

Building Energy Modeling

STRETCH CODE

OCTOBER 20, 2009

RAVI S. SRINIVASAN

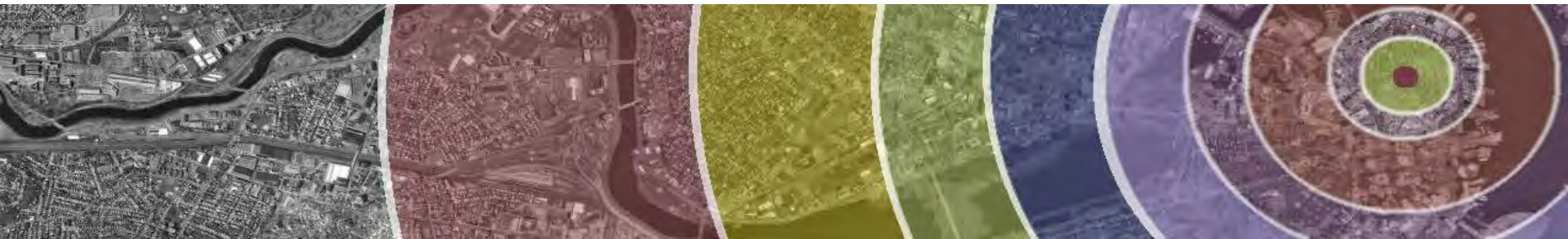
Director of Technology & Innovation

The Green Roundtable

and

N E X U S

Green Building Resource Center



Link to Stretch Code

BUILDING ENERGY MODELING

Summary of "Stretch" Appendix to Mass. Energy Code, Adopted by BBRB May 2009

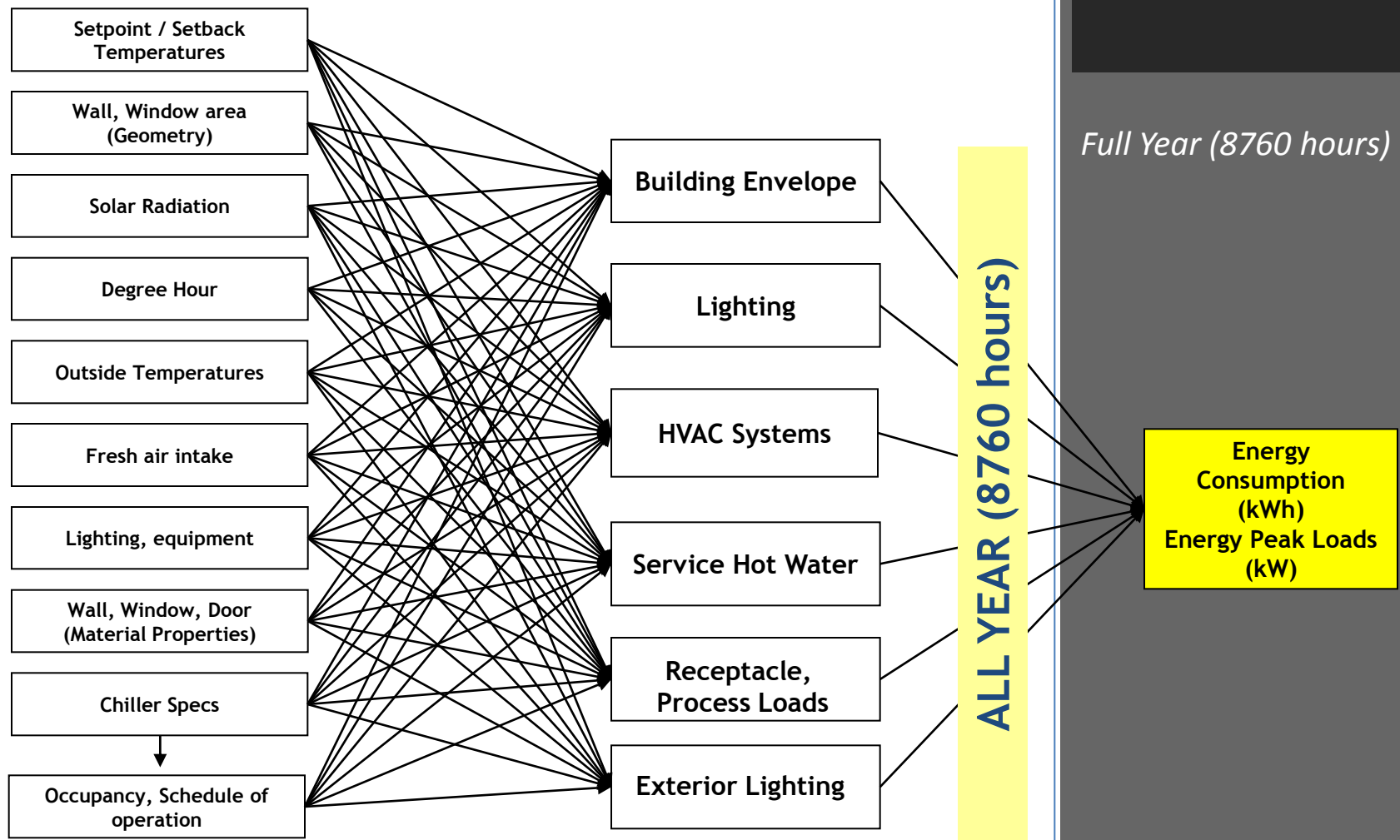
Building category	Definition	Requirements based on energy performance (can do prescriptive instead where shown)	Alternative "pre-scriptive" requirement – specific efficiency measures	Source, comments	Benefit-cost modeling results
New residential	Single-family, multi-family of 3 stories or less	HERS index 65 above 3,000 ft2, 70 below 3,000 ft2, certified by HERS rater; follow Energy Star thermal bypass checklist	None	HERS rating = energy use as % of use under IECC code. Current Mass. code ~ HERS 99; soon-to-be-adopted IECC 2009 ~ HERS 92	Sample 3 bedroom home, estimate \$837/year savings (\$8,103 extra construction cost = \$527/year higher mortgage, but save \$1,364/year energy costs)
Residential additions	Expansions of existing living space	HERS 80 over 2,000 ft2, HERS 85 under 2,000 ft2; certified by HERS rater (or prescriptive option)	Alternative path to a HERS - rating same as residential rehab below		3-bed home, estimate \$40/year savings (\$10,168 extra construction cost = \$661/year, but energy costs \$701/year lower)
Major residential rehab/ alterations	Major alterations as in existing code – excludes storm windows, reroofing, doors, etc.	HERS 80 over 2,000 ft2, HERS 85 under 2,000 ft2; certified by HERS rater (or prescriptive option)	Prescriptive option of Energy Star Homes program; insulation equal to IECC 2009 for climate zone 5	Quality air-sealing and insulation, EnergyStar windows	
Large commercial and large residential multi-family	Commercial above 100,000 ft2; residential 4 stories or more and 100,000 ft2	Energy use 20% below ASHRAE 90.1 2007, determined by modeling	None	DOE, NGRID modeling show energy savings greater than 20%	
Medium commercial and residential multi-family	Commercial 5,000 to 100,000 ft2, residential 4 stories or more and below 100,000 ft2	Energy use 20% below ASHRAE 90.1 2007, determined by modeling	IECC 2009 with NBI Core performance: improved air sealing, insulation, lighting, etc.	Prescriptive based on New Buildings Institute program; used by utilities now for incentive programs	NGRID, NSTAR case studies. Example – 60,000 ft2 office bldg., \$91,000 extra cost, \$29,500 annual energy savings; and \$63,100 NGRID rebate
Small commercial	Below 5,000 ft2	Exempt	Exempt		
Specialty commercial	Supermarkets, labs, warehouses below 40,000 ft2	Exempt	Exempt	Other specialty buildings can apply for waiver	
Commercial alterations		Exempt	Exempt		

