Hospital Design and the 50% Advanced Energy Design Guide

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Course Description

Since 2002, ASHRAE, the Illuminating Engineering Society (IES), USGBC, and AIA, with support from the Department of Energy, have collaborated on a series of Advanced Energy Design Guides (AEDGs) that result in significant energy savings in the built environment beyond what is expected by using only ASHRAE Standard 90.1. The AEDG series of documents is now one of the most popular publications in ASHRAE's history with over 600,000 copies in circulation.

This program provides a brief history of the AEDG Series, and then focuses on the 50% Large Hospital AEDG which will be covered in detail including examples of recommendations, case studies, technologies, systems, and controls to reduce energy use by 50% or more (compared to ASHRAE 90.1-2004).

Recommended audience:

Hospital facility managers and environmental directors, ASHE members, consulting engineers, contractors, facilities managers, and students.

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50% Hospital Advance Energy Design Guide

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Learning Objectives

- Understand importance of, purpose for, and background of, the Advanced Energy Design Guide series
- Learn how to find and use the AEDG documents
- Identify integrated energy saving recommendations in the Large Hospital AEDGs to reduce energy costs
- Reap benefits of using AEDGs to achieve Optimize Energy Performance credits

Advanced Energy Design Guides Goals

- Provide a two-page list of recommendations to reduce energy use in buildings
  - A way, but not the only way, to construct an energy-efficient building that uses significantly less energy than a code-compliant building
  - At least 50% energy savings as compared to ASHRAE/IESNA Standard 90.1-2004
    - 50% progress toward net-zero energy building
- Transfer energy dollars to other resources

AEDG Partnership

- Collaboration of professional organizations and DOE
- Specialized Project Committee for each guide
- Oversight is provided via AEDG Steering Committee
- Backed by DOE's national laboratory leadership, energy simulation, technical analysis and support
- Open peer review and commentary process

Five 50% Guides
Baseline: ASHRAE 90.1-2004

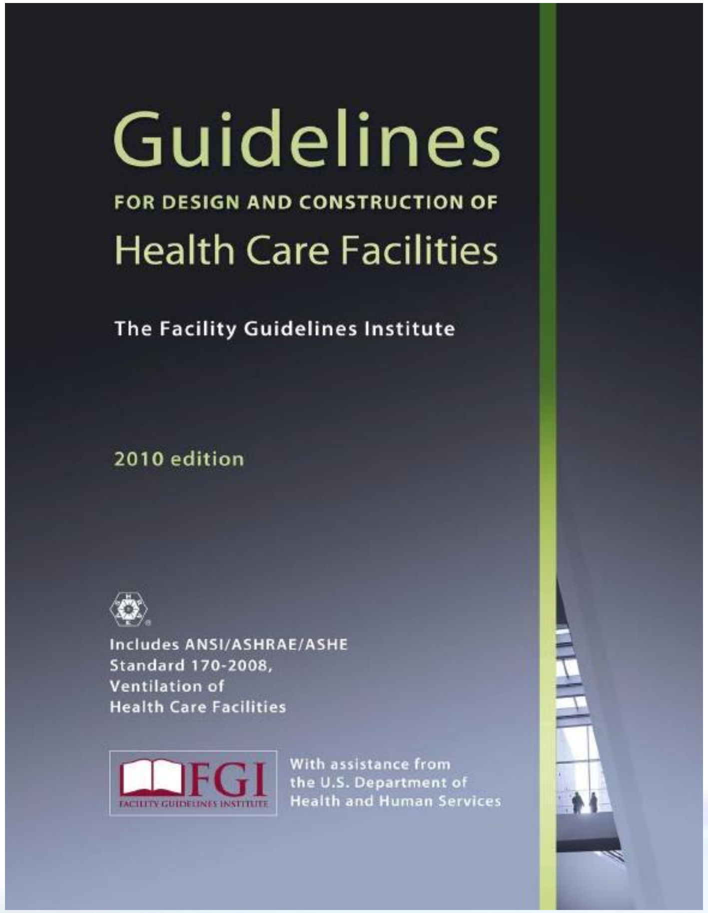
www.ashrae.org/freeaedg

Guide Development

- Meet all requirements of ANSI/ASHRAE Standards
  - 55 (comfort),
  - 62.1 (ventilation and indoor air quality), and
  - 90.1 (energy)
- Based on whole building energy savings
- Energy is independent variable and cost-effectiveness is dependent variable
- Off-the-shelf technology (must be available from at least two manufacturers)
- Building specific expertise for each guide

Specifically for Large Hospital AEDG

- *Guidelines for the Design and Construction of Healthcare Facilities* – 2010 Edition
- Includes ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities



Large Hospital Project Committee

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- Merle McBride (Vice Chair)
- Mara Baum & Ray Pradinuk (AIA)
- Walt Vernon (ASHE)
- Jeff Boldt & Mick Schwedler (ASHRAE)
- John Gill & Joel Loveland (IES)
- John D’Angelo & Kim Shinn (USGBC)
- Tim Peglow (At-Large)
- Eric Bonnema (NREL) and Matt Leach (NREL)

Forward Excerpts

- *“Most important in AEDG for Hospitals is the recognition that patient outcomes, safety, and experience trump all cost- and energy-saving strategies.”*
- *“The AEDG for Large Hospitals shows that existing reliable technologies and design philosophies can be used to reduce energy use in large hospitals by up to 50% of ANSI/ASHRAE/IESNA Standard 90.1-2004….”*

1 - Introduction

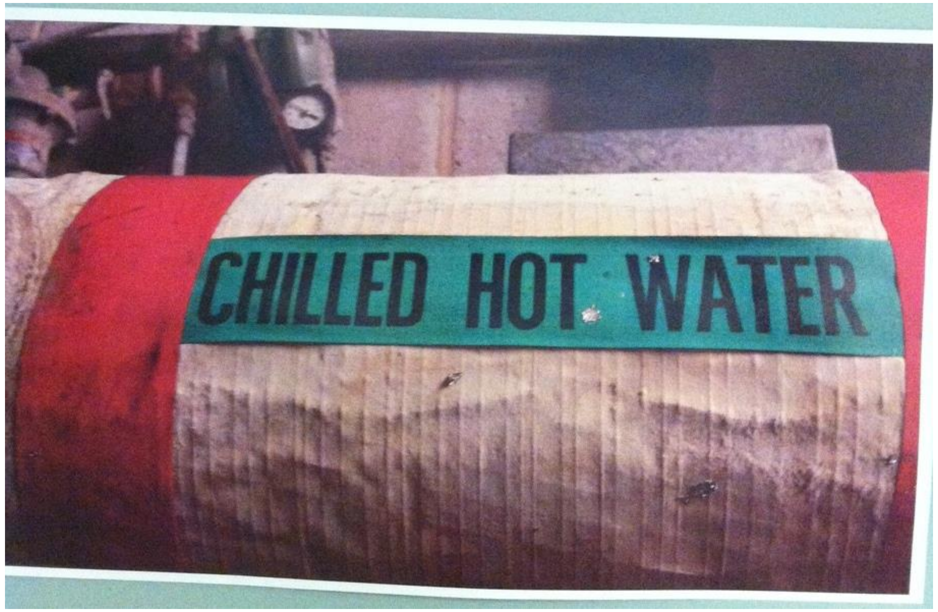
- Conditions to promote health and comfort
  - Ventilation and Indoor Air Quality (IAQ)
    - Refer to Indoor Air Quality Guide
  - Thermal comfort
    - Metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity
  - Visual comfort
    - Daylighting
  - Acoustic comfort

Scope

- Standard hospitals ≥ 100,000 ft2
- Space Types: reception/waiting, examination, treatment, OR, recovery, clean & soiled workrooms, nurses station, nursery, patient room, pharmacy, triage, trauma, ER, physical therapy, cafeteria, kitchen, conference, office, radiology/imaging, storage, mechanical & electrical rooms.
- Excludes: Atypical, special-use spaces

Integrated Design?

- Do we really think we're going to get to 50% energy savings using our present practices?



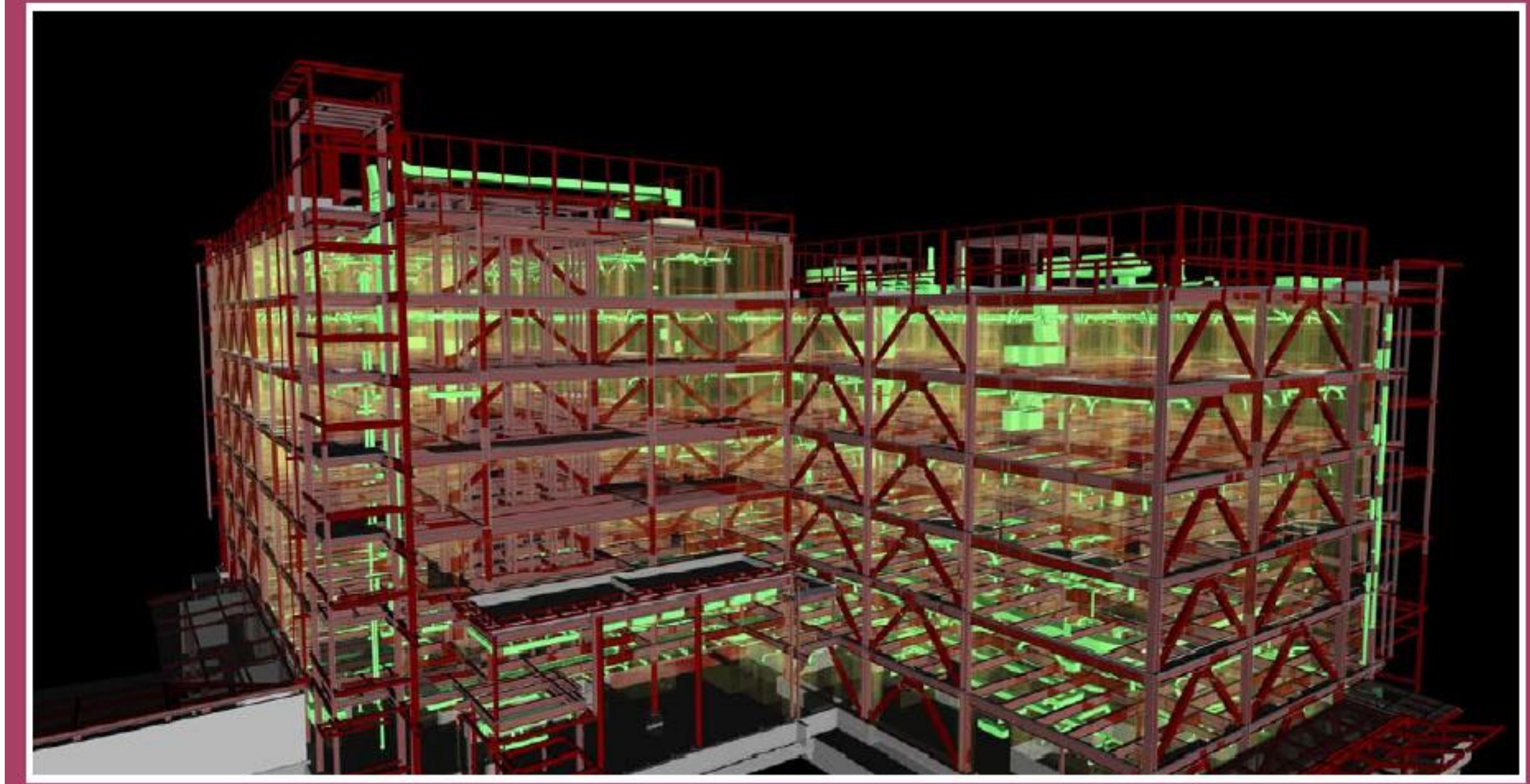
- No, this is **<u>not</u>** good integrated design!

