Energy Modeling to Meet LEED™ Requirements

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Learning Objectives

- Understand how to use modeling software to achieve LEED points
- Understand the methods and requirements of ASHRAE 90.1-2004 Energy Cost Budget and Performance Rating program
- Recognize and avoid the common pitfalls of energy modeling

Today's Topics

- **LEED & 90.1-2004 Energy Analysis**
  - Energy Cost Budget Method (ECB)
  - Performance Rating Method (PRM)
- **Software Requirements**
- **Modeling Requirements**
  - Common Pitfalls Modeling ECB & PRM
- **Question & Answer**

new construction
LEED-NC 2.2

Energy and Atmosphere category

- Prerequisite 2 - Minimum energy performance (EAp2)
  - Energy Cost Budget Method
- Credit 1 - Optimize energy performance (EAc1)
  - Performance Rating Method

10 points

optimize energy performance
LEED-NC 2.2: EAc1

Reduce proposed building energy cost for all loads

- Heating
- Cooling
- Lighting (all)
- Auxiliaries (pumps, fans)
- Water heaters
- Process energy — elevators, plug and other unregulated loads

May earn innovation points

minimum energy performance
LEED-NC 2.2: EAc1

Reduction of proposed energy cost	
New construction*	LEED points
10.5%	1
14	2
17.5	3
21	4
24.5	5
28	6
31.5	7
35	8
38.5	9
42	10

*For a major renovation, compares proposed design to pre-renovated building to determine energy cost savings

ASHRAE Standard 90.1-2004
Modeling Methods

Energy Cost Budget (ECB) Method

- ASHRAE Std 90.1, §11
- Demonstrates code compliance
- Compares proposed building to a “budget” building that minimally complies with mandatory + prescriptive requirements

Performance Rating Method (PRM)

- Appendix G
- Modification of ECB Method
- Quantifies performance that substantially exceeds Std 90.1 requirements

Both ECB & PRM include simulation software requirements

90.1-2004 requirements for Simulation Software

- **Individually simulated hours**
  - ECB – minimum of 1,400
  - PRM – minimum of 8,760
- **Accounts for hourly load variations** (occupancy, lighting and equipment power, thermostat setpoints, HVAC operation)
- **Accounts for thermal mass**
- **Models at least 10 thermal zones**
- **Accounts for unloading curves and condenser relief**

90.1-2004 requirements for Simulation Software

- **Models economizers with integral control**
  - ECB – airside and waterside
  - PRM – airside
- **Calculates energy cost via utility rates or exports energy usage data**
- **Capable of performing design load calculations**
- **Uses hourly values of climate data, such as temperature and humidity**
- **Tested with ASHRAE Standard 140 (ECB)**

90.1-2004 requirements for Simulation Software

Which ones measure up?

- DOE 2.x
- TRACE™ 700
- EnergyPlus
- BLAST
- HAP
- Energy-10

... among others

Requirements
Design Model

Proposed building

- Accurately model design documents
- Include all end-use load components (G)
- Simulate as heated and cooled
- If a system is not designed (e.g., lighting), then match baseline building

Baseline building

- Same number of floors as proposed building
- Conditioned floor area matches that of proposed building

Requirements
Space Use Classification

Proposed building

- Usage specified using building type or space type classifications from lighting section
- If mixed-use facility, may use more than one building type

Baseline building

- Same as proposed design

Requirements
Schedules

Proposed building

- **Include:** Occupancy, lighting power, system operation, thermostat setpoints, miscellaneous equipment power
- **Schedule alteration exceptions (G):** Daylighting, natural ventilation, demand-controlled ventilation, service-water heating load reductions

Baseline building

- **Include:** Same as proposed design
- No daylighting, natural ventilation, demand-controlled ventilation, service water heating load reductions

Requirements
Envelope

Proposed building

- Model architectural drawings or as-built for existing buildings
- Model automated shades or blinds and permanent shading devices

Baseline building

- Same dimensions as proposed design
- Maximum vertical fenestration
  - 50% of wall area (11)
  - 40% of wall area (G)
- Horizontal bands of equal fenestration % on all orientations with no shading devices (G)
- Opaque assemblies match proper 90.1 table
  - Identical heat capacity of proposed design (11)
  - Lightweight assembly (G)
- Rotate model 90°, 180°, 270° … average four results (G)