Building Physics & Components

BUILDING ENERGY MODELING

Approved Energy Modeling Software

US Dept of Energy



Full Year (8760 hours)

ALL YEAR (8760 hours)

Energy Consumption (kWh)
Energy Peak Loads (kW)

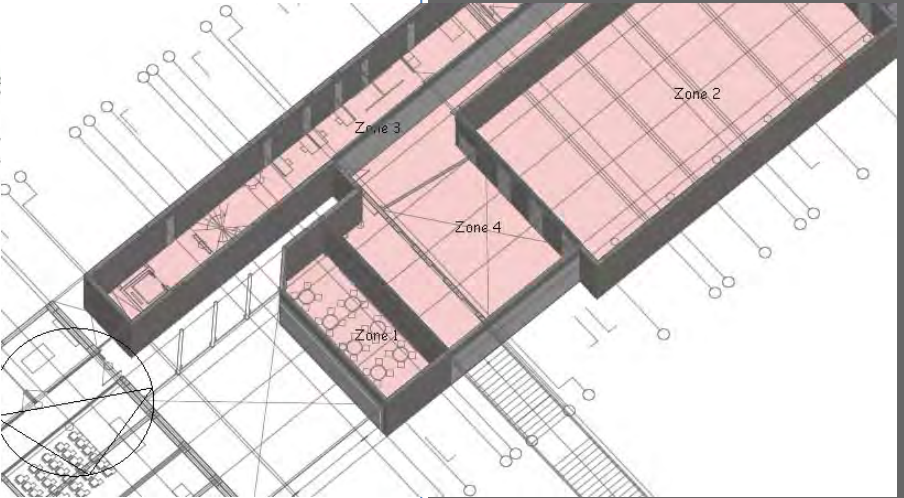
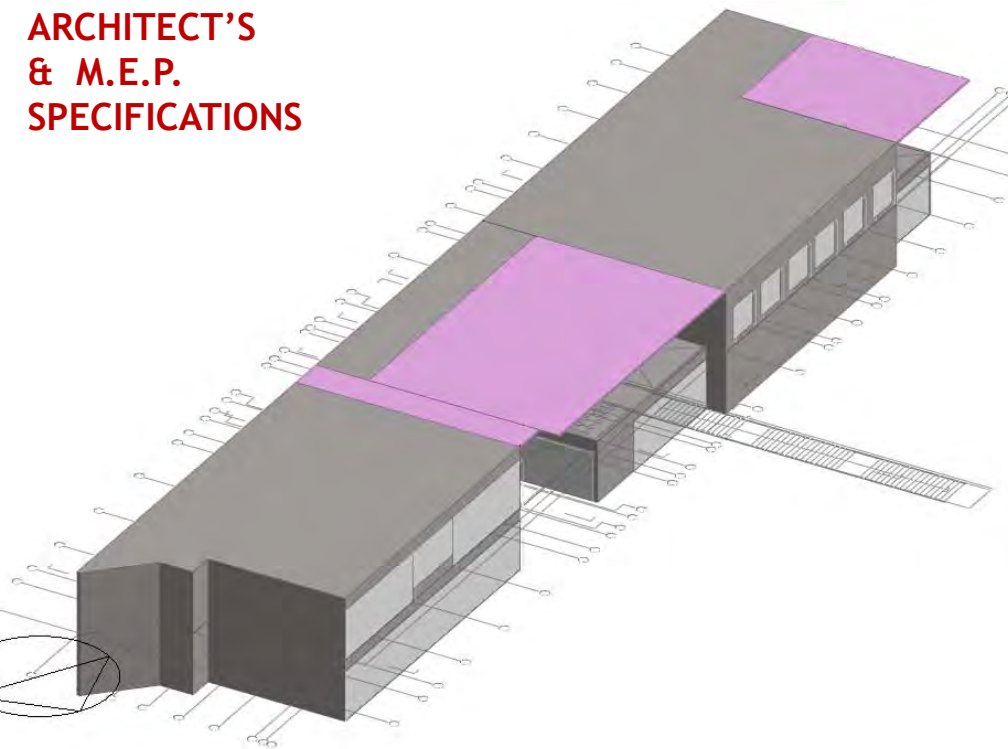
Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION

ARCHITECT'S
& M.E.P.
SPECIFICATIONS



INDUSTRY LEADING FEATURES / BENEFITS

- Energy Efficiency**
- 14.5-21 SEER/11.1-15 EER
- New Aesthetic Design**
- WeatherArmor Ultra™ Cabinet
 - Baked on powder paint
 - Steel louver coil guard
 - Color matched ceramic coated cabinet screws

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION

**ARCHITECT'S
& M.E.P.
SPECIFICATIONS**

Building Envelope

Wall / Internal Partitions (UFactor)
Windows (UFactor, SHGC, VT, Shading Coefficient)
Roof (UFactor, Reflectance)
Floor (UFactor)

Heating, Ventilating & Air-Conditioning

Ventilation type (mechanical)
Heating & Cooling (type, schedule, energy source)

Service Water Heating

Type, operation schedule

Other Equipment

Equipment power density

Activity Schedule

Schedule - hours, days (holidays)

Lighting

Control (auto), Lighting energy (LPD)
Operation schedule, luminaire type, radiant fraction
Task / display light (gain, operation schedule)

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION



BASELINE

INPUTS FROM ASHRAE 90.1-2007

(Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F)

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IESNA Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for study, document, consensus action or requests for change to any part of the standard. The change submission form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, <http://www.ashrae.org>, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2905. E-mail: orders@ashrae.org; Fax: 404-821-5478; Telephone: 404-838-9400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

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Illuminating Engineering Society of North America

ANSI

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org



Appendix G
PERFORMANCE
RATING METHOD (PRM)

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION



BASELINE

INPUTS FROM ASHRAE 90.1-2007

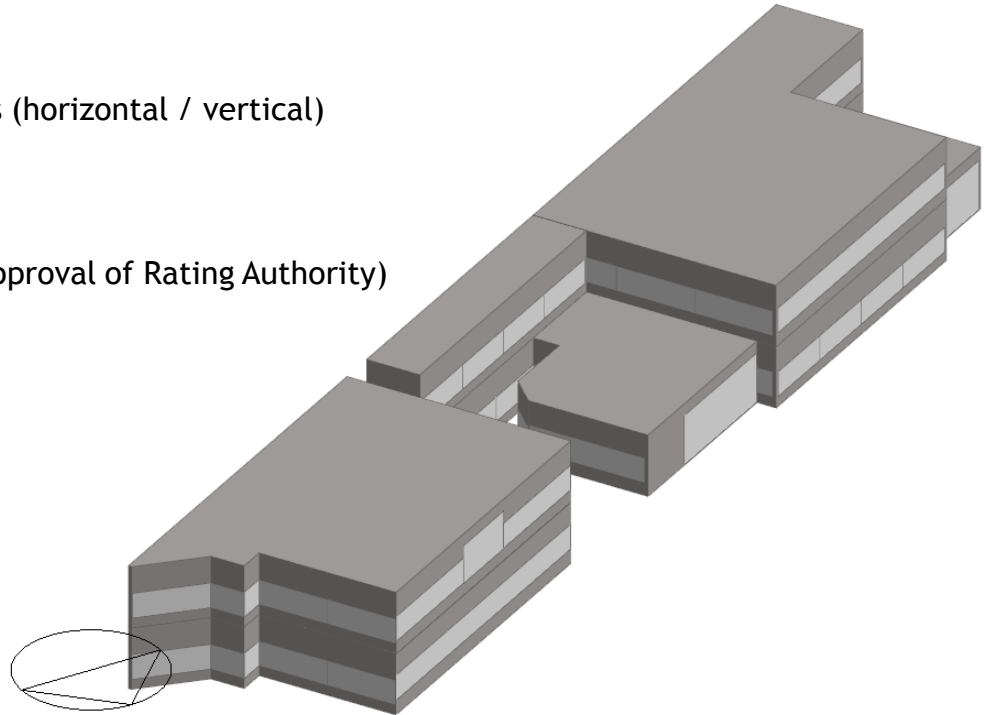
MODEL REQUIREMENTS

Building Geometry

Same as As-Is Design
Do not include shades (horizontal / vertical)