Integrated Design

- Early involvement of **<u>all</u>** team members
- Agreed-upon, objective, and documented common goals
- Open communication about meeting the agreed upon metrics and goals
- Assessment of metrics and goals for a minimum of 3-5 years post-occupancy

All working with reciprocal respect and trust

ASHRAE Digital Lighthouse



Example BIM Output
Reprinted with permission of HOK

Integrated Design

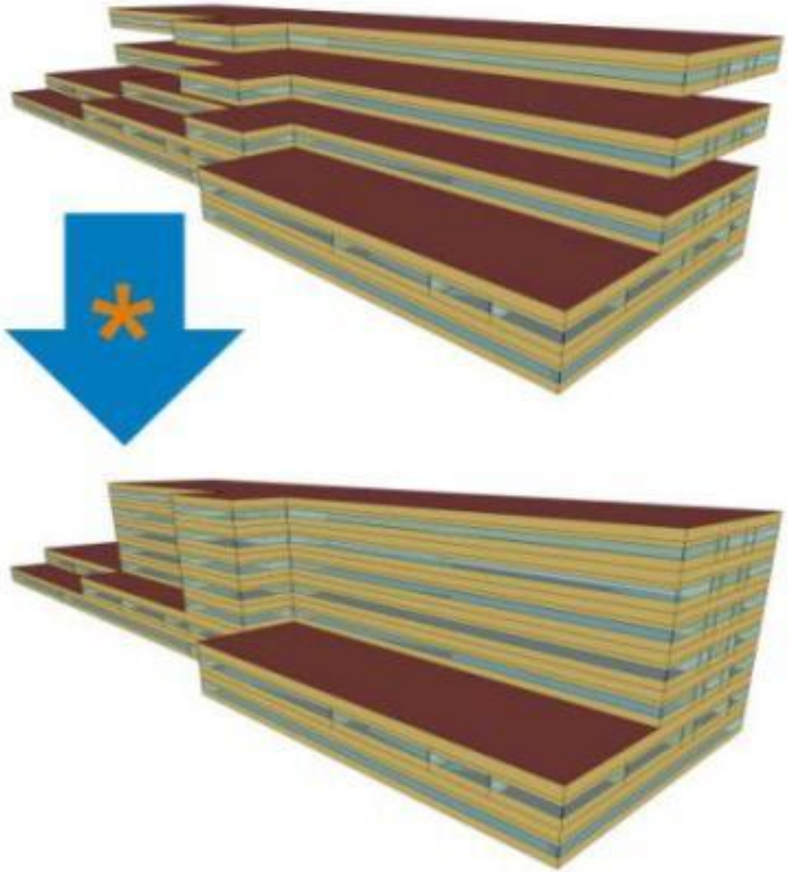
CLEVELAND CLINIC A CASE STUDY

Cleveland Clinic Northeast Ohio Campus
Photos courtesy of Cleveland Clinic

y (left) and Heliport Landing Area (right)

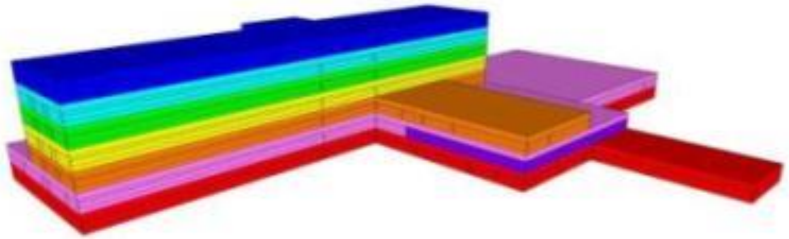
Baseline Prototype Characteristics
50% Hospital AEDG

Model Parameter	Value
Total floor area	427,000 ft^2
Floor-to-floor height	9 ft
Floor-to-ceiling height	14 ft D&T 13 ft IPU/other
Number of floors	7
WWR (floor-to-ceiling)	40%
WWR (floor-to-floor)	26% D&T 28% IPU/other
Glazing sill height	3.6 ft
Glazing height	3.7 ft
Exterior wall type	Mass
Roof type	IEAD
*Floor multiplier of 3 on patient tower	



Baseline Prototype HVAC Systems
50% Hospital AEDG

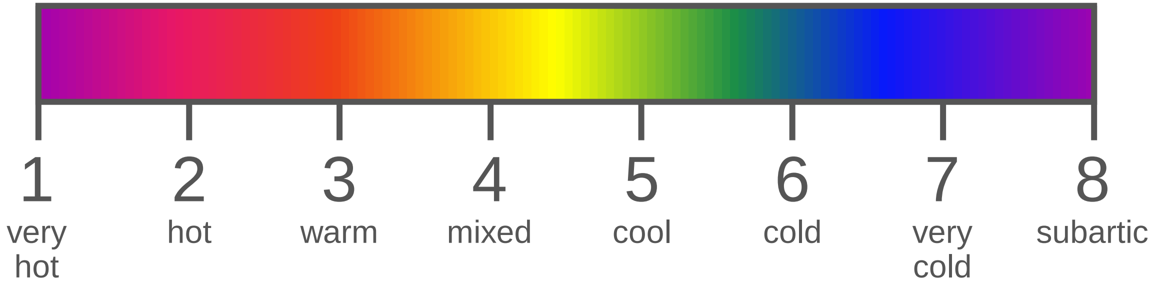
- Central VAV air-handlers
  - Terminal box minimum flow at required ACH for spaces in Standard 170
  - Terminal box minimum flow fraction of 0.3 for spaces not in Standard 170
- 55°F supply air temperature
- Chilled water cooling coils
- Hot water preheat coils
- Variable speed fan
  - 60% static efficiency
  - 8 in w.c. pressure drop
- Electric steam humidifiers
  - Gas-fired humidifiers are not an option in EnergyPlus
  - 1,000,000 W at 354 gal/h
- Hot water terminal reheat



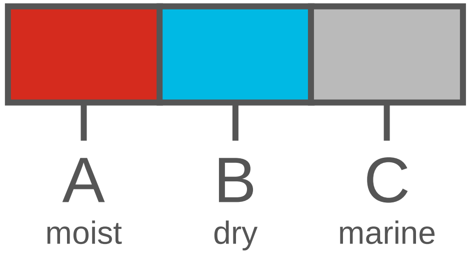
(red)	AHU-1	Floor 1	VAV
(pink)	AHU-2	Floor 2	VAV
(orange)	AHU-3	Floor 3	VAV
(yellow)	AHU-4	Floor 4	VAV
(green)	AHU-5	Floor 5	VAV
(cyan)	AHU-6	Floor 6	VAV
(blue)	AHU-7	Floor 7	VAV
(purple)	SURG	Surgery Suite	VAV