Requirements
Lighting

Proposed building

- Actual lighting power if designed
- If not designed, use Building Area Method
- Include task, furniture-mounted lighting
- Include parking-garage, and facade lighting (G)
- Include automated lighting control (e.g., daylighting)

Baseline building

- Based on same building category, equals maximum allowed in Std 90.1
- Lighting schedules that comply with Std 90.1's control requirements
- No automated lighting control

Requirements
Thermal Blocks

Proposed building

- Model thermal zones or blocks
- Model HVAC as designed …
  If not designed, then identical to baseline
- Model SWH as designed …
  If not designed, then identical to baseline

Baseline building

- Same as proposed
- Model HVAC to comply with Std 90.1 system requirements
- Same energy source as proposed

Requirements
Receptacle & Other Loads

Proposed building

- Receptacle and process loads same as baseline … except as authorized by rating authority

Baseline building

- Other loads, such as motors, must meet minimum Std 90.1 requirements

ECB
Baseline System Type

Condenser Cooling Course	Heating System Classification	Budget System Type: Single Zone Residential System	Budget System Type: Single Zone Non-Residential System	Budget System Type: All Other Systems
Water/ Ground	Electric Resist.	System 5	System 5	System 1
	Heat Pump	System 6	System 6	System 6
	Fossil Fuel	System 7	System 7	System 2
Air/ None	Electric Resist.	System 8	System 9	System 3
	Heat Pump	System 8	System 9	System 3
	Fossil Fuel	System 10	System 11	System 4

Figure 11.4.3 from ASHRAE Standard 90.1-2001

Baseline system descriptions from ASHRAE Standard 90.1-2004: Table 11.3.2A

	System type	Fan control	Cooling	Heating
System 1	VAV w/PFP boxes	VAV	Chilled water	Electric resistance
System 2	VAV w/reheat	VAV	Chilled water	Hot water fossil fuel boiler
System 3	Pkgd rooftop VAV w/PFP boxes	VAV	DX	Electric resistance
System 4	Pkgd rooftop VAV w/reheat	VAV	DX	Hot water fossil fuel boiler
System 5	2-Pipe Fan-Coil	CV	Chilled water	Electric resistance
System 6	Water source heat pump	CV	DX	Electric heat pump & Boiler
System 7	4-Pipe Fan-Coil	CV	Chilled water	Hot water fossil fuel boiler
System 8	Pkgd terminal heat pump	CV	DX	Electric heat pump
System 9	Pkgd rooftop heat pump	CV	DX	Electric heat pump
System 10	Pkgd Terminal Air Conditioner	CV	DX	Hot water fossil fuel boiler
System 11	Pkgd rooftop air conditioner	CV	DX	Fossil fuel furnace

Building type	Baseline HVAC system types • Fossil fuel • Fossil/electric hybrid • Purchased heat	• Electric and other
RESIDENTIAL	**PTAC**	**PTHP**
NONRESIDENTIAL **Floors: 3 or less** **Area: < 75,000 ft²**	**PSZ-AC**	**PSZ-HP**
Floors: 4 or 5 **Area: < 75,000 ft²** **Floors: 5 or less** **Area: ≥ 75,000 ft² ≤ 150,000 ft²**	**Packaged VAV with reheat**	**Packaged VAV w/PFP boxes**
Floors: 5 or more or **Area: > 150,000 ft²**	**VAV with reheat**	**VAV w/PFP boxes**

From ASHRAE Standard 90.1-2004: Table G3.1.1A

System no.	System type	Fan control	Cooling	Heating
1 PTAC	Pkgd terminal air conditioner	CV	DX	Hot water fossil fuel boiler
2 PTHP	Pkgd terminal heat pump	CV	DX	Electric heat pump
3 PSZ-AC	Pkgd rooftop air conditioner	CV	DX	Fossil fuel furnace
4 PSZ-HP	Pkgd rooftop heat pump	CV	DX	Electric heat pump
5 Pkgd VAV w/reheat	Pkgd rooftop VAV w/reheat	VAV	DX	Hot water fossil fuel boiler
6 Pkgd VAV w/PFP boxes	Pkgd rooftop VAV w/reheat	VAV	DX	Electric resistance
7 VAV w/reheat	Pkgd rooftop VAV w/reheat	VAV	Chilled water	Hot water fossil fuel boiler
8 VAV w/PFP boxes	VAV w/reheat	VAV	Chilled water	Electric resistance