Schedules

Same as As-Is Design
Variations allowed (approval of Rating Authority)



Modeling Limitations to the Simulation Program

Substitute a thermodynamically similar component model that can approximate the expected performance of the component that cannot be modeled explicitly.

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION



BASELINE

INPUTS FROM ASHRAE 90.1-2007

BUILDING ENVELOPE REQUIREMENTS

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
<i>Roofs</i>						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-0.218	R-3.8 ci
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.081	R-13.0
<i>Walls, Above-Grade</i>						
Mass	U-0.151 ^a	R-5.7 ci ^a	U-0.104	R-9.5 ci	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel-Framed	U-0.124	R-13.0	U-0.064	R-13.0 + R-7.5 ci	U-0.124	R-13.0
Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.089	R-13.0
<i>Wall, Below-Grade</i>						
Below-Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
<i>Floors</i>						
Mass	U-0.107	R-6.3 ci	U-0.087	R-8.3 ci	U-0.322	NR
Steel-Joist	U-0.052	R-19.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood-Framed and Other	U-0.051	R-19.0	U-0.033	R-30.0	U-0.066	R-13.0
<i>Slab-On-Grade Floors</i>						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-0.950	R-7.5 for 24 in.	F-0.840	R-10 for 36 in.	F-1.020	R-7.5 for 12 in.
<i>Opaque Doors</i>						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-0.500		U-1.450	

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION

BASELINE

INPUTS FROM ASHRAE 90.1-2007



HVAC & DHW REQUIREMENTS

Building Type	Fossil Fuel, Fossil/Electric Hybrid, & Purchased Heat	Electric and Other
Residential	System 1 - PTAC	System 2 - PTHP
Nonresidential & 3 Floors or Less & <75,000 ft ²	System 3 - PSZ-AC	System 4 - PSZ-HP
Nonresidential & 4 or 5 Floors & <75,000 ft ² or 5 Floors or Less & 75,000 ft ² to 150,000 ft ²	System 5 - Packaged VAV w/ Reheat	System 6 - Packaged VAV w/PPF Boxes
Nonresidential & More than 5 Floors or >150,000 ft ²	System 7 - VAV w/Reheat	System 8 - VAV w/PPF Boxes

Notes:
 Residential building types include dormitory, hotel, motel, and multifamily. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters.
 Other building and space types are considered nonresidential.
 Where no heating system is to be provided or no heating energy source is specified, use the "Electric and Other" heating source classification.
 Where attributes make a building eligible for more than one *baseline* system type, use the predominant condition to determine the system type for the entire building.

TABLE G3.1.1B *Baseline System Descriptions*

System No.	System Type	Fan Control	Cooling Type	Heating Type
1. PTAC	Packaged terminal air conditioner	Constant Volume	Direct Expansion	Hot Water Fossil Fuel Boiler
2. PTHP	Packaged terminal heat pump	Constant Volume	Direct Expansion	Electric Heat Pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant Volume	Direct Expansion	Fossil Fuel Furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant Volume	Direct Expansion	Electric Heat Pump
5. Packaged VAV w/ Reheat	Packaged rooftop variable air volume with reheat	VAV	Direct Expansion	Hot Water Fossil Fuel Boiler
6. Packaged VAV w/PPF Boxes	Packaged rooftop variable air volume with reheat	VAV	Direct Expansion	Electric Resistance
7. VAV w/Reheat	Packaged rooftop variable air volume with reheat	VAV	Chilled Water	Hot Water Fossil Fuel Boiler
8. VAV w/PPF Boxes	Variable air volume with reheat	VAV	Chilled Water	Electric Resistance

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION



BASELINE

INPUTS FROM ASHRAE 90.1-2007

LIGHTING (EXTERIOR & INTERIOR) REQUIREMENTS

Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	Uncovered Parking Areas	
	Parking Lots and drives	0.15 W/ft ²
	Building Grounds	
	Walkways less than 10 feet wide	1.0 W/linear foot
	Walkways 10 feet wide or greater	
	Plaza areas	0.2 W/ft ²
	Special Feature Areas	
	Stairways	1.0 W/ft ²
	Building Entrances and Exits	
	Main entries	30 W/linear foot of door width
Other doors	20 W/linear foot of door width	
Canopies and Overhangs		
Canopies (free standing and attached and overhangs)	1.25 W/ft ²	
Outdoor Sales		
Open areas (including vehicle sales lots)	0.5 W/ft ²	
Street frontage for vehicle sales lots in addition to "open area" allowance	20 W/linear foot	
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in	Building Facades	0.2 W/ft ² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270 W per location plus 90 W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	1.25 W/ft ² of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")

Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION

BASELINE

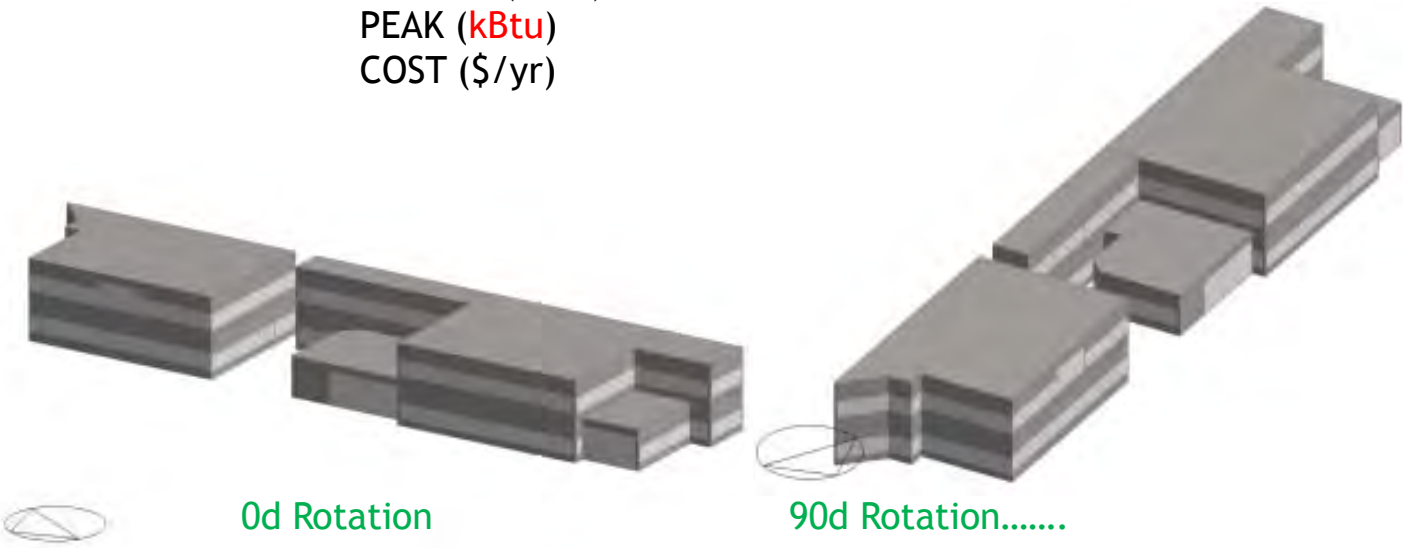
INPUTS FROM ASHRAE 90.1-2007



MODEL REQUIREMENTS

Baseline should be independent of its orientation
→ Baseline is rotated FOUR times (0d, 90d, 180d, 270d)
and average value is computed:

- ENERGY (kBtu)
- PEAK (kBtu)
- COST (\$/yr)



Modeling Process

BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION

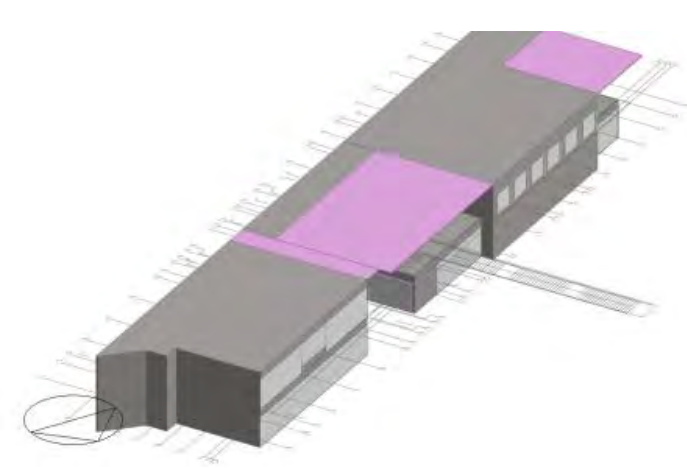


BASELINE

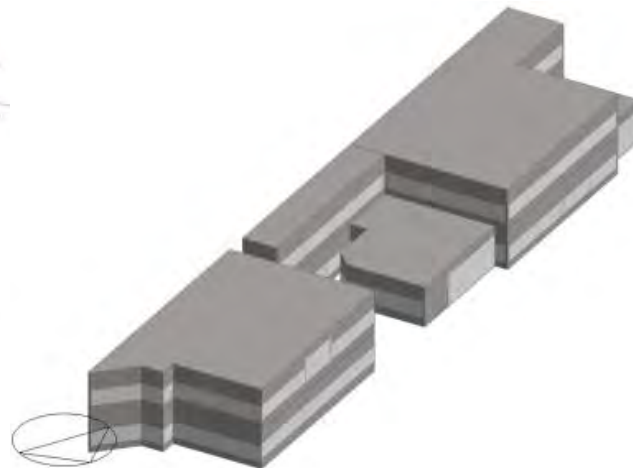
INPUTS FROM ASHRAE 90.1-2007

MODEL REQUIREMENTS

Baseline should be independent of shades
(techniques by which the building can be shaded)