Climate Zones

- Groups climates into 8 zones



- Subcategorizes zones by humidity level

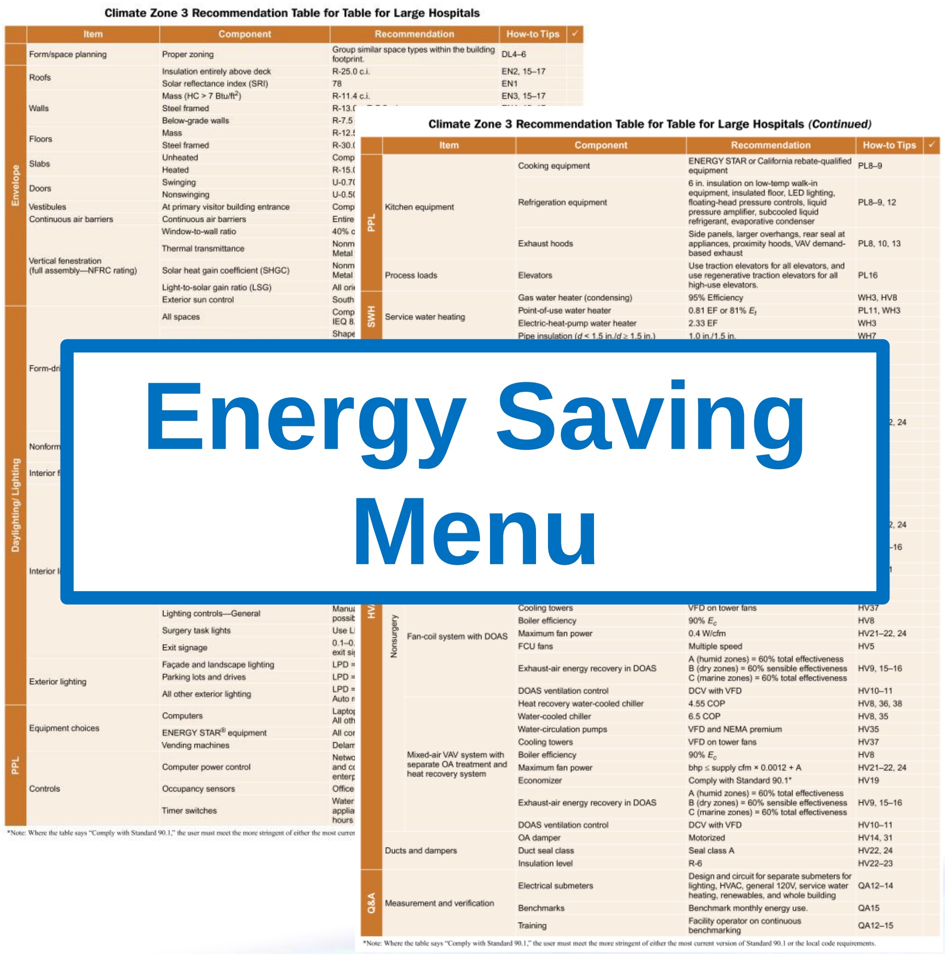


Look up climate zones by location …

Miami = 1A
Seattle = 4C
Reykjavik = 7

Recommendations by Climate Zone; Each CZ table fits on two pages

- **Building envelope**
  - insulation, fenestration, leakage
- **Lighting**
  - interior, exterior, daylighting
- **HVAC**
  - design, equipment, controls
- **Plug/process loads**
  - equipment, controls, kitchens
- **Service water heating**
  - equipment, insulation
- **Measurement & verification**



Source: 50% AEDG Large Hospitals from ASHRAE

Recommendation Table Contents

Item	Component	Recommendation	How-to Tips

- How-to Tips contain
  - Specific recommendations
  - Guidance on good practice for implementation
  - Cautions to avoid known problems

Climate Zone 3 Recommendation Table for Table for Large Hospitals

	Item	Component	Recommendation	How-to Tips	✓
	Form/space planning	Proper zoning	Group similar space types within the building footprint.	DL4–6	
	Roofs	Insulation entirely above deck	R-25.0 c.i.	EN2, 15–17	
		Solar reflectance index (SRI)	78	EN1	
	Walls	Mass (HC > 7 Btu/ft^2)	R-11.4 c.i.	EN3, 15–17	
		Steel framed	R-13.0 + R-7.5 c.i.	EN4, 15–17	
		Below-grade walls	R-7.5 c.i. (Comply with Standard 90.1* in 3A)	EN5, 15–17	
	Continuous air barriers	Continuous air barriers	Entire building envelope	EN13	
	Vertical fenestration (full assembly—NFRC rating)	Window-to-wall ratio	40% of net wall (floor-ceiling)	DL7, EN20	
		Thermal transmittance	Nonmetal framing windows = 0.56 Metal framing windows = 0.65	EN18-20, 22–25	
		Solar heat gain coefficient (SHGC)	Nonmetal framing windows = 0.41 Metal framing windows = 0.6	EN19–20, 23–25	
		Light-to-solar gain ratio (LSG)	All orientations ≥ 1.5	EN24	
		Exterior sun control	South orientation only – PF = 0.5	EN21, DL13–14	
Daylighting/ Lighting	Form-driven daylighting option	All spaces	Comply with LEED for healthcare credits IEQ 8.1 (daylighting) and IEQ 8.2 (views)	DL3–6	
		Diagnostic and treatment block	Shape the building footprint and form such that the area within 15 ft of the perimeter exceeds 40% of the floorplate.	DL6	
		Inpatient units	Ensure that 75% of the occupied space not including patient rooms lies within 20 ft of the perimeter.	DL6	
		Staff areas (exam rooms, nurse stations, offices, corridors); public spaces (waiting, reception); and other regularly occupied spaces as applicable	Design the building form to maximize access to natural light, through sidelighting and toplighting.	DL8–14, 20–23	
	Nonform-driven daylighting option	Staff areas (exam rooms, nurse stations, offices, corridors) and public spaces (waiting, reception)	Add daylight controls to any space within 15 ft of a perimeter window.	DL20–23	
	Interior finishes	Room interior surface average reflectance	Ceilings ≥ 80% Walls ≥ 70%	DL17	
	Interior lighting	Lighting power density (LPD)	Whole building = 0.9 W/ft^2 Space-by-space per Table 5-4	EL1, 12–20	
		Light source efficacy (mean lumens per watt)	T8 & T5 > 2 ft = 92 T8 & T5 < 2 ft = 85 All other >50	EL2–5	
		Ballasts—4 ft T8 Lamps	Nondimming = NEMA Premium Dimming= NEMA Premium Program Start	EL2	
		Ballasts—Fluorescent and HID	Electronic	EL2–5	
		Dimming controls daylight harvesting	Dim all fixtures in daylighted zones.	DL20–23, EL11	
		Lighting controls—General	Manual ON, auto/timed OFF in all areas as possible.	EL6,21	
		Surgery task lights	Use LED lights exclusively.	EL14	
		Exit signage	0.1–0.2 W Light Emitting Capacitor (LEC) exit signs exclusively	EL22	
	Exterior lighting	Façade and landscape lighting	LPD = 0.15 W/ft^2	EL23	
		Parking lots and drives	LPD = 0.1 W/ft^2	EL23	
		All other exterior lighting	LPD = Comply with Standard 90.1* Auto reduce to 25% (12 am–6 am)	EL23	
PPL	Equipment choices	Computers	Laptops = minimum 2/3 of total computers All others = mini desktop computers	PL2	
		ENERGY STAR® equipment	All computers, equipment, appliances	PL5	
		Vending machines	Delamp and specify best in class efficiency.	PL3, 7	
	Controls	Computer power control	Network control with power saving modes and control during unoccupied hours or IT enterprise power management software	PL2	
		Occupancy sensors	Office plug occupancy sensors	PL3	
		Timer switches	Water coolers, coffee makers, small appliances = auto OFF during unoccupied hours	PL3	

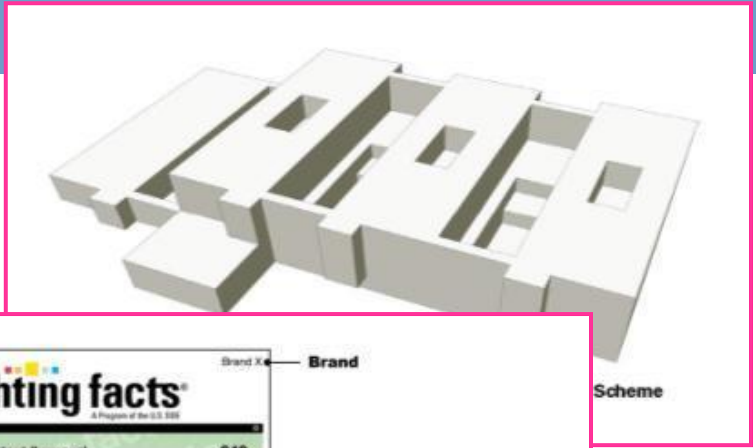
Source: 50% AEDG Large Hospitals from ASHRAE

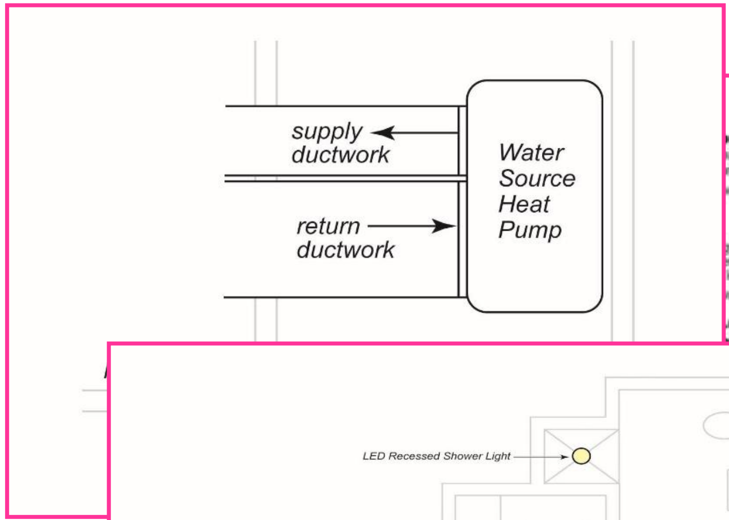
How-to Tips

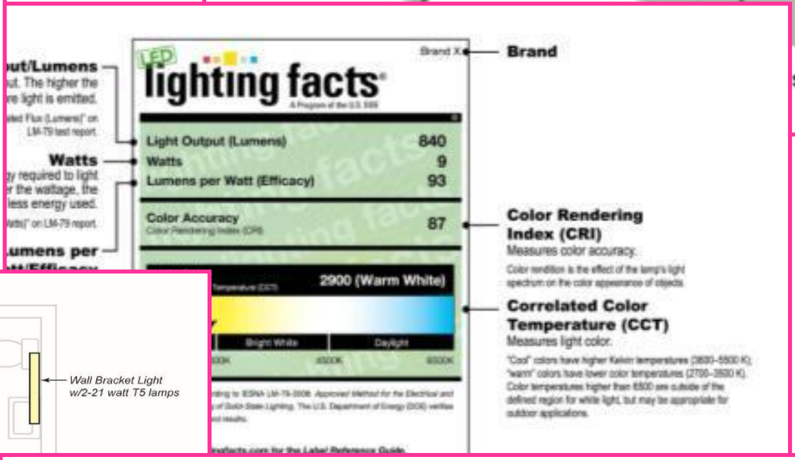
Type	Abbreviation	Number of Tips
Envelope	EN	29
Daylighting	DL	23
Electric lighting	EL	24
Plug and process loads	PL	17
Water heating	WH	7
HVAC	HV	40
Quality Assurance	QA	15
Additional Bonus Savings		
Additional HVAC	HV	5
Renewable energy	RE	4
Electrical distribution	ED	3