Baseline system descriptions from ASHRAE Standard 90.1-2004: Table G3.1.1B

Appendix G
Performance Rating Method

Percent improvement:

$$100 \times \frac{\text{baseline bldg performance} - \text{proposed bldg performance}}{\text{baseline bldg performance}}$$

Both models include all end-use loads (receptacles, process loads, etc.)

Appendix G
Baseline HVAC System

- **Economizer**
  - Inclusion based on climate, floor area, and baseline HVAC
  - High-limit shutoff
- **Fan power is specified**
- **Building area determines number and size(s) of chillers and boilers**

example
Single-Story Office

Synopsis:

- 15,000 ft², natural gas heat, St. Louis (climate zone 4A)
- Modeled per Std 90.1-2004, Appendix G
- No glass or insulation changes
- Options from ASHRAE's *Advanced Energy Design Guide for Small Office Buildings* (based on Std 90.1-1999)

office example

Baseline HVAC System

Per Tables G.3.1.1A & 1B in Appendix G, Std 90.1-2004:

System 3
Packaged single-zone air conditioner

- Packaged rooftop air conditioner
- Constant-volume fan control
- Direct-expansion cooling
- Fossil fuel heating

example

Office Building Layout

plan view

elevation view

office example

Modeling Energy Options

Option	Baseline design	Proposed design
Lighting	1.0 W/ft² (max office-bldg allowance)	0.9 W/ft²
Daylighting	None	Cont. Dimmer
Economizer	None required	Comparative enthalpy
Fan modulation	Constant volume	Variable volume
Fan-pressure optimization	Not applicable	Yes
Equipment efficiency	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
Ventilation Based on	ASHRAE Std 62	ASHRAE Std 62 & Ventilation reset