As-Is (designed)



Baseline

Modeling Process

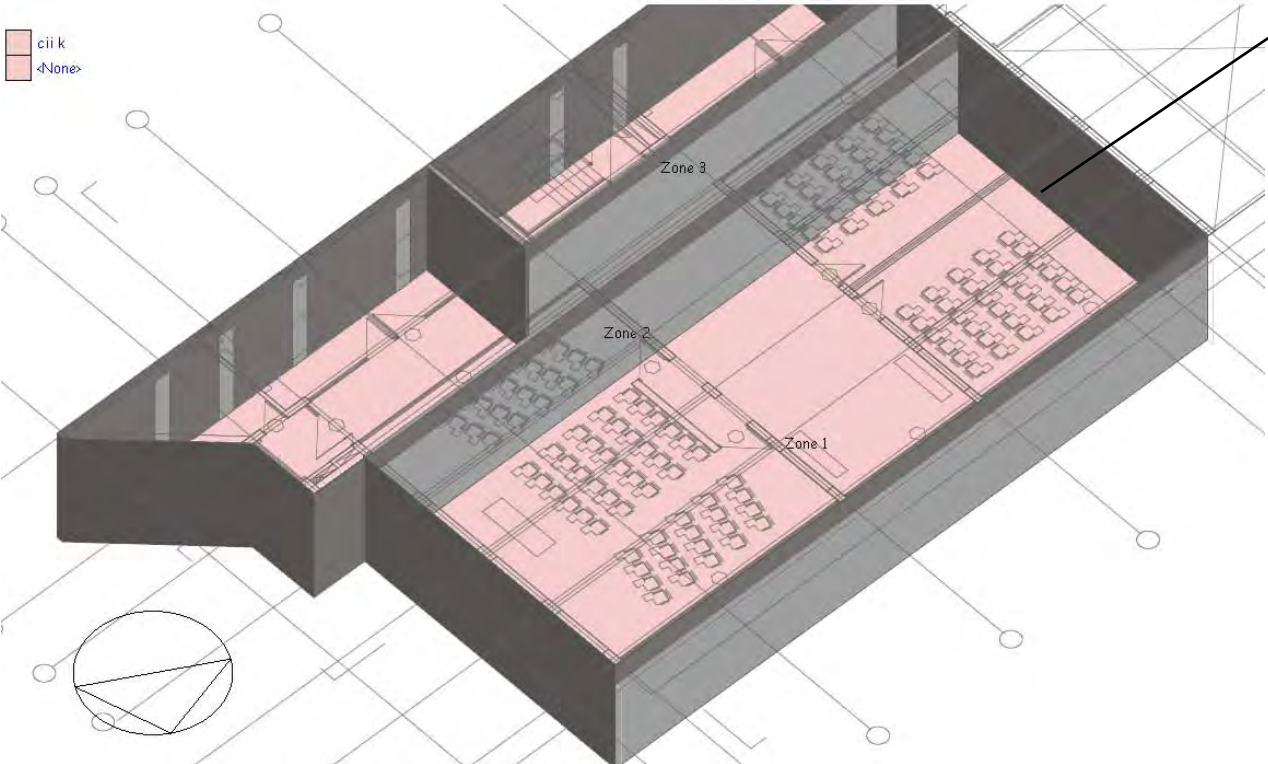
BUILDING ENERGY MODELING

AS - IS

CURRENT DESIGN SPECIFICATION

BASELINE

INPUTS FROM ASHRAE 90.1-2007



Zoning (for Energy Modelling is a critical component)

Modeling Process

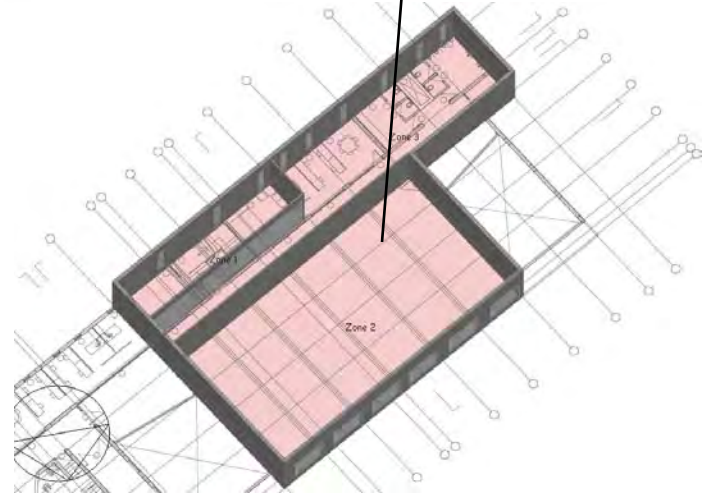
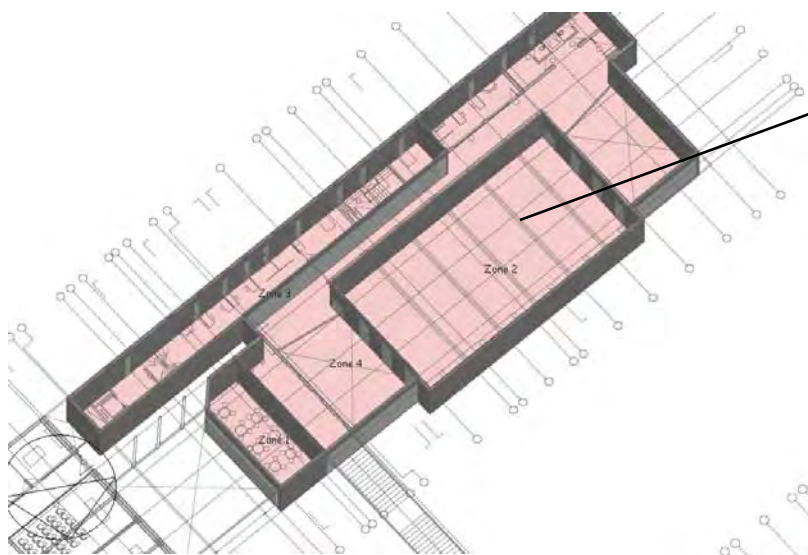
BUILDING ENERGY MODELING