How-to Tip Examples

Illustrations of Concepts







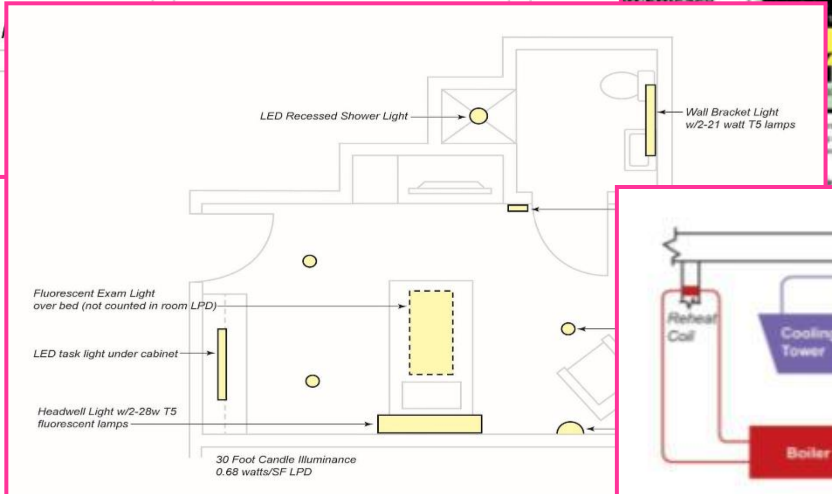


Figure 5-18 (EL11) Patient Room Lighting

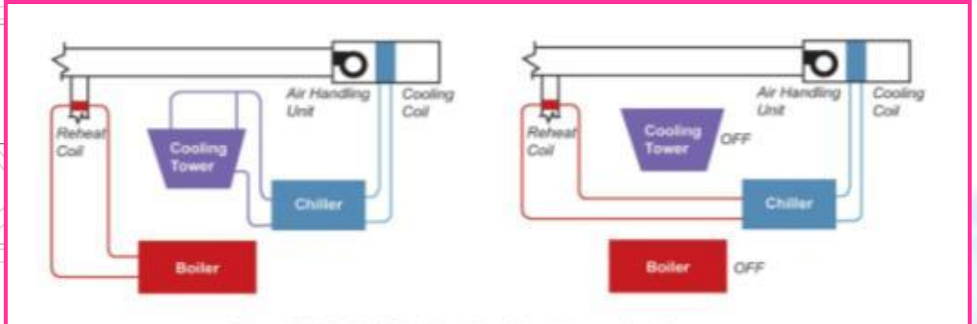


Figure 5-36 (HV38) Principle of Condenser Heat Recovery

Source: 50% AEDG Large Hospitals from ASHRAE

More How-to Tips

Tables of Information

Table 5-5 Efficacy Values for Different Linear Fluorescent Lamp/Ballast Combinations (with Two Lamps)

Ballast	Lamp Selection				
	F32T8 Standard	F32T8 Premium	F32T8 High Performance	F28T5 Standard	F28T5 Premium
Generic Standard Instant Start (59 W, 0.87 BF-T8/1.0 T5)	77	80	87	NA	NA
Standard Instant Start Low Light Level (54 W, 0.78 BF)	75	78	85	NA	NA
Standard Instant Start High Light Level (74 W, 1.15 BF)	81	84	92	NA	NA
Standard Program Start Normal Light Level (60 W, 0.88 BF)	78	82	88	95	100
Program Start Low Light Level (56 W, 0.78 BF)	73	75	82	NA	NA
Dimming Rapid Start (64 W max, 0.88 BF-T8/1.0 T5)	72	75	81	NA	[illegible]
High-Performance Normal Light Level (55 W, 0.88 BF-T8/ 1.0 T5)	85	90	95	95	[illegible]
High-Per[illegible] Leve[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
High-Per[illegible] Leve[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
High-Pe[illegible] Step[illegible] (54 W, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EN1 ***Cool Roofs*** (Climate Zones: ❶ ❷ ❸)

For a roof to be considered a cool roof, a Solar Reflectance Index (SI[illegible] ommended. A high reflectance keeps much of the sun's energy from [illegible] high thermal emissivity surface radiates away any solar energy that [illegible] roof to cool more rapidly. Cool roofs are typically white and have a [illegible] cial roof products that qualify as cool roofs fall into three categories: [illegible] and metal panels. Examples are presented in Table 5-1.

Table 5-1 Examples of Cool Roofs

Category	Product	Reflectance		
Single ply	White polyvinyl chloride (PVC)	0.86	[illegible]	[illegible]
	White chlorinated polyethylene (CPE)	0.86	[illegible]	[illegible]
	White chlorosulfonated polyethylene (CPSE)	0.85	[illegible]	[illegible]
	White thermoplastic polyolefin (TSO)	0.77	0.87	95
Liquid applied	White elastomeric, polyurethane, acrylic coating	0.71	0.86	86
	White paint (on metal or concrete)	0.71	0.85	86
Metal panels	Factory-coated white finish	0.90	0.87	113

Climate Zones Specified

EN7 ***Floors, Metal Joist, or Steel Framed*** (Climate Zones: all)

[illegible]ulation should be installed parallel to the framing members and in intimate contact with the [illegible]oring system supported by the framing member in order to avoid the potential thermal short-[illegible]cuiting associated with open or exposed air spaces. Nonrigid insulation should be supported [illegible]m below and no less frequently than 24 in. on center.

[illegible]ab-on-Grade Floors, Unheated (Climate Zones: ❹ ❺ ❻ ❼ ❽)

[illegible]gid c.i. should be used around the perimeter of the slab and should reach the depth listed in [illegible] recommendation or to the bottom of the footing, whichever is less.

[illegible]ab-on-Grade Floors, Heated (Climate Zones: all)

[illegible]ntinuous rigid insulation should be used around the perimeter of the slab and should reach to [illegible] depth listed or to the frost line, whichever is deeper. Additionally, in climate zone 8, contin-[illegible]us insulation should be placed below the slab as well.

Note: In areas where termites are a concern and rigid insulation is not recommended for [illegible] under the slab, a different heating system should be used.

Cleveland Clinic 100th Street Garage

Cleveland Clinic is a large, multispecialty, not-for-profit, academic medical center whose main campus is located in Cleveland, Ohio. In 2011, Cleveland Clinic used the CBEA high-efficiency parking structure lighting specification as the basis of award for conversion of their 100th Street garage from high-pressure sodium to LED. The garage is 970,250 ft^2 with over 1500 parking spaces on six partially closed floors and a rooftop level. There are 830 main garage fixtures, 28 site lighting fixtures on the roof, and 65 stairwell fixtures. In addition to being a lower wattage source, LED allowed step dimming not possible with the existing lights. 620 of the replacement lights used occupancy sensors to toggle between a high and low power setting, and the 218 fixtures closest to the perimeter used photo and occupancy sensors.

The energy savings per year is 1,276,583 kWh per year, yielding a 4.2 year simple payback. With utility incentives, the payback was reduced to 3.2 years. In addition to the energy savings, the higher quality light allowed a better performance for existing security cameras and an overall "safer" feeling for patients and staff.

Highlighted Information

Source: 50% AEDG for Large Hospitals from ASHRAE

Building Envelope Recommendations

Climate Zone 3 Recommendation Table for Table for Large Hospitals

	Item	Component	Recommendation	How-to Tips	✓
	Form/space planning	Proper zoning	Group similar space types within the building footprint.	DL4–6	
	Roofs	Insulation entirely above deck	R-25.0 c.i.	EN2, 15–17	

Vertical Fenestration

- **Window to wall Ratio:** 40%
- **Thermal Transmittance:** Nonmetal 0.56, Metal 0.65
- **SHGC:** Nonmetal framing 0.41, Metal framing 0.6
- **Light-to-solar gain ratio:** ≥ 1.5
- **Exterior sun control:** South orientation Projection Factor = 0.5

	Item	Component	Recommendation	How-to Tips	✓
	Vertical fenestration (full assembly—NFRC rating)	Window-to-wall ratio	40% of net wall (floor-ceiling)	DL7, EN20	
		Thermal transmittance	Nonmetal framing windows = 0.56 Metal framing windows = 0.65	EN18-20, 22–25	
		Solar heat gain coefficient (SHGC)	Nonmetal framing windows = 0.41 Metal framing windows = 0.6	EN19–20, 23–25	
		Light-to-solar gain ratio (LSG)	All orientations ≥ 1.5	EN24	
		Exterior sun control	South orientation only – PF = 0.5	EN21, DL13–14	

Source: 50% AEDG for Large Hospitals from ASHRAE

Lighting Recommendations

Form-driven daylighting option	All spaces	Comply with LEED for healthcare credits IEQ 8.1 (daylighting) and IEQ 8.2 (views)	DL3–6
	Diagnostic and treatment block	Shape the building footprint and form such that the area within 15 ft of the perimeter exceeds 40% of the floorplate.	DL6
	Inpatient units	Ensure that 75% of the occupied space not including patient rooms lies within 20 ft of the perimeter.	DL6
	Staff areas (exam rooms, nurse stations, offices, corridors); public spaces (waiting, reception); and other regularly occupied spaces as applicable	Design the building form to maximize access to natural light, through sidelighting and toplighting.	DL8–14, 20–23
	Staff areas (exam rooms, nurse stations,	Add daylight controls to any space within 15	

- Form-driven daylighting option (design the building to maximize access to natural light, sidelighting, toplighting
- Non form-driven daylighting option (any space within 15 feet of perimeter window)
- Interior finishes
- Interior lighting
- Exterior lighting