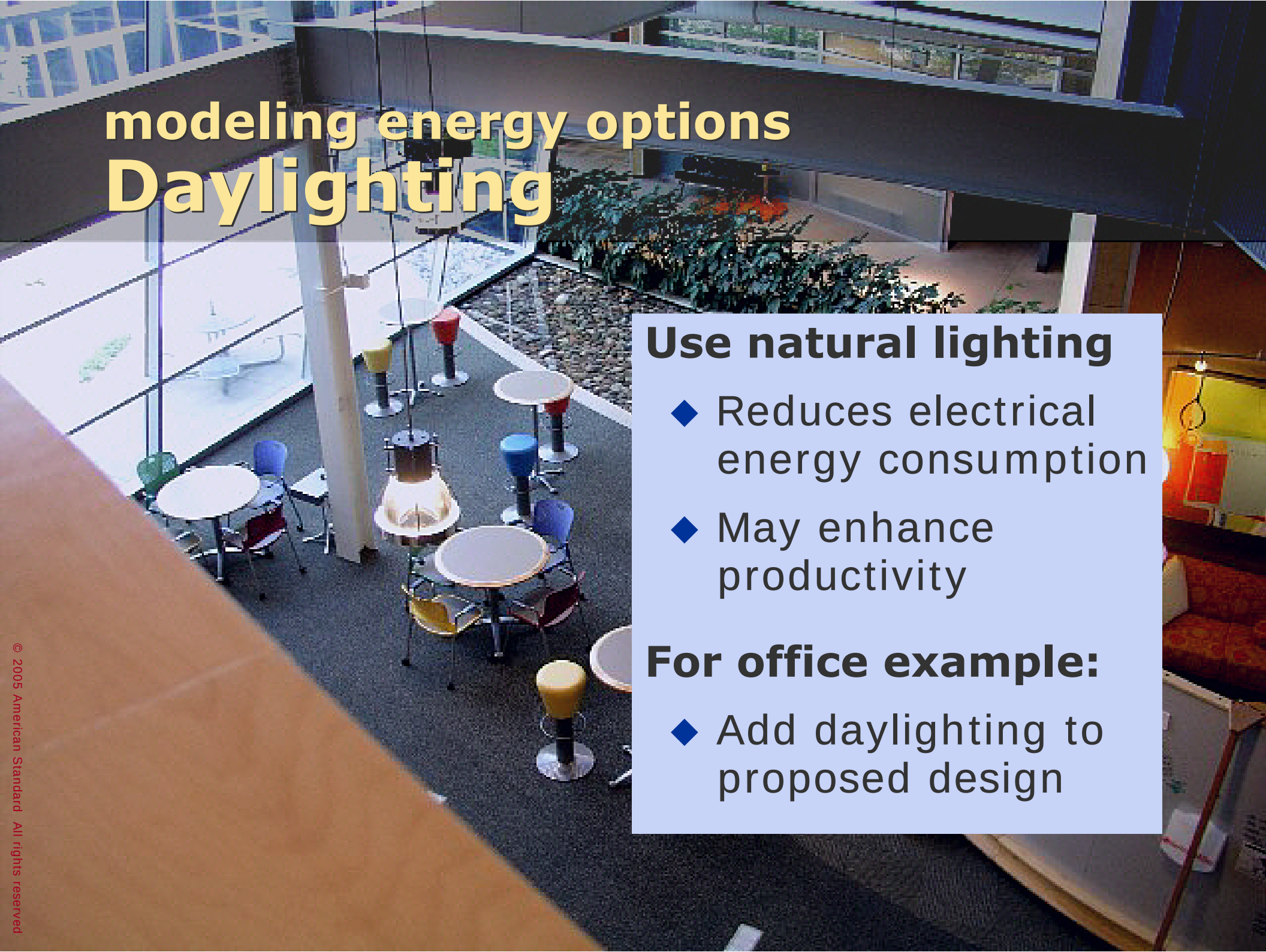
modeling energy options
Lighting Power

Reduce the lighting load

- Directly reduces electrical energy consumption
- Indirectly reduces HVAC cooling load

For office example:

- Change 0.9 W/ft² (proposed) to 1.0 W/ft² (baseline)



modeling energy options
Daylighting

Use natural lighting

- Reduces electrical energy consumption
- May enhance productivity

For office example:

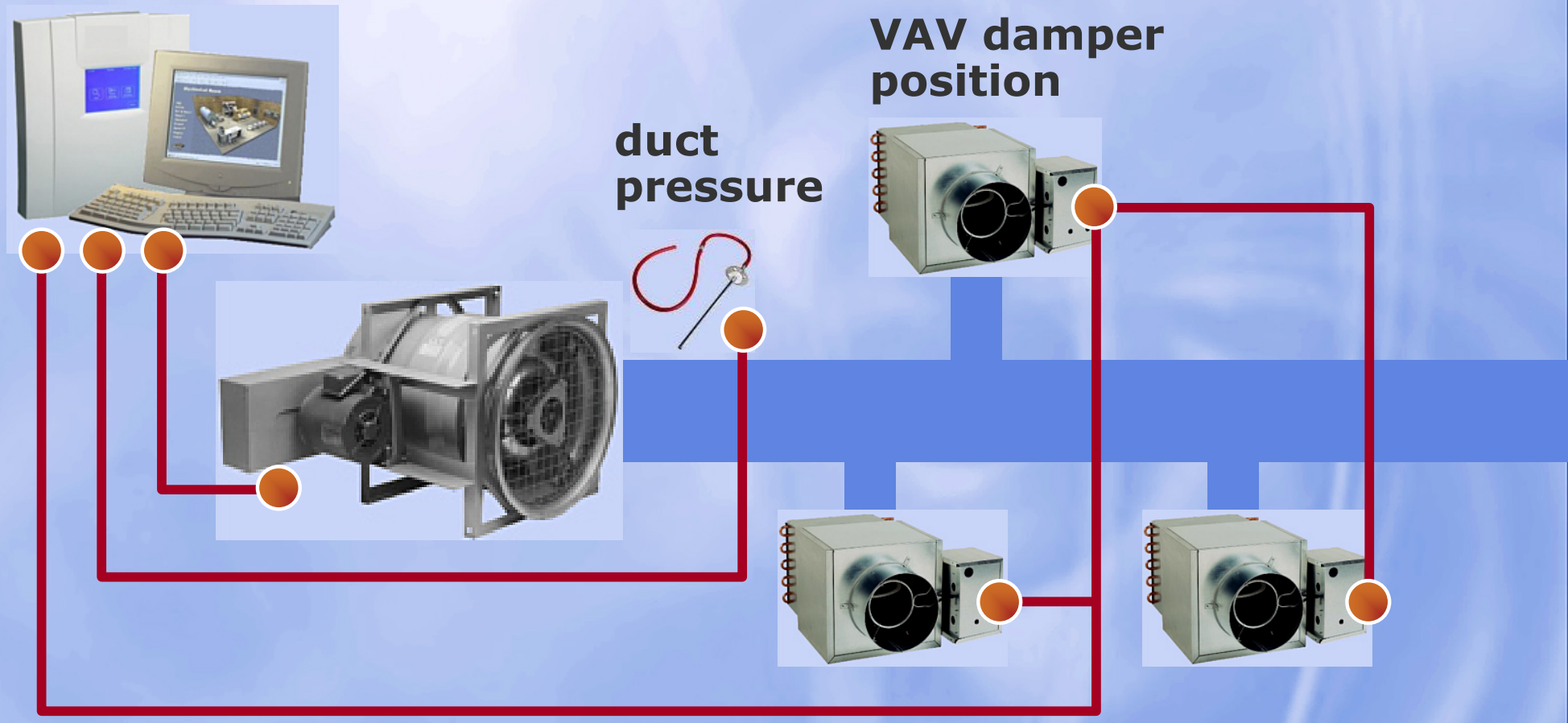
- Add daylighting to proposed design

office example

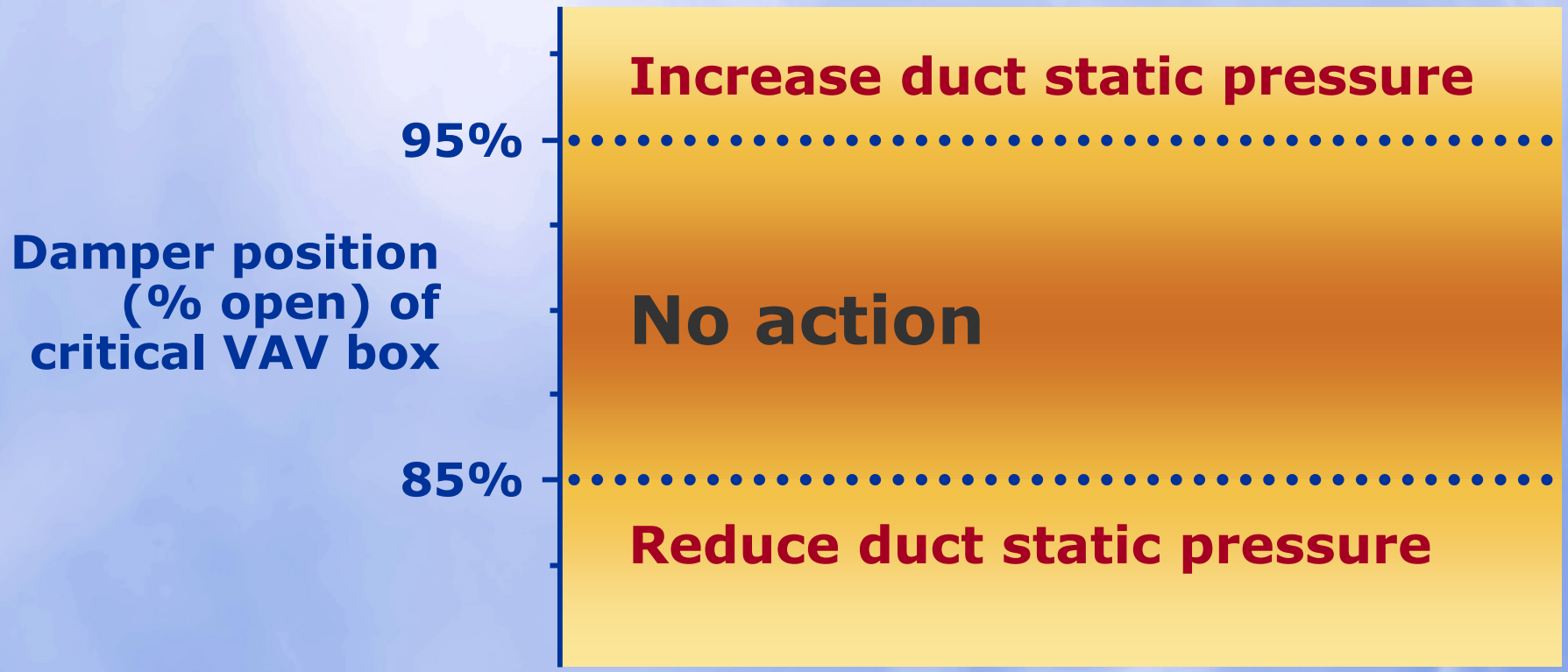
HVAC System Options

- **Economizer**
  - Reduces mechanical cooling load when outdoor air is suitable
  - Increases ventilation air for occupants
- **Variable air volume**
  - Helps control humidity at part load
  - Delivers colder air to the space than constant volume

office example
Fan-Pressure Optimization



fan-pressure optimization
Control Logic



dynamic system OA control
Ventilation Reset

RA

central station air handler with controls

- Total supply airflow

OA

SA

- Reset outdoor airflow

communicating BAS

- Critical space identified
- Sys vent efficiency
- New OA setpoint

DDC/VAV terminals

- Required ventilation
- Supply airflow
- Calculated ventilation fraction

office example

Baseline Model

Building orientation	Annual energy cost
 As proposed	$24,057
 90° from proposed	$25,032
 180° from proposed	$24,072
 270° from proposed	$25,198
Average	$24,590

office example

Energy Cost Comparison

Proposed design = $17,706
Baseline design = $24,590

So, proposed design:

$$100 \times \frac{\text{baseline bldg performance} - \text{proposed bldg performance}}{\text{baseline bldg performance}}$$

$$100 \times \frac{24{,}590 - 17{,}706}{24{,}590} = 27.995\% \text{ improvement}$$

office example

EAc1 Points Earned

Reduction of proposed energy cost	
New construction*	**LEED-NC 2.2 points**
10.5%	1
14	2
17.5	3
21	4
24.5	5
28	6
31.5	7
35	8
38.5	9
42	10

No rounding, so 27.995% improvement is eligible for 5 points

Energy Cost Budget
Common Mistakes

Envelope

- Maximum % glass ignored
- Opaque assembly heat capacity not constant
- Roof solar outside shortwave reflectance not set to 0.45 or 0.3

General