AS - IS

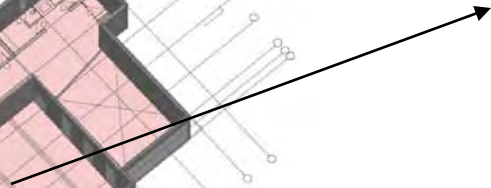
CURRENT DESIGN SPECIFICATION

BASELINE

INPUTS FROM ASHRAE 90.1-2007

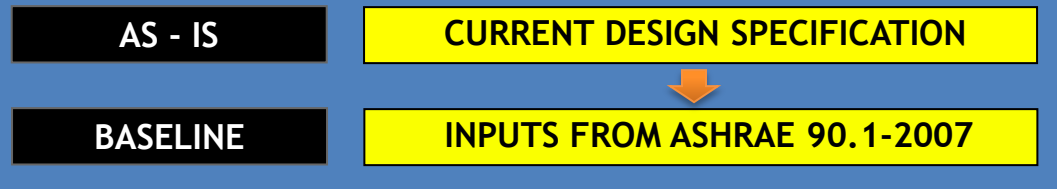


Zoning based on HVAC systems' design



Modeling Process

BUILDING ENERGY MODELING



ENERGY COST SAVINGS (\$)
STRETCH CODE >= 20%

PERFORMANCE RATING METHOD RESULTS

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.
 * Denotes the base alternative for the ECB study.