	Exit signage	0.1–0.2 W Light Emitting Capacitor (LEC) exit signs exclusively	EL22
Exterior lighting	Façade and landscape lighting	LPD = 0.15 W/ft^2	EL23
	Parking lots and drives	LPD = 0.1 W/ft^2	EL23
	All other exterior lighting	LPD = Comply with Standard 90.1* Auto reduce to 25% (12 am–6 am)	EL23

Source: 50% AEDG for Large Hospitals from ASHRAE

Daylighting Example

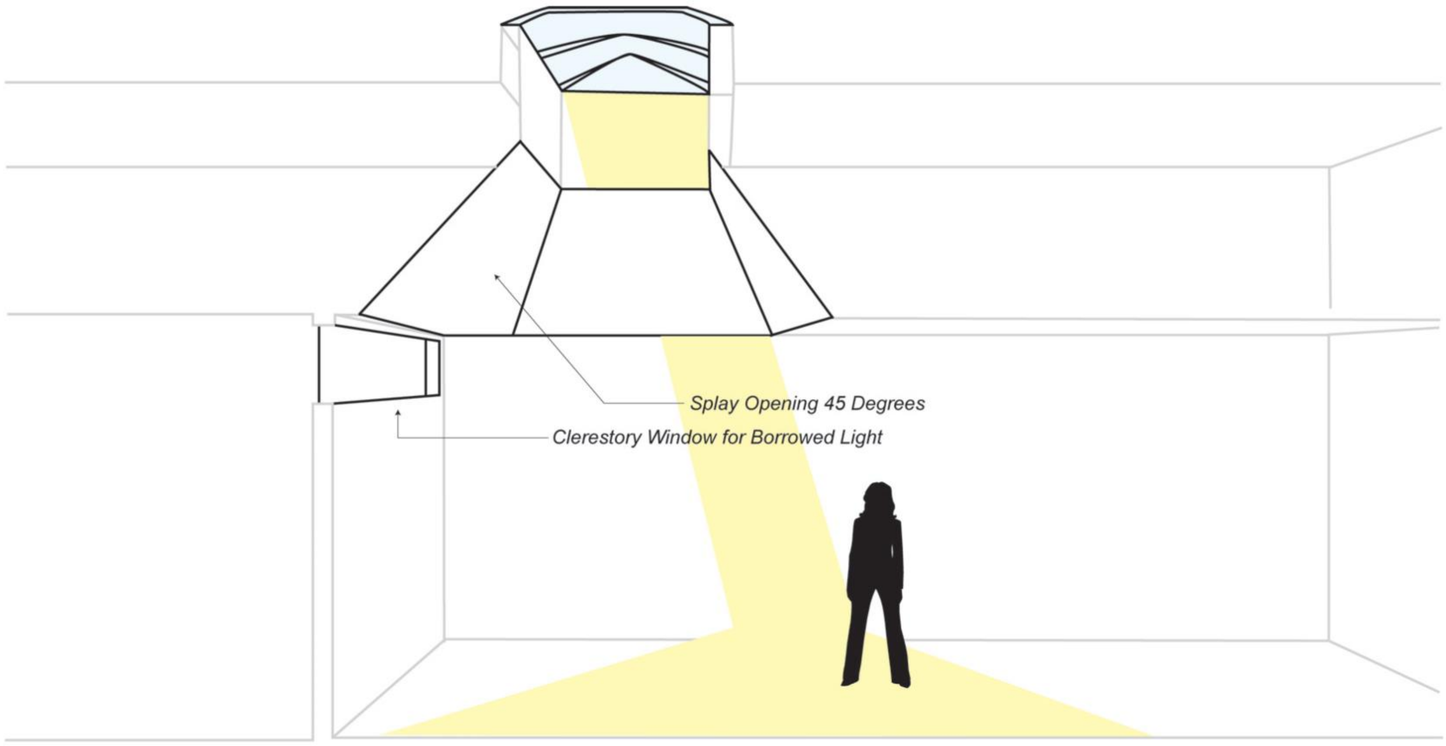


Figure 5-13 (DL13) Roof Skylight Section

Source: 50% AEDG Large Hospitals from ASHRAE

Electric Lighting: LDR

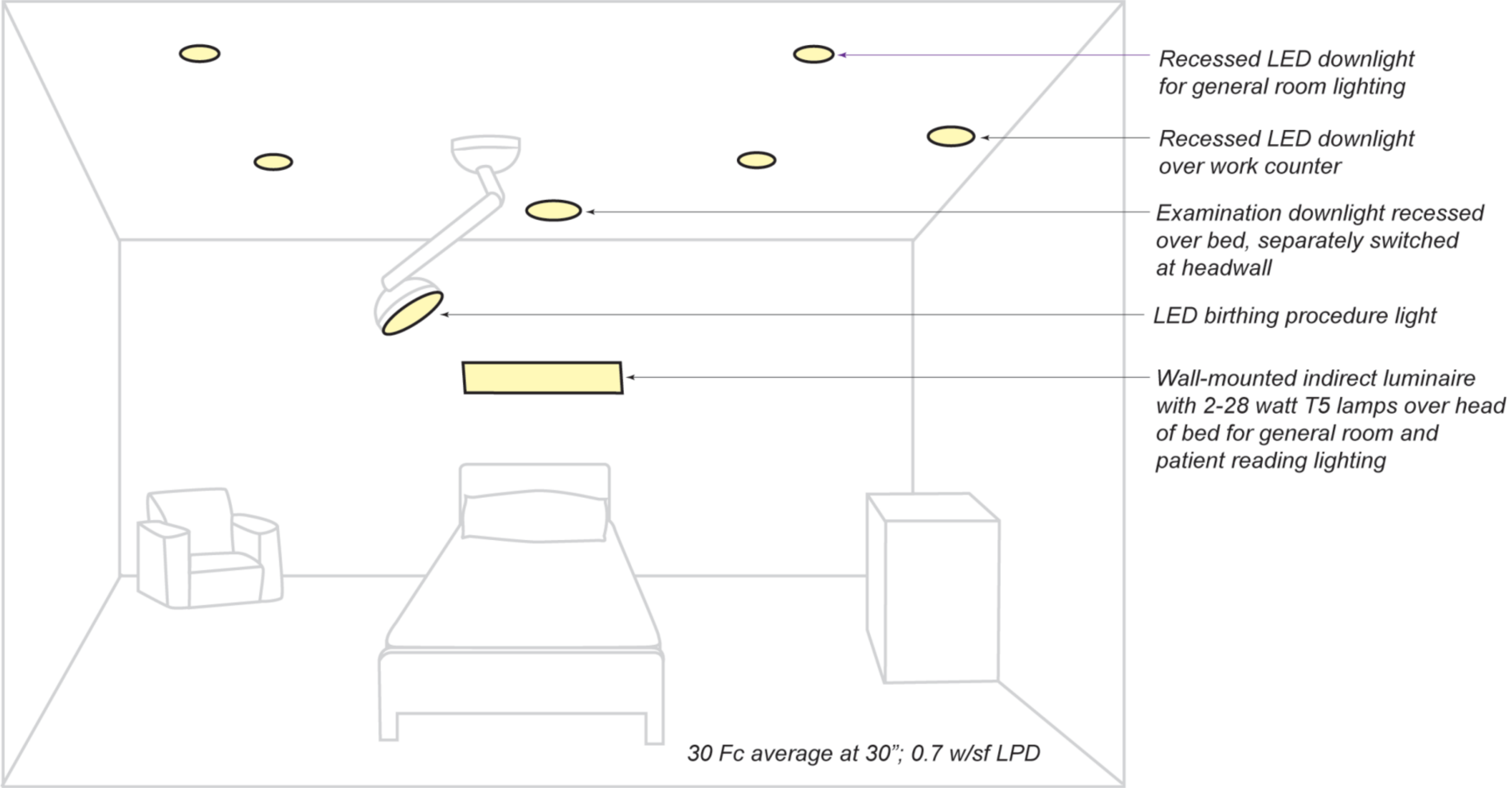


Figure 5-24 (EL17) Labor, Deliver, and Recovery (LDR) Lighting Plan

Source: 50% AEDG for Large Hospitals from ASHRAE

Plug Load Recommendations

Table 5-8 Recommendations for Efficient Plug Load Equipment

Equipment/Appliance Type	Purchase Recommendation	Operating Recommendation
Desktop computer	ENERGY STAR only	Implement sleep mode software
Laptop computer or tablet —use where practical to minimize energy consumption	ENERGY STAR only	Implement sleep mode software
Computer monitors	ENERGY STAR flat screen monitors only	Implement sleep mode software
Printer	Consider multifunction devise, ENERGY STAR only	Implement sleep mode software
Copy machine	Consider multifunction devise, ENERGY STAR only	Implement sleep mode software
Fax machine	Consider multifunction devise, ENERGY STAR only	Implement sleep mode software
Water Cooler	ENERGY STAR only	N/A
Refrigerator	ENERGY STAR only	N/A
Vending machines	ENERGY STAR only	De-lamp display lighting
TV, VCR, DVD, DVR	ENERGY STAR with flat screens and sleep modes	Many of these items are only used during peak times and should be unplugged with occupancy sensors

Source: 50% AEDG for Large Hospitals from ASHRAE

Plug and Process Load Recommendations

- **Computers:** laptops = minimum 2/3 of total computers, Power savings during unoccupied hours
- **Energy Star®:** computers, equipment appliances
- **Vending machines:** delamp and specify best in class efficiency
- **Occupancy sensors:** office plugs
- **Timer switches:** coffee makers, small appliances during unoccupied hours
- **Kitchen equipment**: Cooking equipment, refrigeration equipment, exhaust hoods
- **Elevators**: traction for all, regenerative traction for high-use

PPL			refrigerant, evaporative condenser	
		Exhaust hoods	Side panels, larger overhangs, rear seal at appliances, proximity hoods, VAV demand-based exhaust	PL8, 10, 13
	Process loads	Elevators	Use traction elevators for all elevators, and use regenerative traction elevators for all high-use elevators.	PL16