- Thermally dissimilar HVAC zones combined into thermal blocks

Energy Cost Budget
Common Mistakes

Systems

- Incorrect baseline system selection
- Packaged unit supply fan, condenser fan, compressor energy not properly separated
- IPLV requirement ignored
- SEER input as EER
- Equipment sizing ratio (actual/design) not used to determine baseline equipment capacity
- Fan cycling not modeled
- Fan power limitation ignored or improperly calculated
- Optimum start controls not modeled (>10,000 CFM)
- Static pressure setpoint reset not modeled (VAV fan system power > 5 hp)

Performance Rating Method
Common Mistakes

Envelop

- Maximum glass % assumed to be the same as ECB
- Lightweight assembly not used
- Roof solar outside shortwave reflectance not set to 0.3
- Glass not evenly distributed in horizontal bands across all orientations

Performance Rating Method
Common Mistakes

Systems

- Incorrect baseline system selection
- Packaged unit supply fan, condenser fan, compressor energy not properly separated
- IPLV requirement ignored
- Unmet load hours exceed 300 hours or proposed model exceeds baseline by more than 50 unmet hours
- Fan cycling not modeled
- Fan power improperly calculated
- Pump power limitations ignored
- 8760 hour simulation not used

What We Covered

- **Modeling requirements for LEED-NC Version 2.2**
  ASHRAE/IESNA Standard 90.1-2004
  - **Energy Cost Budget**
  - **Performance Rating Method**
- **Office example**
  Reducing building loads also reduces equipment capacity and energy use
- **Common mistakes**

THANK YOU

This concludes the ASHRAE & AIA Continuing Education Systems Program

Please visit the website

www.ashraemadison.org/crc2007

Questions or Comments??

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