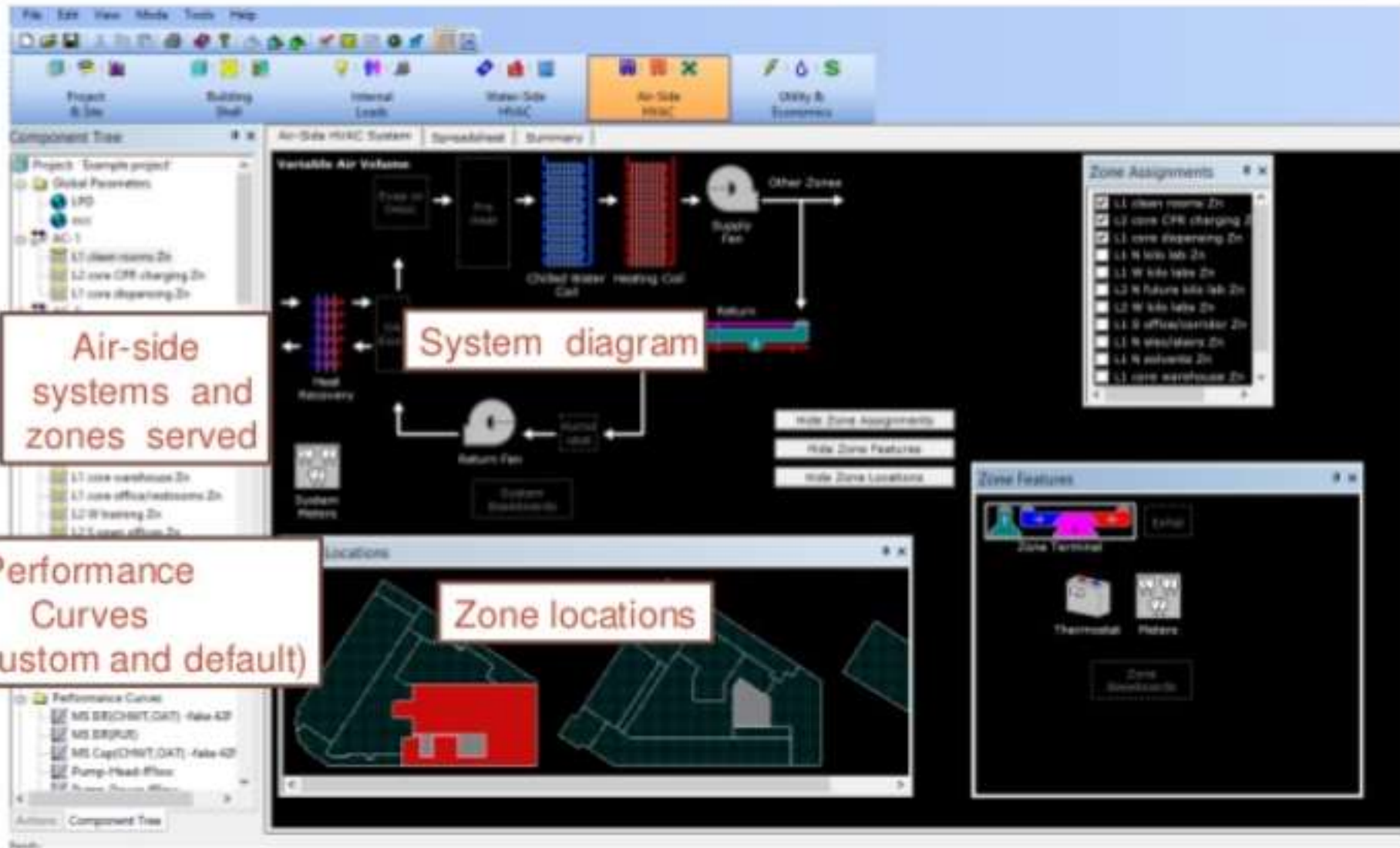
S-2

S-1

Multiple Coils

HW Loop

Air-side HVAC tab



References

ANSI/ASHRAE. 2004. *ANSI/ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

ANSI/ASHRAE/IESNA. 2004a. *ANSI/ASHRAE/IESNA Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

ANSI/ASHRAE/IESNA. 2004b. *User's Manual for ANSI/ASHRAE/IESNA Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

ASHRAE. 2004. *Advanced Energy Design Guide for Small Office Building*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

ASHRAE. 2006. *ASHRAE Green Guide: The Design, Construction, and Operation of Sustainable Buildings*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia.

Torcellini, P., S. Pless, M. Deru, and D. Crawley. 2006. *Zero Energy Buildings: A Critical Look at the Definition*. CP-550-39833, National Renewable Energy Laboratory, Golden, Colorado.

Torcellini, P., S. Pless, M. Deru, B. Griffith, N. Long, and R. Judkoff. 2006a. *Lessons Learned from Case Studies of Six High-Performance Buildings*. TP-550-37542, National Renewable Energy Laboratory, Golden, Colorado.

Torcellini, P., M. Deru, B. Griffith, K. Benne, M. Halverson, D. Winiarski, and D.B. Crawley. 2008. *DOE Commercial Building Benchmark Models*. CP-550-43291, National Renewable Energy Laboratory, Golden, Colorado.

Wassner, M., and M. J. Brandemuhl. 2006. *Effect of Data Availability on Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations*. ASHRAE Transactions 111(1), pp. 214-225.



THANK YOU