Source: 50% AEDG for Large Hospitals from ASHRAE

Food Service and Refrigeration

Table 5-9 Commercial Food Service Appliance ASTM Standard Test Methods

ASTM #	Appliance Type
F1275-03	Griddles
F1361-05	Open deep-fat fryers
F1484-05	Steam cookers
F1496-99(2005)	Convection ovens
F1521-03	Standard test methods for performance of range tops
F1605-95(2001)	Double-sided griddles
F1639-05	Combination ovens
F1695-03	Underfired broilers
F1696-96(2003)	Energy performance of single-rack hot-water sanitizing, door-type commercial dishwashing machines
F1704-05	Capture and containment performance of commercial kitchen exhaust ventilation systems
F1784-97(2	[illegible]
F1785-97(2	[illegible]
F1786-97(2	[illegible]
F1787-98(2	[illegible]
F1817-9	[illegible]
F1920-98(2	[illegible]
F1964-99(2	[illegible]
F1965-99(2	[illegible]
F1991-99(2	[illegible]
F2022-0	[illegible]
F2093-0	[illegible]
F2140-0	[illegible]
F2141-0	[illegible]
F2142-0	[illegible]
F2143-0	[illegible]
F2144-0	[illegible]
F2237-03	Upright overfired broilers
F2238-03	Rapid cook ovens
F2239-03	Conveyor broilers
F2324-03	Prerinse spray valves
F2379-04	Powered open warewashing sinks
F2380-04	Conveyor toasters
F2472-05	Staff-served hot-deli cases
F2473-05	Water bath rethermalizers
F2474-05	Heat gain to space performance of commercial kitchen ventilation/appliance systems
F2519-05	Grease particle capture efficiency of commercial kitchen filters and extractors
F2644-07	Commercial patio heaters

Table 5-10 Refrigeration Technology Savings Estimates and Applications

Technology	Estimated Savings Potential (NRC 2011)	Applicable To New Construction?	Applicable To Retrofit?
Floating head pressure controls	3% to 10%	Yes	Yes
Liquid pressure amplifier	Up to 20%	Yes	Yes
Subcooled liquid refrigerant			
Oversized condenser	5% to 9%	Yes	No
Mechanical subcooler	Up to 25%	Yes	Yes
Evaporative condensers	3% to 9%	Yes	Yes

Source: 50% AEDG for Large Hospitals from ASHRAE

Service Water Heating Recommendations

SWH	Service water heating	Gas water heater (condensing)	95% Efficiency	WH3, HV8
		Point-of-use water heater	0.81 EF or 81% E_t	PL11, WH3
		Electric-heat-pump water heater	2.33 EF	WH3
		Pipe insulation (d < 1.5 in./d ≥ 1.5 in.)	1.0 in./1.5 in.	WH7

Service water heating

- **Gas water heater:** condensing, 95% efficiency
- **Point-of-use water heater:** 0.81 EF or 81% Et
- **Electric-heat-pump water heater:** 2.33 EF
- **Pipe insulation**: 1.0 in. for d < 1.5 in., 1.5 in. for d ≥ 1.5 in.

Heating system

- No central steam for hot-water distribution system
- Point-of-use steam for humidification and sterilization

Source: 50% AEDG for Large Hospitals from ASHRAE

Measurement and Verification Recommendations

Q&A	Measurement and verification	Electrical submeters	Design and circuit for separate submeters for lighting, HVAC, general 120V, service water heating, renewables, and whole building	QA12–14
		Benchmarks	Benchmark monthly energy use.	QA15
		Training	Facility operator on continuous benchmarking	QA12–15

- **Electrical submeters:** lighting, HVAC, general 120V, service water heating, renewables, whole building
- **Benchmarks:** monthly energy use
- **Training:** facility operator – on continuous benchmarking

Source: 50% AEDG for Large Hospitals from ASHRAE

Case Studies

SWEDISH ISSAQUAH HOSPITAL A CASE STUDY

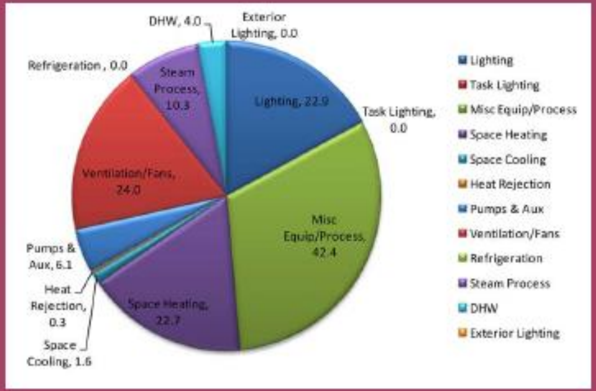
Located in the Issaquah Highlands near Seattle, Washington, Swedish Issaquah is a 350,000 ft^2, four-story acute-care hospital with 175 beds, and is the first greenfield hospital to be built in King County in 25 years. When fully complete, it will be part of a 550,000 ft^2 campus that includes the acute-care hospital (composed of emergency, surgery, imaging, labor and delivery, pediatrics, intensive-care unit, cancer, and medical/surgical facilities), a 200,000 ft^2 medical office building (MOB), and a stand-alone central utility plant (CUP) connected by a utility tunnel.

INTEGRATED DESIGN

Design began in May of 2009 with an EUI target of 150 kBtu/ft^2·yr or lower. Similar hospitals in the Pacific Northwest have an EUI of about 260–265 kBtu/ft^2·yr. Using an integrated project delivery approach, all the stakeholders were brought together early in the process. This spirit of cooperation and involvement extended through completion of construction and included the pipe fitters and sheet metal installers. Once it was understood that efficiency was a key element of the design, even the number of pipe bends and duct offsets became important.

The design team met weekly to discuss how best to expedite design. The integrated design approach carried through into the roles and responsibilities shared by the mechanical design engineer and contractor. All major equipment, pipe racks, ductwork, skids, and assemblies

Swedish Issaquah Hospital
Photos courtesy of CollinsWoerman (reprinted with permission)



Annual Energy End-Use Breakdown (EUI)
Modeled EUI = 135 kBtu/ft^2·yr

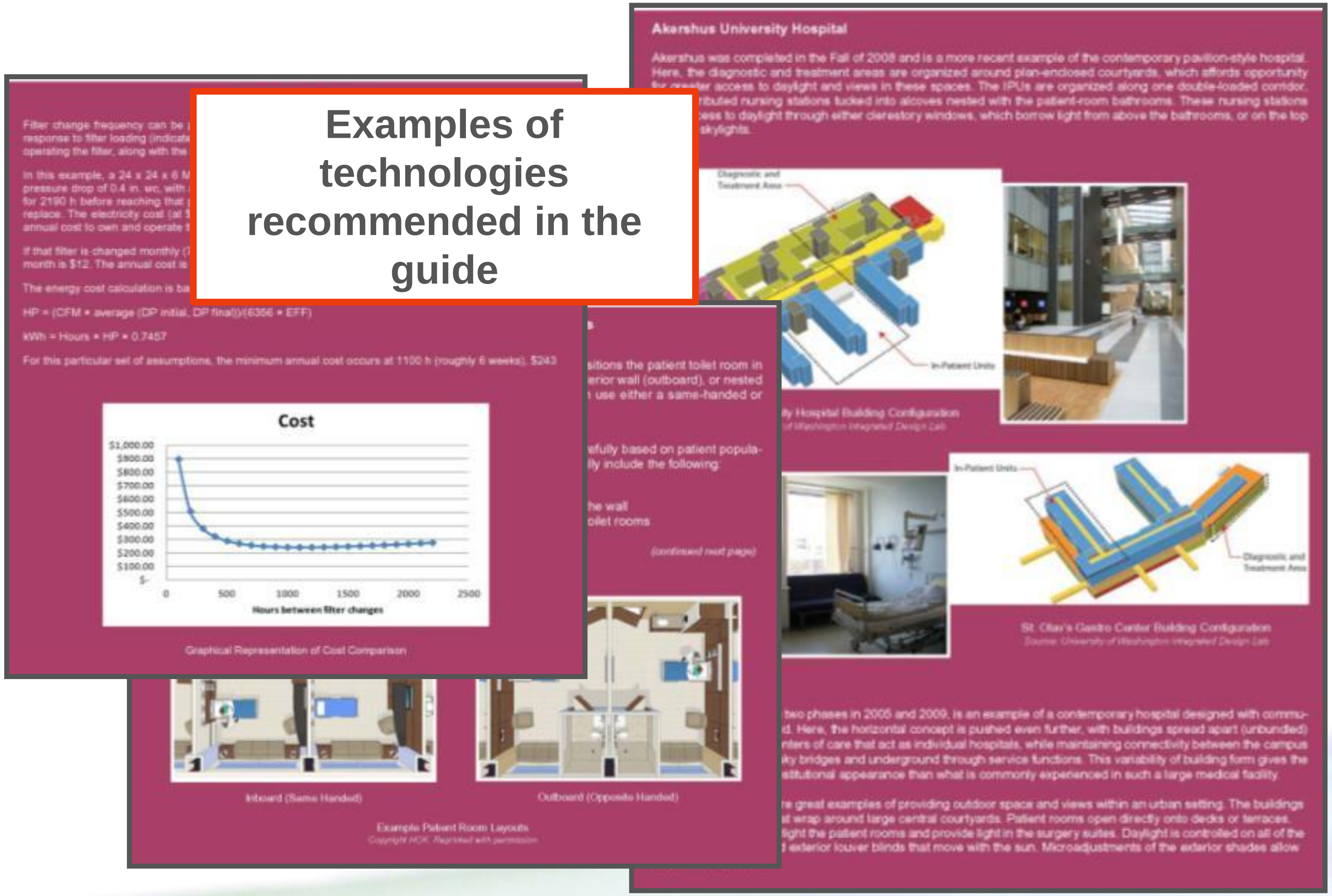
Energy Savings Analysis

Strategy	Total Cost	Annual Energy Savings	Simple Payback
Light Occupancy Sensors		$22,941	
VAV	$973,047	$342,183	3 years
Heat Recovery System	$1,103,971	$115,081	10 years
Low Static Pressure AHUs	$398,312	$31,742	13 years
Low Static Pressure Ducts	$314,983	$19,538	16 years
VSD Chiller	$208,998	$11,144	19 years

Examples of High Performance Buildings – Demonstrates Flexibility in Achieving Advanced Energy Savings

Source: 50% AEDG Large Hospitals from ASHRAE

Technology Examples



Source: 50% AEDG Large Hospitals from ASHRAE

HV1 – First Tip

HV1 – Thermal Zoning

"Coordinate the location of nonclinical spaces so that they can be served by HVAC systems that can be setback or shut down when their locations are unoccupied (with temperature setback control and optimized start up). Typical examples are administration and finance offices, dining, outpatient services, and occupational/physical therapy areas."