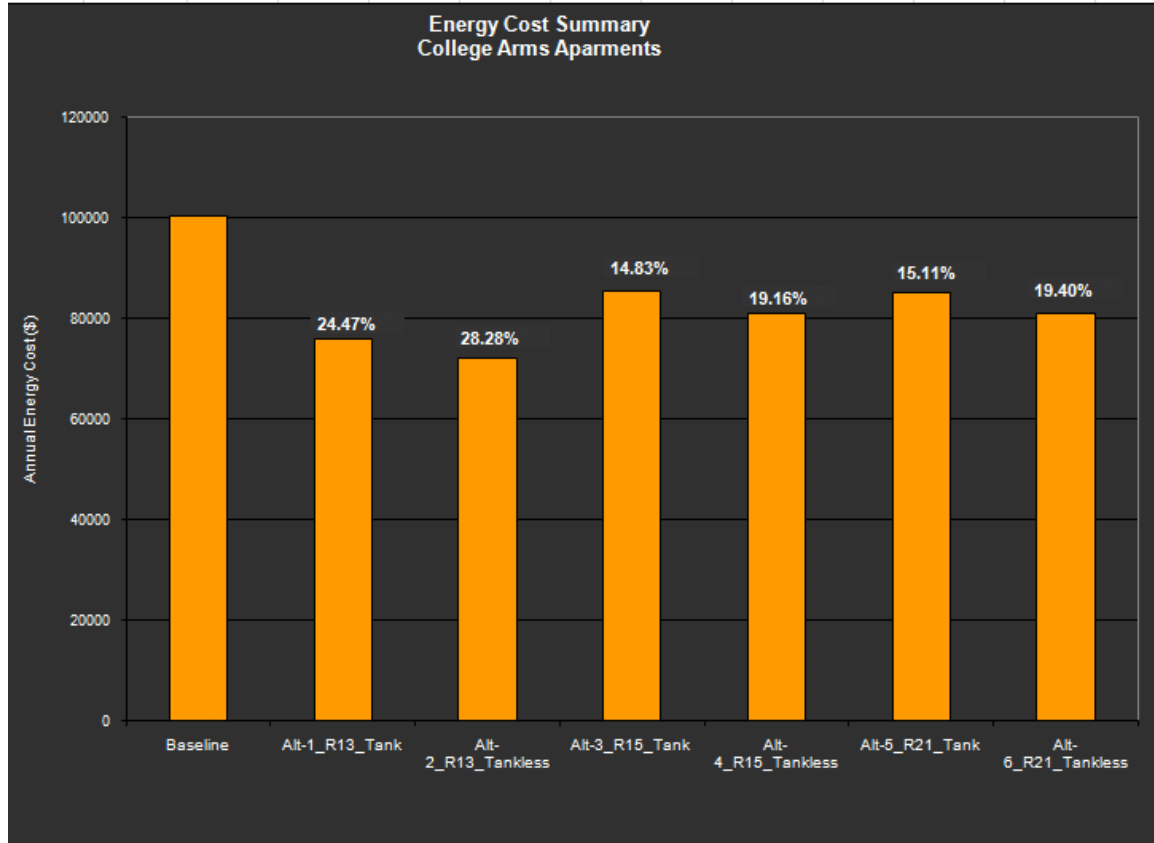
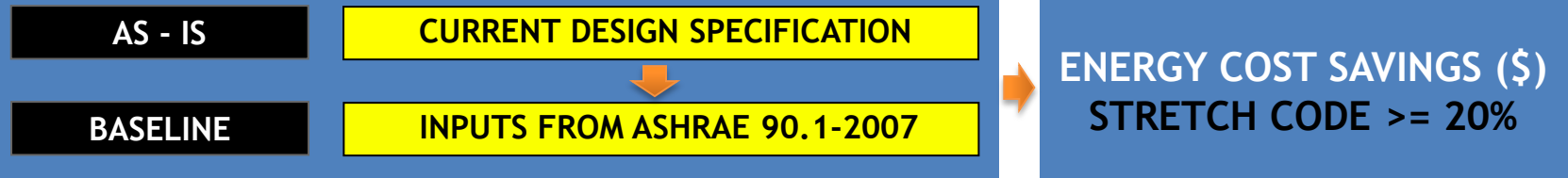
		* Alt-1 As Is Design with Baseli			Alt-2 ASHRAE 90-1-2001 Baselin			Alt-3 As Is Design with Lighting			Alt-4 As Is Design with Lighting		
		Energy 10 ⁶ Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10 ⁶ Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10 ⁶ Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10 ⁶ Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	1,372.4	33	395	1,372.4	100	395	1,002.5	73	290	1,002.5	73	290
Space Heating	Electricity	502.4	12	486	836.2	166	643	604.4	120	497	112.3	22	99
Space Cooling	Electricity	427.5	10	476	452.0	106	523	376.2	88	447	97.0	23	63
Pumps	Electricity	0.0	0	0	0.0	0	0	0.0	0	0	3.0	0	4
Heat Rejection	Electricity	83.0	2	67	89.3	108	73	73.6	89	63	0.0	0	0
Fans - Conditioned	Electricity	532.0	13	65	533.4	100	66	532.5	100	65	262.6	49	30
Receptacles - Conditioned	Electricity	647.4	16	235	998.1	154	248	998.1	154	248	998.1	154	248
Stand-alone Base Utilities	Gas	534.4	13	61	534.4	100	61	534.4	100	61	534.4	100	61
Total Building Consumption		4,099.0			4,815.7			4,121.6			3,009.8		

		* Alt-1 As Is Design with Baseli			Alt-2 ASHRAE 90-1-2001 Baselin			Alt-3 As Is Design with Lighting			Alt-4 As Is Design with Lighting		
Total	Number of hours heating load not met	0			0			0			0		
	Number of hours cooling load not met	0			0			0			0		

		* Alt-1 As Is Design with Baseli		Alt-2 ASHRAE 90-1-2001 Baselin		Alt-3 As Is Design with Lighting		Alt-4 As Is Design with Lighting	
		Energy 10 ⁶ Btu/yr	Cost/yr \$/yr	Energy 10 ⁶ Btu/yr	Cost/yr \$/yr	Energy 10 ⁶ Btu/yr	Cost/yr \$/yr	Energy 10 ⁶ Btu/yr	Cost/yr \$/yr
Electricity		3,564.6	85,539	4,281.3	102,736	3,587.2	86,080	2,475.5	59,403
Gas		534.4	4,799	534.4	4,799	534.4	4,799	534.4	4,799
Total		4,099	90,337	4,816	107,535	4,122	90,879	3,010	64,201

Modeling Process

BUILDING ENERGY MODELING



USGBC LEED™ Comparison

BUILDING ENERGY MODELING

Rating System	Reference Guide
LEED for New Construction	GREEN BUILDING DESIGN & CONSTRUCTION 2009 Edition
LEED for Core & Shell	
LEED for Schools	
LEED for Healthcare*	
LEED for Retail*	
LEED for Commercial Interiors	GREEN INTERIOR DESIGN & CONSTRUCTION 2009 Edition
LEED for Retail Interiors*	
LEED for Existing Buildings	GREEN BUILDING OPERATIONS & MAINTENANCE 2009 Edition
LEED for Existing Schools*	



USGBC LEED™ Comparison

BUILDING ENERGY MODELING

STRETCH CODE (COMMERCIAL - ENERGY MODELING) IS COMPATIBLE WITH USGBC LEED™ ENERGY MODELING REQUIREMENTS

LEED for New Construction

LEED for Core & Shell

LEED for Schools

Both use ASHRAE 90.1-2007 for Baseline Energy Consumption computation

20% better than ASHRAE 90.1-2007 is equivalent to:

5 points (New Construction & Schools)

7 points (Core & Shell)



If the project is already proceeding with LEED™ Certification, there is no double work.

Questions

BUILDING ENERGY MODELING

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