Major Energy Uses in a Large Hospital

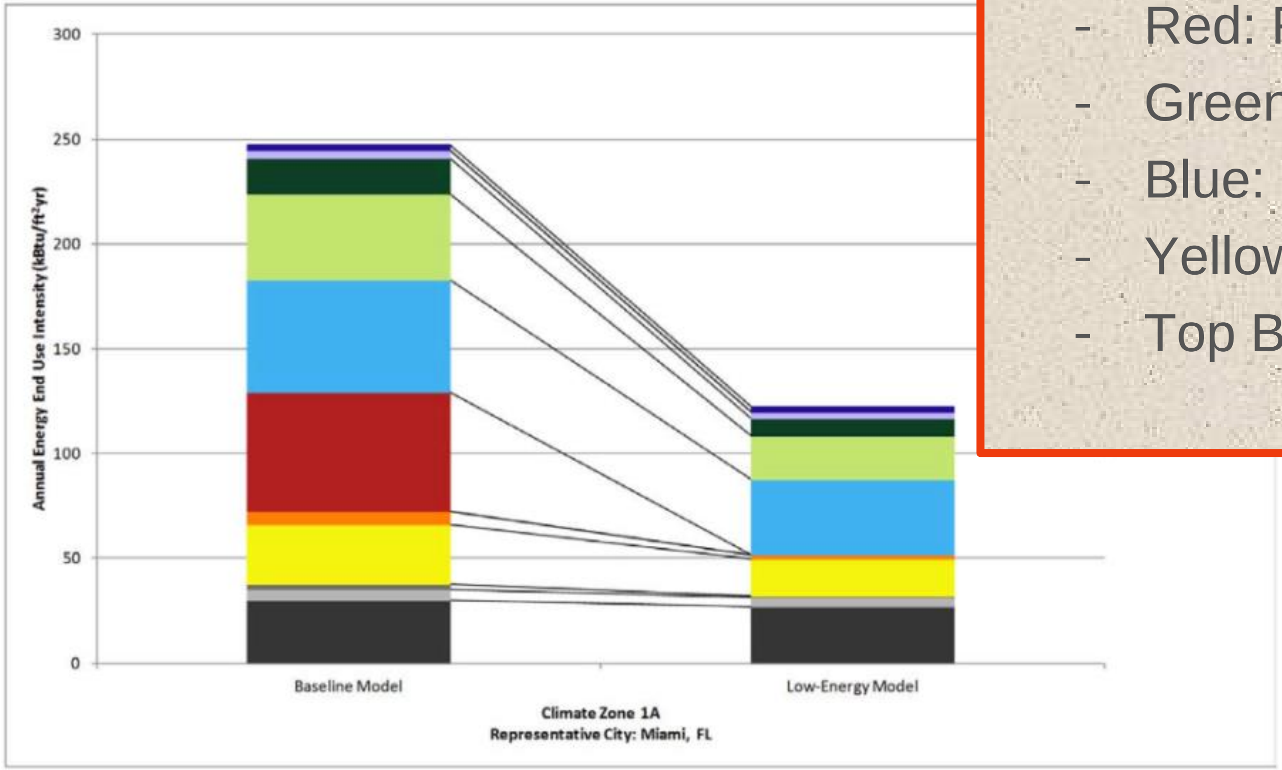


Figure 3-1 Comparison of Baseline to Prescriptive 50% AEDG Solution Showing Breakdown of Energy Savings Components

- Where are the savings?
  - Red: Reheat
  - Green: Fans
  - Blue: Cooling
  - Yellow: Interior lights
  - Top Black: Pumps

Source: 50% AEDG Large Hospitals from ASHRAE

Aggressively Address Reheat

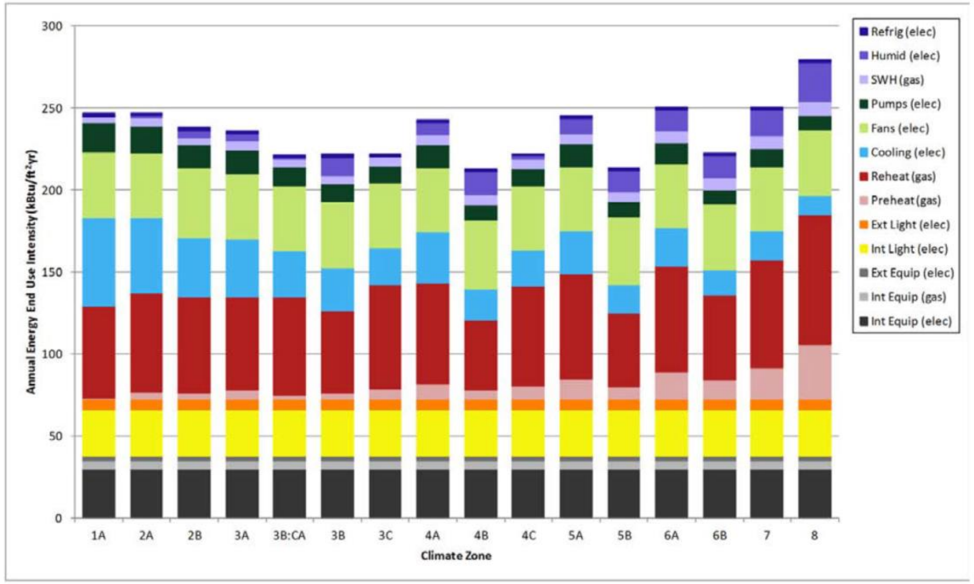


Figure 3-18 Reheat Energy (in Red) Compared to other Energy Uses in Healthcare Facilities

- Supply dry air to OR
- Recover heat from chilled water system

Source: 50% AEDG Large Hospitals from ASHRAE

HVAC systems included in tables:

Surgery areas

- Chilled-water air-handling system

Non-surgery areas

- Water-source heat pumps with a dedicated outdoor-air system (DOAS)
- Four-pipe fan coils with DOAS
- Chilled-water VAV air-handling system with separate OA treatment

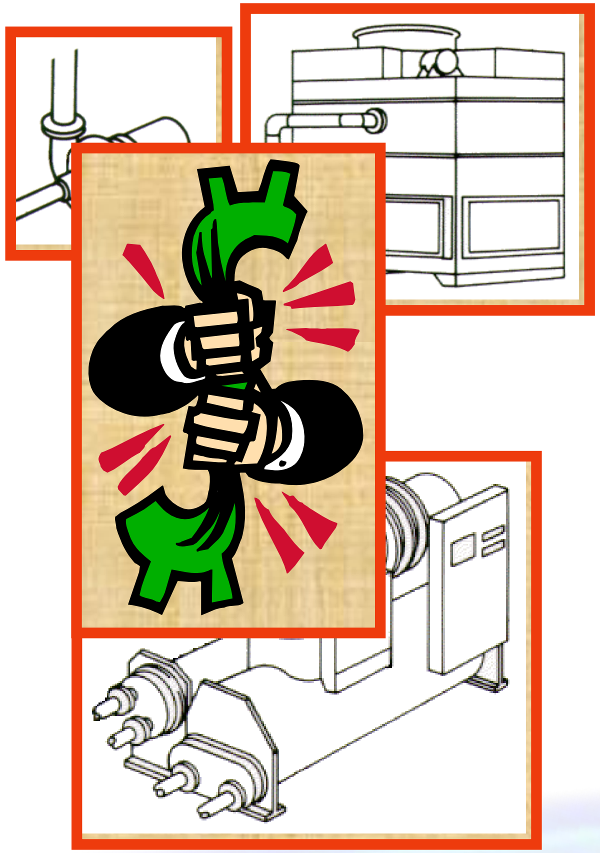
50% AEDG for Large Hospitals
Surgery Areas

- Chiller plant
  - Chiller: 6.50 COP (0.54 kW/ton) full load
  - 15° F chilled water ΔT
  - 14° F condenser water ΔT
  - Variable-speed cooling tower fans
  - Control to minimize chiller + tower energy
- Central, chilled-water AHU
  - Consider series desiccant wheel for low dew-point applications

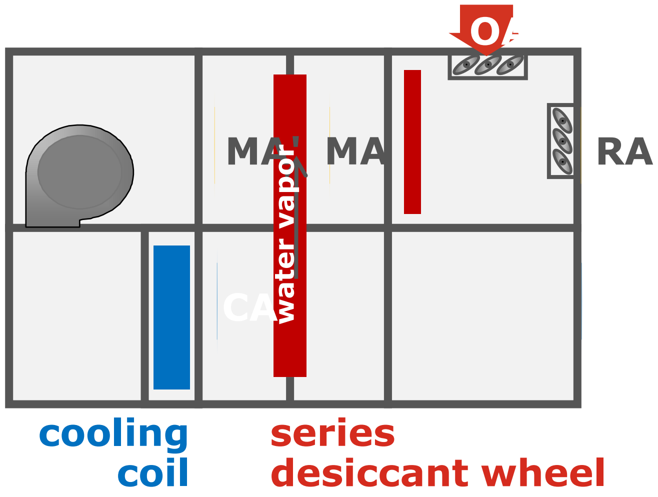
Source: 50% AEDG for Large Hospitals from ASHRAE

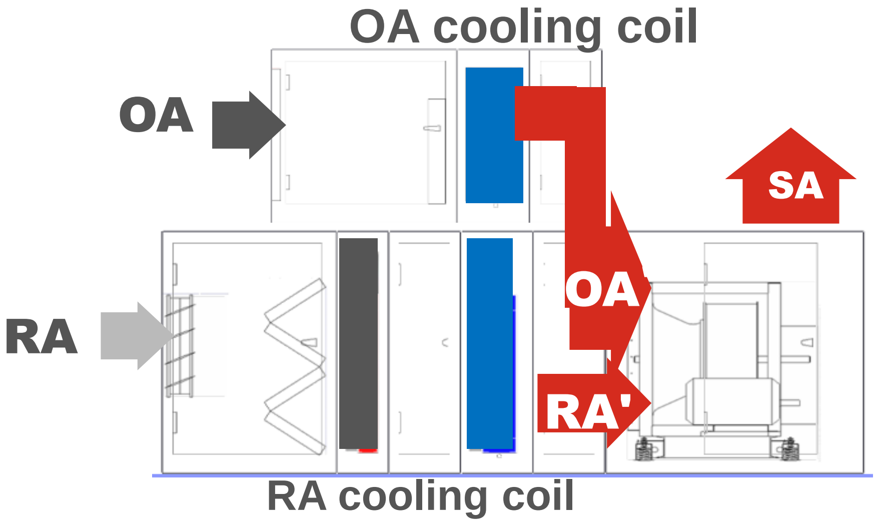
Use AEDG recommendations to Balance Installed and Operating Costs

- Reduced flow rates results in
  - Smaller pumps, pipes, and cooling towers
  - Lower operating costs
- Variable primary flow results in
  - Fewer pumps
  - Lower operating costs
- Heat recovery chillers result in
  - Reduced energy purchased for reheat
  - Reduced tower energy, make-up water and water treatment costs



Aggressively Address Reheat





Series desiccant wheel
Provide low humidity levels in the OR while minimizing reheat energy

Dual-Path Air Handler
Treat outdoor air separately

50% AEDG for Large Hospitals
WSHPs with DOAS

- WSHPs
  - Two-stage or variable-speed compressors
  - Variable-speed fans
  - ≥ 4 tons, but encouraged for smaller units also
  - Cooling: 17.6 EER (part load), 15.0 EER (full load)
  - Heating: 5.7 COP (part load), 5.0 COP (full load)
- Dedicated OA system
  - Deliver air cold when possible
  - Exhaust-air energy recovery (60% effective)
  - Demand-controlled ventilation

50% AEDG for Large Hospitals
Fan-Coils with DOAS

- Multiple-speed or variable-speed fans
- Chiller plant
  - Chiller: 6.50 COP (0.54 kW/ton)
  - 15°F chilled water ΔT
  - 14°F condenser water ΔT
  - Variable-speed cooling tower fans
  - Control to minimize chiller + tower energy
- Dedicated OA system
  - Deliver air cold when possible
  - Exhaust-air energy recovery (60% effective)
  - Demand-controlled ventilation

How-To Tips

HVAC	Nonsurgery	Fan-coil system with DOAS	Water-cooled chiller	6.5 COP	HV8, 35	
			Water-circulation pumps	VFD and NEMA premium	HV35	
			Cooling towers	VFD on tower fans	HV37	
			Boiler efficiency	90% E_c	HV8	
			Maximum fan power	0.4 W/cfm	HV21–22, 24	
			FCU fans	Multiple speed	HV5	
			Exhaust-air energy recovery in DOAS	A (humid zones) = 60% total effectiveness B (dry zones) = 60% sensible effectiveness C (marine zones) = 60% total effectiveness	HV9, 15–16	
			DOAS ventilation control	DCV with VFD	HV10–11	

HV5 *Fan-Coils w*

In fan-coil sy
factory desig
and possibly
Fan coils

The cooling equipment, heating equipment, and fans should meet or exceed the efficiency levels listed in the recommendation tables in Chapter 4 or listed in this chapter (HV8). The cooling equipment should also meet or exceed the part-load efficiency level, where shown. Performance requirements for ducted fan coils are (1) 0.30 W/cfm design supply air to a space with VAV operation and (2) coil chilled-water ΔTs of at least 14°F.

corridor (or some other noncritical space), or in a closet adjacent to the space (see the WSHP figure in HV2 as an example). However, the equipment should be located to meet the acoustic goals of the space; this may require that the fan coils be located outside of the space while also attempting to minimize fan power, ducting, and wiring. Fan coils should be equipped with a variable-speed fan to automatically enable VAV operation and enhance motor efficiency.

All the fan coils are connected to a common water distribution system. Cooling is provided

Source: 50% AEDG for Large Hospitals from ASHRAE

50% AEDG for Large Hospitals
Chilled-Water VAV System

- Separate treatment of OA
  - Exhaust-air energy recovery (60% effective)
  - Demand-controlled ventilation
- Chiller plant
  - Water-cooled heat recovery chiller: 4.55 COP
  - Water-cooled cooling-only chiller: 6.50 COP
  - 15° F chilled water ΔT
  - 14° F condenser water ΔT
  - Variable-speed cooling tower fans
  - Control to minimize chiller + tower energy

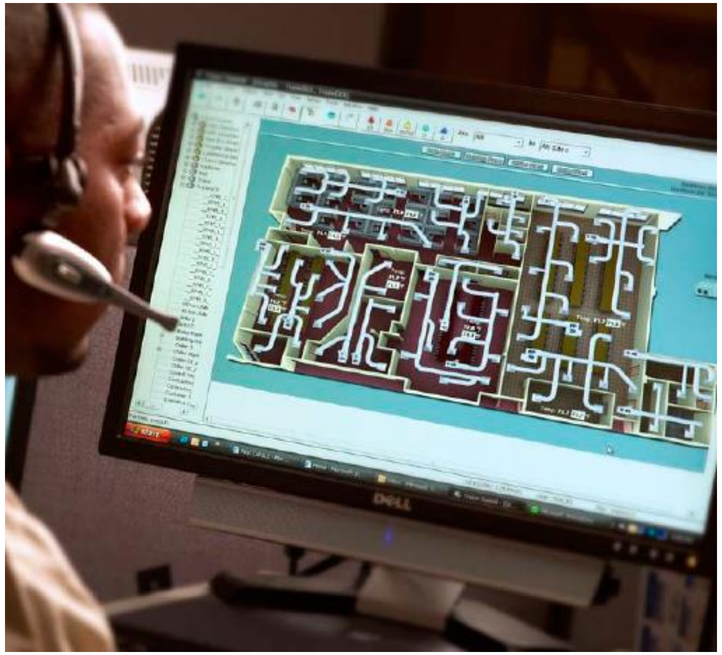
Demand Control Ventilation

- Sensing technologies
  - CO2 sensors in densely occupied spaces
  - Occupancy sensors where population variation is minimal
  - Time-of-day for zones that are sparsely occupied or predicted occupancy patterns
- Std 170
  - *“Reduce airflow rates during unoccupied hours in surgery rooms and other spaces with minimum air-change requirements”*
  - Maintain pressurization requirements

High-Performance VAV System

Optimized VAV system controls

- Optimal start/stop
- Fan-pressure optimization
- Supply-air-temperature reset
- Ventilation optimization (including demand-controlled ventilation)



Additional Bonus Savings

- Other HVAC Strategies
- Radiant Heating/Cooling with Displacement Ventilation, Fan Arrays, Evaporative Condensing,
- Combined Heat and Power, Water Restricted Locations
- Renewable Energy
- Photovoltaic, Wind Turbine, Solar Hot Water Systems, Power Purchase Agreements
- Electrical Distribution
- Transformer Efficiency, System Design, Metering

50% Large Hospital AEDG

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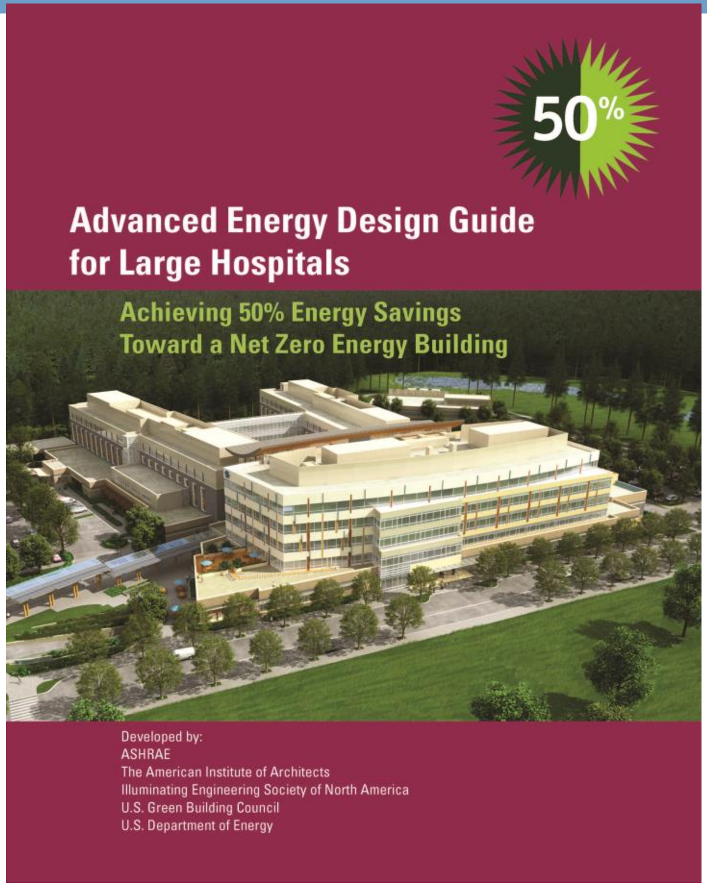

Source: 50% AEDG Large Hospitals from ASHRAE

Questions?

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